Thorlabs APT Controllers

Host-Controller Communications Protocol

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Contents

Introduction

1. Purpose and Scope

This document describes the low-level communications protocol and commands used between the host PC and controller units within the APT family. The information contained in this document is intended to help third party system developers to write their own applications to interface to the Thorlabs range of controllers without the constraints of using a particular operating system or hardware platform. The commands described here are those which are necessary to control movement; there is an additional set of commands, used for calibration or test, which will not be detailed as these are not required for the external system developer.

2. Electrical interface

The APT family of controllers provides a USB and an RS-232 interface to communicate with the host PC. The communications protocol is identical in both cases but developers wishing to use the USB interface should be aware of the USB enumeration scheme used in the system.

2.1 USB Interface

The electrical interface within the APT controllers uses a Future Technology Devices International (FTDI), type FT232BM USB peripheral chip to communicate with the host PC. This is a USB2.0 compliant USB1.1 device. This USB interfacing chip provides a serial port interface to the embedded system (i.e. APT controller) and USB interface to the host control PC. While the overall communications protocol is independent of the transport layer (for example, Ethernet or serial communications could also be used to carry commands from the host to the controller), the initial enumeration scheme described below is specific to the USB environment.
FTDI supply device drivers and interfacing libraries (for Windows, Linux and other platforms) used to access the USB chip. Before any PC USB communication can be established with an APT controller, the client program is required to set up the necessary FTDI chip serial port settings used to communicate to the APT controller embedded system. Within the APT software itself the following FTDI library calls are made to set up the USB chip serial port for each APT USB device enumerated on the bus:-

```
// Set baud rate to 115200.
ftStatus = FT_SetBaudRate(m_hFTDevice, (ULONG)uBaudRate);

// 8 data bits, 1 stop bit, no parity
ftStatus = FT_SetDataCharacteristics(m_hFTDevice, FT_BITS_8, FT_STOP_BITS_1,
FT_PARITY_NONE);

// Pre purge dwell 50ms.
Sleep(uPrePurgeDwell);

// Purge the device.
ftStatus = FT_Purge(m_hFTDevice, FT_PURGE_RX | FT_PURGE_TX);

// Post purge dwell 50ms.
Sleep(uPostPurgeDwell);
```

```
// Reset device.
ftStatus = FT_ResetDevice(m_hFTDevice);

// Set flow control to RTS/CTS.
ftStatus = FT_SetFlowControl(m_hFTDevice, FT_FLOW_RTS_CTS, 0, 0);

// Set RTS.
ftStatus = FT_SetRts(m_hFTDevice);
```

2.2 USB Device Enumeration

The APT Server PC software supplied is designed to work with a number of different types of controller. The purpose of the enumeration phase is for the host to establish what devices are present in the system and initialise the GUI accordingly. Initially this is done by enumerating the USB devices connected to the system and reading the serial number information contained in the USB device descriptor.

For the Thorlabs range of controllers, this serial number is an 8-digit decimal number. The first two digits (referred to as the prefix) describe the type of controller, while the rest of the digits make up a unique serial number. By extracting the prefix, the host can therefore establish what type of hardware is connected to the system.

In most cases, specifically with benchtop controllers, the USB serial number contains sufficient information for the host to know the exact type of hardware is connected. There is a range of other controller products where several controller cards (without their own individual USB peripheral chip) can be plugged into a motherboard and it is only the motherboard that has USB connectivity. These are generally referred to as a card slot (or bay) type of system (for example, the BSC103 controller). In these systems, a second enumeration state is carried out; however, this second state is done within the protocol framework that will be detailed in this document.

For the controller types, the USB prefixes can be the following:

USB S/N	Type of product	Thorlabs code
20xxxxxx	Legacy single channel stepper driver	BSC001
25xxxxxx	Legacy single channel mini stepper driver	BMS001
30xxxxxx	Legacy dual channel stepper driver	BSC002
35xxxxxx	Legacy dual channel mini stepper driver	BMS002
40xxxxxx	Single channel stepper driver	BSC101
60xxxxxx	OptoSTDriver (mini stepper driver)	OST001
63xxxxxx	OptoDCDriver (mini DC servo driver)	ODC001
70xxxxxx	Three channel card slot stepper driver	BSC103
80xxxxxx	Stepper Driver T-Cube	TST001
83xxxxxx	DC servo driver T-Cube	TDC001
73xxxxxx	Brushless DC motherboard	BBD102/BBD103
94xxxxxx	Brushless DC motor card	BBD102/BBD103

Of these listed above, currently only the BSC103 (serial number prefix 70) and the BBD10x are card slot type of controllers.

2.3 RS-232 Interface

The RS-232 interface uses the 9-way D-Type male connector on the rear panel, marked ‘INTERCONNECT’. Communications parameters are fixed at:

- 115200 bits/sec
- 8 data bits, 1 stop bit
- No parity
- No handshake

By nature, the RS-232 interface provides point-to-point communications, and therefore there is no device enumeration as there is with USB based communications.

3. Overview of the Communications Protocol

The communications protocol used in the Thorlabs controllers is based on the message structure that always starts with a fixed length, 6-byte *message header* which, in some cases, is followed by a variable length *data packet*. For simple commands, the 6-byte message header is sufficient to convey the entire command. For more complex commands, for example, when a set of parameters needs to be passed on, the 6 byte header is not enough and in this case the header is followed by the data packet.

The header part of the message always contains information that indicates whether or not a data packet follows the header and if so, the number of bytes that the data packet contains. In this way the receiving process is able to keep tracks of the beginning and the end of messages.

Note that in the section below describing the various byte sequences, the C-type of notation will be used for hexadecimal values (e.g. 0x55 means 55 hexadecimal) and logical operators (e.g. | means logic bitwise OR). Values that are longer than a byte follow the Intel little-endian format.

4. Description of the message header

The 6 bytes in the message header are shown below:

<table>
<tr><td>Byte:</td><td>byte 0</td><td>byte 1</td><td>byte 2</td><td>byte 3</td><td>byte 4</td><td>byte 5</td></tr>
<tr><td>Meaning if no data packet to follow</td><td colspan="2">message ID</td><td>param1</td><td>param2</td><td>dest</td><td>source</td></tr>
<tr><td>Meaning if data packet to follow</td><td colspan="2">message ID</td><td colspan="2">data packet length</td><td>dest | 0x80</td><td>source</td></tr>
</table>

The meaning of some of the fields depends on whether or not the message is followed by a data packet. This is indicated by the most significant bit in byte 4, called the destination byte*,* therefore the receiving process must first check if the MSB of byte 4 is set.

If this bit is not set, then the message is a header-only message and the interpretation of the bytes is as follows:

message ID: describes what the action the message requests
param1: first parameter (if the command requires a parameter, otherwise 0)

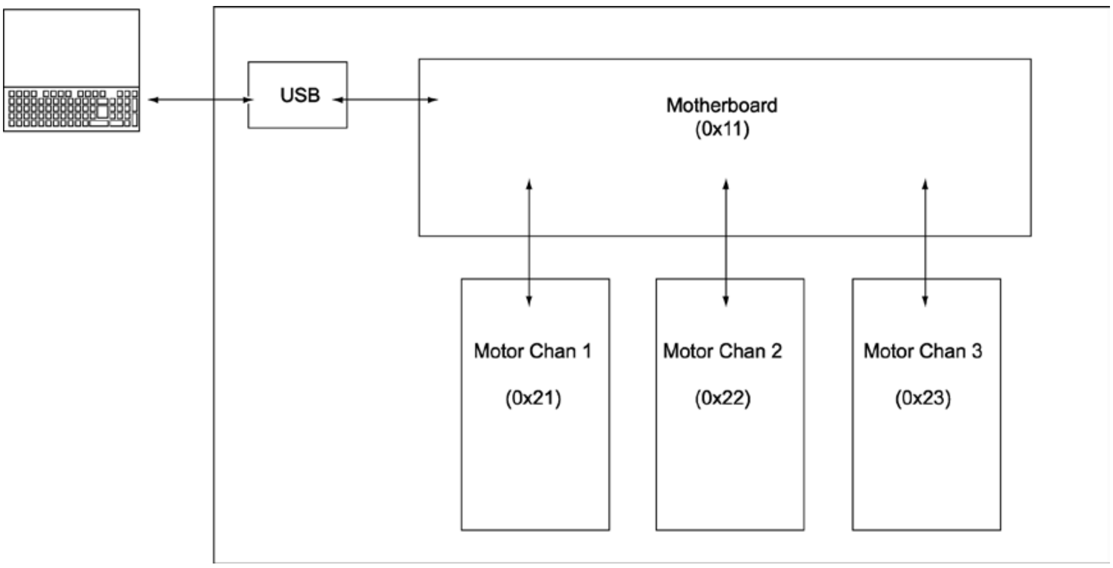
param2: second parameter (if the command requires a parameter, otherwise 0)
dest: the destination module
source: the source of the message

The meaning of the source and destination bytes will be detailed later.
If the MSB of byte 4 is set, then the message will be followed by a data packet and the interpretation of the header is the following:

message ID:	describes what the action the message requests
datapacket length:	number of bytes to follow after header Note: although this is a 2-byte long field, currently no datapacket exceeds 255 bytes in length.
dest: | 0x80	the destination module logic OR'd with 0x80 (noted by d|)
source:	the source of the data

The source and destination fields require some further explanation. In general, as the name suggests, they are used to indicate the source and destination of the message. In non-card-slot type of systems the source and destination of messages is always unambiguous, as each module appears as a separate USB node in the system. In these systems, when the host sends a message to the module, it uses the source identification byte of 0x01 (meaning host) and the destination byte of 0x50 (meaning "generic USB unit"). (In messages that the module sends back to the host, the content of the source and destination bytes is swapped.)

In card-slot (bay) type of systems, there is only one USB node for a number of sub-modules, so this simple scheme cannot be used. Instead, the host sends a message to the motherboard that the sub-modules are plugged into, with the destination field of each message indicating which *slot* the message must be routed to. Likewise, when the host receives a message from a particular sub-module, it knows from the source byte which slot is the origin of the message – see Fig below.



Numerically, the following values are currently used for the source and destination bytes:

```
0x01        Host controller (i.e control PC)
0x11        Rack controller, motherboard in a card slot system or
            comms router board
0x21        Bay 0 in a card slot system
0x22        Bay 1 in a card slot system
0x23        etc.
0x24        etc.
0x25        etc.
0x26        etc.
…
0x2A        Bay 9 in a card slot system
0x50        Generic USB hardware unit
```

In slot-type systems the host can also send messages to the motherboard that the sub-modules are plugged into (destination byte = 0x11). In fact, as a very first step in the communications process, the host must send a message to the motherboard to find out which slots are used in the system.

Note that although in theory this scheme would allow communication between individual sub-modules (the source of the message could be a sub-module and the destination another one), current systems do not use this option.

5. General message exchange rules

The type of messages used in the communications exchange between the host and the sub-modules can be divided into 4 general categories:

(a) Host issues a command, sub-module carries out the command without acknowledgement (i.e. no response is sent back to the host).

Typically, these are commands which require no information from the sub-module, for example setting the digital outputs to a particular state.

(b) Host issues a command (message request) and the sub-module responds by sending data back to the host.

For example, the host may request the sub-module to report the state of the digital inputs.

(c) Following a command from the host, the sub-module periodically sends a message to the host without further prompting.

These messages are referred to as *status update messages*. These are typically sent automatically every 100 msec from the sub-module to the host, showing, amongst other things, the position of the stage the controller is connected to. The meters on the APT User GUI rely on these messages to show the up-to-date status of the stage.

(d) Rarely – error messages, exceptions. These are spontaneously issued by the sub-module if some error occurs. For example, if the power supply fails in the sub-module, a message is sent to the host PC to inform the user.

Apart from the last two categories (status update messages and error messages), in general the message exchanges follow the SET -> REQUEST -> GET pattern, i.e. for most commands a trio of messages are defined. The SET part of the trio is used by the host (or, sometimes in card-slot systems the motherboard) to set some parameter or other. If then the host requires some information from the sub-module, then it may send a REQUEST for this information, and the sub-module responds with the GET part of the command. Obviously, there are cases when this general scheme does not apply and some part of this message trio is not defined. For consistency, in the description of the messages this SET->REQUEST->GET scheme will be used throughout.

Note that, as the scheme suggests, this is a master-slave type of system, so sub-modules never send SET and REQUEST messages to the host and GET messages are always sent to the host as a destination.

In all messages, where a parameter is longer than a single character, the bytes are encoded in the Intel format, least significant byte first.

6. Format Specifiers

format	encoding
word	Unsigned 16 bit integer (2 bytes) in the Intel (little-endian) format for example decimal 12345 (3039H) is encoded as the byte sequence 39, 30
short	Signed 16 bit integer (2 bytes) in 2's compliment format for example decimal -1 is encoded as the byte sequence FF, FF
dword	Unsigned 32 bit integer (4 bytes) in the Intel (little-endian) format for example decimal 123456789 (75BCD15H) is encoded as the byte sequence 15, CD, 5B, 07
long	Signed 32 bit integer (4 bytes) in 2's compliment format for example decimal -1 is encoded as the byte sequence FF, FF 4 bytes in the Intel (little-endian) format for example decimal -123456789 (FFFFFFFFF8A432EBH) is encoded as the byte sequence EB, 32, A4, F8,
char	1 byte (2 digits)
char[N]	string of N characters

7. Single Precision Floating Point Format

Single-precision floating-point format is a computer number format that occupies 4 bytes (32 bits) in computer memory and represents a wide dynamic range of values by using a floating point.
Where message parameters use floating point variables, the system uses the IEEE 754 standard.

8. Conversion between position, velocity and acceleration values in standard physical units and their equivalent APT parameters.

To convert between the position and encoder counters in the stage being driven, and real world units, (e.g. mm) the system uses certain conversion (scaling) factors. These conversion factors differ depending on the stage being driven and the controller being used.

Background

The principle described below is the same for all APT motion stepper and brushed or brushless DC controllers and stages, but the individual distance and time conversion factors will be typically different for each stage and/or controller.
In real life, the physical units needed to describe position, velocity and acceleration are related to position and time measurement units (millimetres/degrees and seconds). In motion controllers, however, normally the system only knows the distance travelled in encoder counts (pulses) as measured by an encoder fitted to the motor shaft. In most cases the motor shaft rotation is also scaled down further by a gearbox and a leadscrew. In any case, the result is a scaling factor between encoder counts and position. The value of this scaling factor depends on the stage. In the section below this scaling factor will be represented by the symbol EncCnt.
Time is related to the sampling interval of the system, and as a result, it depends on the motion controller. Therefore, this value is the same for all stages driven by a particular controller. In the sections below the sampling interval will be denoted by T.
The sections below describe the position, velocity and acceleration scaling factors for all the controllers and stages that are used with these controllers. The symbols POS_{APT}, VEL_{APT} and ACC_{APT} are used to denote the position, velocity and acceleration values used in APT commands, whereas the symbols Pos, Vel and Acc denote physical position, velocity and

acceleration values in mm, mm/sec and mm/sec^2 units for linear stages and degree, degree/sec and degree/sec^2 for rotational stages.
As APT parameters are integer values, the APT values calculated from the equations need to be rounded to the nearest integer.

Brushed DC Controller (TDC001) driven stages

Mathematically:
POS_{APT} = EncCnt × Pos
VEL_{APT} = EncCnt × T × 65536 × Vel
ACC_{APT} = EncCnt × T^2 × 65536 × Acc
where T = 2048 / 6 × 10^6

The value of EncCnt and the resulting conversion factors are listed below for each stage:

Stage	EncCnt per mm	Scaling Factor	
		Velocity (mm/s)	Acceleration (mm/s^2)
MTS25-Z8	34304	767367.49	261.93
MTS50-Z8	34304	767367.49	261.93
PRM1-Z8	1919.64	42941.66	14.66
Z8xx	34304	767367.49	261.93
Z6xx	24600	550292.68	187.83

Brushless DC Controller (TBD001, BBD10X and BBD20X) driven stages

Mathematically:
POS_{APT} = EncCnt × Pos
VEL_{APT} = EncCnt × T × 65536 × Vel
ACC_{APT} = EncCnt × T^2 × 65536 × Acc
where T = 102.4 × 10^{-6}

Linear Stages
The value of EncCnt and the resulting conversion factors are listed below for each stage:

Stage	EncCnt per mm	Scaling Factor	
		Velocity (mm/s)	Acceleration (mm/s^2)
DDSM100	2000	13421.77	1.374
DDS220	20000	134217.73	13.744
DDS300	20000	134217.73	13.744
DDS600	20000	134217.73	13.744
MLS203	20000	134217.73	13.744

Rotary Stages
The value of EncCnt and the resulting conversion factors are listed below for each stage:

Stage	EncCnt per 360°	Scaling Factor		
		EncCnt per °	Velocity (°/s)	Acceleration (°/s^2)
DDR100	3276800	9102.22	61083.98	6.255
DDR05	2000000	5555.55	37282.7	3.81775

Stepper Motor Controller (TST001 BSC00x, BSC10x, MST601) Driven Stages

For these stepper controllers the server sends absolute micro-steps to the controllers. Depending on the stage and the stepper motor concerned there are different micro step values required to move either a linear distance in millimetres or a rotational distance in degrees.
In general for 200 full step motors (the majority of our motors) the above range of stepper controllers is designed to insert 128 micro steps for every full step of the stepper.
So for a 200 full step motor the number of micro steps per full turn is defined as follows

<u>Full turn micro steps = Motor full steps per turn x Number of Micro steps per full step</u>

For a 200 full step motor this is given by :- <u>Full turn micro steps = 200 x 128 = 25600</u>

However the ZST and ZFS range of actuators have 24 full steps per revolution and furthermore, both motors are fitted with a gearbox. The ZST has a ratio 40.866:1, while the ZFS has a ratio 400:9.
So, for the ZST series, a 1mm move requires 24 x 128 x 40.866 = 125540.35 µsteps, while for the ZFS series, a 1mm move requires 24 x 128 x 400/9 = 136533.33 µsteps.

Each stage can either be a direct drive or driven through a gear box. The table below indicates the relationship between absolute micro steps and a positional output in millimetres or degrees

This table is relevant for the range of controllers listed above. Note that micro step values are for a position of 1mm, a velocity of 1mm/sec and an acceleration of 1mm/sec/sec

Stage	Gearing	Position	Micro Step Values		
			Position(µs)	Velocity(µs/sec)	Acceleration(µs/sec^2)
ZST Series	0.0245 mm/turn	1mm	125540.35	125540.35	125540.35
ZFS Series	0.0225 mm/turn	1 mm	136533.33	136533.33	136533.33
DRV001	0.5mm/turn	1mm	51200	51200	51200
DRV013	1mm/turn	1mm	25600	25600	25600
DRV014	1mm/turn	1mm	25600	25600	25600
NRT100	1mm/turn	1mm	25600	25600	25600
NRT150	1mm/turn	1mm	25600	25600	25600
LTS150	1mm/turn	1mm	25600	25600	25600
LTS300	1mm/turn	1mm	25600	25600	25600
DRV113	1.25mm/turn	1mm	20480	20480	20480
DRV114	1.25mm/turn	1mm	20480	20480	20480
FW103*	No gear	0.998deg	71	71	71
NR360**	5.4546deg/turn	0.999deg	4693	4693	4693

*Note that there is no exact value of micro steps to get to exactly 1 degree this is because 1 turn represents 360 degrees which is 25600 micro steps. So actual resolution is 360/25600 = 0.0140625 degrees per micro step.

**Note that there is no exact value of micro steps to get to exactly 1 degree this is because 1 turn represents 5.4546 degrees which is 25600 micro steps. So actual resolution is 5.4546/25600 = 0.0002131 degrees

Stepper Motor Controller (TST101, BSC20x, MST602) Driven Stages

The BSC20x series and MST602 stepper controllers include a Trinamics encoder with a resolution of 2048 microsteps per full step, giving 409600 micro-steps per revolution for a 200 step motor.
However the ZST and ZFS range of actuators have 24 full steps per revolution and furthermore, both motors are fitted with a gearbox. The ZST has a ratio 40.866:1, while the ZFS has a ratio 400:9.
So, for the ZST series, a 1mm move requires 24 x 2048 x 40.866 = 2008645.63 µsteps, while for the ZFS series, a 1mm move requires 24 x 2048 x 400/9 = 2184533.33 µsteps.

This table is relevant only for the Trinamic-based range of controllers listed above. Note that micro step values are for a position of 1mm, a velocity of 1mm/sec and an acceleration of 1mm/sec/sec.

Stage	Gearing	Position	Trinamic converted Values		
			Position(µs)	**Velocity(µs/sec)**	**Acceleration(µs/sec^2)**
ZST Series	0.0245 mm/turn	1mm	2008645.63	107824097.5	22097.3
ZFS Series	0.0225 mm/turn	1mm	2184533.33	117265749.2	24111.85
DRV001	0.5mm/turn	1mm	819200	43974656	9012
DRV013	1mm/turn	1mm	409600	21987328	4506
DRV014	1mm/turn	1mm	409600	21987328	4506
NRT100	1mm/turn	1mm	409600	21987328	4506
NRT150	1mm/turn	1mm	409600	21987328	4506
LTS150	1mm/turn	1mm	409600	21987328	4506
LTS300	1mm/turn	1mm	409600	21987328	4506
MLJ050	1mm/turn	1mm	409600	21987328	4506
DRV113	1.25mm/turn	1mm	327680	17589862	3605
DRV114	1.25mm/turn	1mm	327680	17589862	3605
FW103*	No gear	1.0002deg	1138	61088	13
NR360**	5.4546deg/turn	0.99997deg	75091	4030885	826

In the above table the numbers that need to be sent to the controllers are based upon the Trinamics chip set conversions. The position is just the absolute number of micro-steps as before, as compared with the BSC10X range, the only difference is the 16 times greater resolution. However for velocity and acceleration different conversion factors are required to get to correct motion profiles. For example, if a velocity of 409600 micro-steps per sec is required, then multiply by 53.68 i.e. 409600*53.68 gives 21987328 which for a 1mm lead screw would give 1mm/sec.
To accelerate at a rate of 409600 micro-steps/sec/sec (1mm/sec/sec), divide 409600 by 90.9 which gives 4506.

Generic System Control Messages

Introduction

The messages described here are either system control messages, or else generic messages which apply to several or all controller types. Please see the list of controller specific commands for details on applicability to a specific controller type.

MGMSG_MOD_IDENTIFY 0x0223

Function: Instruct hardware unit to identify itself (by flashing its front panel LEDs).

Command structure (6 bytes):

0	1	2	3	4	5
header only					
23	02	00	*00*	*d*	*s*

Example: Identify controller #1 (i.e. bay 0 of the TDC001 controller) by flashing its front panel LED.

TX 23, 02, 00, 00, 21, 01

MGMSG_MOD_SET_CHANENABLESTATE 0x0210
MGMSG_MOD_REQ_CHANENABLESTATE 0x0211
MGMSG_MOD_GET_CHANENABLESTATE 0x0212

Function Sent to enable or disable the specified drive channel.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
10	02	Chan Ident	Enable State	d	s

Channel Idents
0x01 channel 1
0x02 channel 2

For the TIM101 4 channel controller, the following idents are also used
0x04 channel 3
0x08 channel 4

Enable States
0x01 enable channel
0x02 disable channel

For single channel controllers such as the BBD10X, TDC001, the Chan Ident byte is always set to CHAN1.

Note: Although the BBD102 is in fact a 2-channel controller, 'channel' in this sense means "motor output channel within this module". Electrically, the BBD102 is a bay system, with two bays, each of them being a single channel controller, so only one channel can be addressed. There are controllers in the Thorlabs product range which indeed have multiple output channels (for example the MST601 module) for which the channel ident is used to address a particular channel.

Example: Enable the motor channel in bay 2

TX 10, 02, 01, 01, 22, 01

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	02	Chan Ident	0	d	s

As above, for single channel controllers such as the BBD10X, TDC001, the Chan Ident byte is always set to CHAN1.

GET:

Response structure (6 bytes):

0	1	2	3	4	5
header only					
12	02	Chan Ident	Enable State	d	s

The meaning of the parameter bytes “Chan Ident” and “Enable State” is the same as for the SET version of the commands.

MGMSG_HW_DISCONNECT 0x0002

Function: Sent by the hardware unit or host when either wants to disconnect from the Ethernet/USB bus.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
02	00	00	00	d	s

Example: Disconnect the BBD103 from the USB bus

TX 02, 00, 00, 00, 11, 00

MGMSG_HW_RESPONSE 0x0080

Function: Sent by the controllers to notify APT Server of some event that requires user intervention, usually some fault or error condition that needs to be handled before normal operation can resume. The message transmits the fault code as a numerical value – see Return Codes.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
80	00	00	00	d	s

Example: The BBD103 unit has encountered an over current condition

TX 80, 00, 00, 00, 01, 11

MGMSG_HW_RICHRESPONSE 0x0081

Function: Similarly to HW_RESPONSE, this message is sent by the controllers to notify APT Server of some event that requires user intervention, usually some fault or error condition that needs to be handled before normal operation can resume. However unlike HW_RESPONSE, this message also transmits a printable text string. Upon receiving the message, APT Server displays both the numerical value and the text information, which is useful in finding the cause of the problem.

REQ:

Response structure (74 bytes):

6 byte header followed by 68 byte (0x44) data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
header						*data*									
81	00	44	00	d|	s	MsgIdent		Code		<--------Notes------->					

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
data															
<--------Notes-------->															

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
data															
<-------- Notes -------->															

48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
data															
<-------- Notes -------->															

64	65	66	67	68	69	70	71	72	73
data									
<--------Notes-------->									

Data structure:

field	description	format
MsgIdent	If the message is sent in response to an APT message, these bytes show the APT message number that evoked the message. Most often though the message is transmitted as a result of some unexpected fault condition, in which case these bytes are 0x00, 0x00	word
Code	This is an internal Thorlabs specific code that specifies the condition that has caused the message (see Return Codes).	word]
Notes	This is a zero-terminated printable (ascii) text string that contains the textual information about the condition that has occurred. For example: "Hardware Time Out Error".	char[64 bytes]

MGMSG_HW_START_UPDATEMSGS 0x0011

Function: Sent to start status updates from the embedded controller. Status update messages contain information about the position and status of the controller (for example limit switch status, motion indication, etc). The messages will be sent by the controller periodically until it receives a STOP STATUS UPDATE MESSAGES command. In applications where spontaneous messages (i.e. messages which are not received as a response to a specific command) must be avoided the same information can also be obtained by using the relevant GET_STATUTSUPDATES function.

Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	00	Update Rate	Unused	d	s

The first data byte can be used to specify the update rate with which status updates are received from the controller. However, the parameter is ignored for the BBD101/102/103 controllers and the update rate is fixed at 10 regardless of the parameter sent.

REQUEST: N/A

MGMSG_HW_STOP_UPDATEMSGS 0x0012

Function: Sent to stop status updates from the controller – usually called by a client application when it is shutting down, to instruct the controller to turn off status updates to prevent USB buffer overflows on the PC.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
12	00	00	00	d	s

REQUEST: N/A
GET: N/A

MGMSG_HW_REQ_INFO 0x0005
MGMSG_HW_GET_INFO 0x0006

Function: Sent to request hardware information from the controller.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
05	00	00	00	d	s

Example: Request hardware info from controller #1

TX 05, 00, 00, 00, 11, 01

GET:
Response structure (90 bytes):
6 byte header followed by 84 byte (0x54) data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
header						*data*									
06	00	54	00	d|	s	<-Serial Number >				<--------Model Number------->					

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
data															
<Model> No		<Type>		<Firmware> Version >				<------------------------------Notes---------------------------->							

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
data															
<--- Notes --->															

48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
data															
<--- Notes --->															

64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
data															
<----------------------------Notes-------------------------->								Empty Space							

80	81	82	83	84	85	86	87	88	89
data									
<---------Empty Space------->				HW Version		Mod State		<-nchs-->	

Data structure:

field	description	format
serial number	unique 8-digit serial number	long
model number	alphanumeric model number	char[8]
type	hardware type: 45 = multi-channel controller motherboard 44 = brushless DC controller	word
firmware version	firmware version byte[20] = minor revision number byte[21] = interim revision number byte[22] = major revision number byte[23] = unused	byte[4]
notes	arbitrary alphanumeric information string	char[48]
Empty Space	Not Used	byte [12]
HW Version	The hardware version number	word
Mod State	The modification state of the hardware	word
nchs	number of channels	word

Example: Returned hardware info from controller #1

RX 06, 00, 54, 00, 81, 22, 89, 53, 9A, 05, 49, 4F, 4E, 30, 30, 31, 20, 00, 2C, 00, 02, 01, 39, 00, 42, 72, 75, 73, 68, 6C, 65, 73, 73, 20, 44, 43, 20, 4D, 6F, 74, 6F, 72, 20, 49, 4F, 4E, 20, 44, 72, 69, 76, 65, 00, 00…, 11, 00, 01, 00, 00, 00, 01, 00

Header: *06, 00, 54, 00, 81, 22*: Get Info, 54H (84) byte data packet, Motor Channel 2.
Serial Number: 89, 53, 9A, 05: 94000009
Model Number: 49, 4F, 4E, 30, 30, 31, 20, 00: ION001
Type*: 2C, 00:* 44 – Brushless DC Controller Card
firmware Version: 02, 01, 39, 00: 3735810
Notes: 42, 72, 75, 73, 68, 6C, 65, 73, 73, 20, 44, 43, 20, 4D, 6F, 74, 6F, 72, 20, 49, 4F, 4E, 20, 44, 72, 69, 76, 65, 00…: BRUSHLESS DC MOTOR ION DRIVE…..
Empty Space: 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00
HW Version: 01, 00 Hardware version 01
Mod State: 03, 00, Modification stage 03.
No Chan: 01, 00: 1 active channel

MGMSG_RACK_REQ_BAYUSED 0x0060
MGMSG_RACK_GET_BAYUSED 0x0061

Function: Sent to determine whether the specified bay in the controller is occupied.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
60	00	Bay Ident	00	d	s

Bay Idents
0x01 Bay 1
0x02 Bay 2 to
0x09 Bay 10

Example: Is controller bay #1 (i.e. bay 0) occupied

TX 60, 00, 00, 00, 11, 01

GET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
61	00	Bay Ident	Bay State	d	s

Bay Idents
0x01 Bay 1
0x02 Bay 2 to
0x09 Bay 10

Bay States
0x01 Bay Occupied
0x02 Bay Empty (Unused)

Example: Controller bay #1 (i.e. bay 0) is occupied

RX 61, 00, 00, 01, 11, 01

MGMSG_HUB_REQ_BAYUSED 0x0065
MGMSG_HUB_GET_BAYUSED 0x0066

Function: Sent to determine which bay a specific T-Cube is fitted.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
65	00	00	00	d	s

TX 65, 00, 00, 00, 50, 01

GET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
66	00	Bay Ident	00	d	s

Bay Idents
-0x01 T-Cube being standalone, i.e. off the hub.
0x00 T-Cube on hub, but bay unknown
0x01 Bay 1
0x02 Bay 2 to
0x06 Bay 6

Example: Which hub bay is the T-Cube unit fitted

RX 66, 00, 06, 00, 01, 50

MGMSG_RACK_REQ_STATUSBITS 0x0226
MGMSG_RACK_GET_STATUSBITS 0x0227

This method is applicable only to the MMR modular rack, and 2- and 3-channel card slot type controllers such as the BSC103 and BPC202.

Function: The USER IO connector on the rear panel of these units exposes a number of digital inputs. This function returns a number of status flags pertaining to the status of the inputs on the rack modules, or the motherboard of the controller unit hosting the single channel controller card.
These flags are returned in a single 32 bit integer parameter and can provide additional useful status information for client application development. The individual bits (flags) of the 32 bit integer value are described below.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
26	02	Status Bits	00	d	s

GET:
Response structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	7	8	9	10
header						*Data*			
27	02	04	00	d|	s	StatusBits			

Data Structure:

field	description	format
StatusBits	The status bits for the associated controller channel. The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following table.	dword

Hex Value	Bit Number	Description
0x00000001	1	Digital output 1 state (1 - logic high, 0 - logic low).
0x00000002	2	Digital output 2 state (1 - logic high, 0 - logic low).
0x00000004	3	Digital output 3 state (1 - logic high, 0 - logic low).
0x00000008	4	Digital output 4 state (1 - logic high, 0 - logic low).

Example: With destination being 0x11 (motherboard – see Introduction) and bay being bay 1, slot 2 (0x22)

TX 27, 02, 04, 00, 01, 22, 00, 00, 00, 00

Header: 27, 02, 04, 00, 01, 22: GetStatusBits, 04 byte data packet, bay 1 slot 2.

MGMSG_RACK_SET_DIGOUTPUTS 0x0228
MGMSG_RACK_REQ_DIGOUTPUTS 0x0229
MGMSG_RACK_GET_DIGOUTPUTS 0x0230

This method is applicable only to the MMR rack modules, and 2- and 3-channel card slot type controllers such as the BSC103 and BPC202.

Function: The USER IO connector on the rear panel of these units exposes a number of digital outputs. These functions set and return the status of the outputs on the rack modules, or the motherboard of the controller unit hosting the single channel controller card.
These flags are returned in a single 32 bit integer parameter and can provide additional useful status information for client application development. The individual bits (flags) of the 32 bit integer value are described below.

SET:
Data structure (6 bytes)

0	1	2	3	4	5
header only					
28	02	Dig OP	00	d	s

Hex Value	Bit Number	Description
0x00000001	1	Digital input 1 state (1 - logic high, 0 - logic low).
0x00000002	2	Digital input 2 state (1 - logic high, 0 - logic low).
0x00000004	3	Digital input 3 state (1 - logic high, 0 - logic low).
0x00000008	4	Digital input 4 state (1 - logic high, 0 - logic low).

Example: With destination being 0x11 (motherboard – see Introduction) and bay being bay 1, slot 2 (0x22), set Digital output 1 high

TX 28, 02, 01, 22, 11, 01,

Header: 28, 02, 01, 22, 11, 01: SetDigOutputs, 01 OP1 High, bay 1 slot 2, d=motherboard, s=PC.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
29	02	00	00	d	s

GET:
Response structure (6 bytes)

0	1	2	3	4	5
header only					
30	02	00	00	d	s

See SET above for structure

MGMSG_MOD_SET_DIGOUTPUTS 0x0213
MGMSG_MOD_REQ_DIGOUTPUTS 0x0214
MGMSG_MOD_GET_DIGOUTPUTS 0x0215

Function: The CONTROL IO connector on the rear panel of the unit exposes a number of digital outputs. The number of outputs available depends on the type of unit. This message is used to configure these digital outputs.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
00	05	Bit	00	d	s

Note. On brushless DC controllers (e.g. BBD201), the digital output and trigger output use a common pin. Before calling this message to set the digital output, the trigger functionality must be disabled by calling the Set_Trigger message.

The outputs are set (and returned) in the bits of the Bits parameter, input No 1 being the least significant bit and input No 4 being the most significant. The number of bits used is dependent on the number of digital outputs present on the associated hardware unit.

For example, to turn on the digital output on a BSC201 motor controller, the least significant bit of the Bits parameter should be set to 1. Similarly, to turn on all four digital outputs on a BNT001 NanoTrak unit, the bits of the Bits parameter should be set to 1111 (15), and to turn the same outputs off, the Bits should be set to 0000.

Example: Set the digital input of the BSC201 controller on:

TX 13, 02, 01, 00, 50, 01

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
14	02	Bits	00	d	s

GET:
Response structure (6 bytes):

0	1	2	3	4	5
header only					
15	02	Bit	00	d	s

For structure see SET message above.

Motor Control Messages

Introduction

The 'Motor' messages provide the functionality required for a client application to control one or more of the Thorlabs series of motor controller units. This range of motor controllers covers DC servo and stepper drivers in a variety of formats including compact Cube type controllers, benchtop units and 19" rack based modular drivers. Note for ease of description, the TSC001 T-Cube Solenoid Controller is considered here as a motor controller. The list of controllers covered by the motor messages includes:

BSC001 – 1 Channel Benchtop Stepper Driver
BSC002 – 2 Channel Benchtop Stepper Driver
BMS001 – 1 Channel Benchtop Low Power Stepper Driver
BMS002 – 2 Channel Benchtop Low Power Stepper Driver
MST601 – 2 Channel Modular Stepper Driver
MST602 – 2 Channel Modular Stepper Driver (2013 onwards)
BSC101 – 1 Channel Benchtop Stepper Driver (2006 onwards)
BSC102 – 2 Channel Benchtop Stepper Driver (2006 onwards)
BSC103 – 3 Channel Benchtop Stepper Driver (2006 onwards)
BSC201 – 1 Channel Benchtop Stepper Driver (2012 onwards)
BSC202 – 2 Channel Benchtop Stepper Driver (2012 onwards)
BSC203 – 3 Channel Benchtop Stepper Driver (2012 onwards)
BBD101 – 1 Channel Benchtop Brushless DC Motor Driver
BBD102 – 2 Channel Benchtop Brushless DC Motor Driver
BBD103 – 3 Channel Benchtop Brushless DC Motor Driver
BBD201 – 1 Channel Benchtop Brushless DC Motor Driver
BBD202 – 2 Channel Benchtop Brushless DC Motor Driver
BBD203 – 3 Channel Benchtop Brushless DC Motor Driver
OST001 – 1 Channel Cube Stepper Driver
ODC001 – 1 Channel Cube DC Servo Driver
TST001 – 1 Channel T-Cube Stepper Driver
TDC001 – 1 Channel T-Cube DC Servo Driver
TSC001 – 1 Channel T-Cube Solenoid Driver
TDIxxx – 2 Channel Brushless DC Motor Driver

The motor messages can be used to perform activities such as homing stages, absolute and relative moves, changing velocity profile settings and operation of the solenoid state (TSC001 T-Cube). With a few exceptions, these messages are generic and apply equally to both single and dual channel units.
Where applicable, the target channel is identified in the Chan Ident parameter and on single channel units, this must be set to CHAN1_ID. On dual channel units, this can be set to CHAN1_ID, CHAN2_ID or CHANBOTH_ID as required.

For details on the operation of the motor controller, and information on the principles of operation, refer to the handbook supplied with the unit.

MGMSG_HW_YES_FLASH_PROGRAMMING 0x0017

Function: This message is sent by the server on start up, however, it is a deprecated message (i.e. has no function) and can be ignored.

Command structure (6 bytes):

0	1	2	3	4	5
header only					
17	00	Unused	Unused	d	s

REQUEST: N/A

MGMSG_HW_NO_FLASH_PROGRAMMING 0x0018

Function: This message is sent on start up to notify the controller of the source and destination addresses. A client application must send this message as part of its initialization process.

SET:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
18	00	00	00	d	s

REQUEST: N/A
GET: N/A

MGMSG_MOT_SET_POSCOUNTER 0x0410
MGMSG_MOT_REQ_POSCOUNTER 0x0411
MGMSG_MOT_GET_POSCOUNTER 0x0412

Function: Used to set the 'live' position count in the controller. In general, this command is not normally used. Instead, the stage is homed immediately after power-up (at this stage the position is unknown as the stage is free to move when the power is off); and after the homing process is completed the position counter is automatically updated to show the actual position. From this point onwards the position counter always shows the actual absolute position.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
10	04	06	00	d|	s	Chan Ident		Position			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Position	The new value of the position counter as a 32-bit signed integer, encoded in the Intel format. The scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the position counter for channel 2 to 10.0 mm

TX 10, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00

Header: 10, 04, 06, 00, A2, 01: SetPosCounter, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Position: 40, 0D, 03, 00: Set Counter to 10 mm (10 x 20,000)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	04	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
12	04	06	00	d|	s	Chan Ident		Position			

For structure see SET message above.

MGMSG_MOT_SET_ENCCOUNTER 0x0409
MGMSG_MOT_REQ_ENCCOUNTER 0x040A
MGMSG_MOT_GET_ENCCOUNTER 0x040B

Function: Similarly to the PosCounter message described previously, this message is used to set the encoder count in the controller and is only applicable to stages and actuators fitted with an encoder. In general, this command is not normally used. Instead, the stage is homed immediately after power-up (at this stage the position is unknown as the stage is free to move when the power is off); and after the homing process is completed the position counter is automatically updated to show the actual position. From this point onwards the encoder counter always shows the actual absolute position.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
09	04	06	00	d|	s	Chan Ident		Encoder Count			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Encoder Count	The new value of the encoder counter as a 32-bit signed integer, encoded in the Intel format. The scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the encoder counter for channel 2 to 10.0 mm

TX 09, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00

Header: 09, 04, 06, 00, A2, 01: SetEncCounter, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Position: 40, 0D, 03, 00: Set Counter to 10 mm (10 x 20,000)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	04	Chan Ident	00	d	s

GET:

Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
0B	04	06	00	d|	s	Chan Ident		Encoder Count			

For structure see SET message above.

MGMSG_MOT_SET_VELPARAMS 0x0413
MGMSG_MOT_REQ_VELPARAMS 0x0414
MGMSG_MOT_GET_VELPARAMS 0x0415

Function: Used to set the trapezoidal velocity parameters for the specified motor channel. For DC servo controllers, the velocity is set in encoder counts/sec and acceleration is set in encoder counts/sec/sec.
For stepper motor controllers the velocity is set in microsteps/sec and acceleration is set in microsteps/sec/sec.

SET:
Command structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
13	04	0E	00	d|	s	Chan Ident		Min Velocity			

12	13	14	15	16	17	18	19
Data							
Acceleration				Max Velocity			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Minimum (Start) Vel	The minimum (start) velocity in encoder counts/sec Currently, this 4 byte value is always zero	long
Acceleration	The acceleration in encoder counts /sec/sec. 4 byte unsigned long value. If applicable, the scaling between real time values and this parameter is detailed in Section 8.	long
Maximum Vel	The maximum (final) velocity in encoder counts /sec. 4 byte unsigned long value. If applicable, the scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the trapezoidal velocity parameters for chan 2 as follows:

Min Vel: zero
Acceleration: 10 mm/sec/sec
Max Vel: 99 mm/sec

TX 13, 04, 0E, 00, A2, 01, 01, 00, 00, 00, 00, 00, B0, 35, 00, 00, CD, CC, CC, 00

Header: 13, 04, 0E, 00, A2, 01: Set Vel Params, 0EH (14) byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Min Vel: *00, 00, 00, 00:* Set min velocity to zero
Accel: *89, 00, 00, 00:* Set acceleration to 10 mm/sec/sec (13.744 x 10)
Max Vel: *9E, C0, CA, 00:* Set max velocity to 99 mm/sec (134218 x 99)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
14	04	Chan Ident	00	d	s

GET:
Response structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
15	04	0E	00	d|	s	Chan Ident		Min Velocity			

12	13	14	15	16	17	18	19
Data							
Acceleration				Max Velocity			

For structure see SET message above.

MGMSG_MOT_SET_JOGPARAMS 0x0416
MGMSG_MOT_REQ_JOGPARAMS 0x0417
MGMSG_MOT_GET_JOGPARAMS 0x0418

Function: Used to set the velocity jog parameters for the specified motor channel, For DC servo controllers, values set in encoder counts. For stepper motor controllers the values is set in microsteps.

SET:

Command structure (28 bytes)

6 byte header followed by 22 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
16	04	16	00	d|	s	Chan Ident		Jog Mode		Jog Step Size	

12	13	14	15	16	17	18	19	20	21
Data									
Jog Step Size		Jog Min Velocity				Jog Acceleration			

22	23	24	25	26	27
Data					
Jog Max Velocity				Stop Mode	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Jog Mode	This 2 byte value can be 1 for continuous jogging or 2 for single step jogging. In continuous jogging mode the movement continues for as long as the jogging trigger (the jogging button on the GUI or an external signal) is being active. In single step mode triggering jogging initiates a single move whose step size is defined as the next parameter (see below).	word
Jog Step Size	The jog step size in encoder counts. The scaling between real time values and this parameter is detailed in Section 8.	long
Jog Min Velocity	The minimum (start) velocity in encoder counts /sec. Currently, this 4 byte value is always zero.	long
Jog Acceleration	The acceleration in encoder counts /sec/sec The scaling between real time values and this parameter is detailed in Section 8.	long
Jog Max Velocity	The maximum (final) velocity in encoder counts /sec. The scaling between real time values and this parameter is detailed in Section 8.	long
Jog Stop Mode	The stop mode. This 16 bit word can be 1 for immediate (abrupt) stop or 2 for profiled stop (with controlled deceleration).	word

Example: MLS203 and BBD102: Set the jog parameters for channel 2 as follows:
Jog Mode: Continuous
Jog Step Size:0.05 mm
Jog Min Vel: Zero
Jog Accel: 10 mm/sec/sec
Jog Max Vel: 99 mm/sec
Jog Stop Mode: Profiled

TX 16, 04, 16, 00, A2, 01, 01, 00, 01, 00, E8, 03, 00, 00, 00, 00, 00, 00, B0,35, 00, 00, CD, CC, CC, 00, 02, 00

Header: 16, 04, 16, 00, A2, 01: Set Jog Params, 16H (28) byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Jog Mode: *01,00,:* Set jog mode to 'continuous'
Jog Step Size: *E8, 03, 00, 00:* Set jog step size to 0.05 mm (1,000 encoder counts).
Jog Min Vel: 00, 00, 00, 00: Set min jog velocity to zero
Jog Accel: *89, 00, 00, 00:* Set acceleration to 10 mm/sec/sec (13.744 x 10)
Jog Max Vel: *9E, C0, CA, 00:* Set max velocity to 99 mm/sec (134218 x 99)
Jog Stop Mode: 02, 00: Set jog stop mode to 'Profiled Stop'.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
17	04	Chan Ident	00	d	s

GET:
Response structure (28 bytes)
6 byte header followed by 22 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
18	04	16	00	d|	s	Chan Ident		Jog Mode		Jog Step Size	

12	13	14	15	16	17	18	19	20	21
Data									
Jog Step Size		Jog Min Velocity				Jog Acceleration			

22	23	24	25	26	27
Data					
Jog Max Velocity				Stop Mode	

For structure see SET message above.

MGMSG_MOT_REQ_ADCINPUTS 0x042B
MGMSG_MOT_GET_ADCINPUTS 0x042C

Function: This message reads the voltage applied to the analog input on the rear panel CONTROL IO connector, and returns a value in the ADCInput1 parameter. The returned value is in the range 0 to 32768, which corresponds to zero to 5 V.
Note. The ADCInput2 parameter is not used at this time.
In this way, a 0 to 5V signal generated by a client system could be read in by calling this method and monitored by a custom client application. When the signal reaches a specified value, the application could instigate further actions, such as a motor move.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
2B	04	Chan Ident	00	d	s

GET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
2B	04	04	00	d|	s	ADCInput1		ADCInput2	

Data Structure:

field	description	format
ADCInput1	The voltage state of the analog input pin, in the range 0 to 32768, which corresponds to zero to 5 V.	word
ADCInput2	Not used	word

Example: Get the ADC input state

RX 2C, 04, 04, 00, A2, 01, 01, 00, 00, 00,

Header: 2B, 04, 04, 00, A2, 01: GetADCInputs, 04 byte data packet, Channel 2.
ADCInput1: 00, 80: ADC Input 1 = 5V
ADCInput2: 00, 00: Not Used r

MGMSG_MOT_SET_POWERPARAMS 0x0426
MGMSG_MOT_REQ_POWERPARAMS 0x0427
MGMSG_MOT_GET_POWERPARAMS 0x0428

Note for BSC20x, MST602 and TST101 controller users
If the controllers listed above are used with APTServer, the ini file will typically have values set of 5 for the rest power and 30 for the move power. Although these values are loaded when the server boots only the rest power value is used. This allows the user to set the rest current as normal. The move power however is not used. The move power is set within the controller as a function of velocity. This command can be used only to set the rest power. The command MGMSG_MOT_REQ_POWERPARAMS will return the default values or the values that were set.

Function: The power needed to hold a motor in a fixed position is much smaller than that required for a move. It is good practice to decrease the power in a stationary motor in order to reduce heating, and thereby minimize thermal movements caused by expansion. This message sets a reduction factor for the rest power and the move power values as a percentage of full power. Typically, move power should be set to 100% and rest power to a value significantly less than this.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
26	04	06	00	d|	s	Chan Ident		RestFactor		MoveFactor	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
RestFactor	The phase power value when the motor is at rest, in the range 1 to 100 (i.e. 1% to 100% of full power).	word
MoveFactor	The phase power value when the motor is moving, in the range 1 to 100 (i.e. 1% to 100% of full power).	word

Example: Set the phase powers for channel 2 for TST001 unit

TX 26, 04, 06, 00, A2, 01, 01, 00, 0A, 00, 64, 00

Header: 26, 04, 06, 00, A2, 01: SetPowerParams, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TST001)
RestFactor: 0A, 00: Set rest power to 10% of full power
MoveFactor: 64, 00: Set move power to 100% of full power

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
27	04	Chan Ident	00	d	s

GET:

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
28	04	06	00	d|	s	Chan Ident		RestFactor		MoveFactor	

For structure see SET message above.

MGMSG_MOT_SET_GENMOVEPARAMS 0x043A
MGMSG_MOT_REQ_GENMOVEPARAMS 0x043B
MGMSG_MOT_GET_GENMOVEPARAMS 0x043C

Function: Used to set the general move parameters for the specified motor channel. At this time this refers specifically to the backlash settings.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
3A	04	06	00	d|	s	Chan Ident		Backlash Distance			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Backlash Distance	The value of the backlash distance as a 4 byte signed integer, which specifies the relative distance in position counts. The scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the backlash distance for chan 2 to 1 mm:

TX 3A, 04, 06, 00, A2, 01, 01, 00, 20, 4E, 00, 00,

Header: 3A, 04, 06, 00, A2, 01: SetGenMoveParams, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Backlash Dist: *20, 4E, 00, 00:* Set backlash distance to 1 mm (20,000 encoder counts).

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
3B	04	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
3C	04	06	00	d|	s	Chan Ident		Backlash Distance			

For structure see SET message above.

MGMSG_MOT_SET_MOVERELPARAMS 0x0445
MGMSG_MOT_REQ_MOVERELPARAMS 0x0446
MGMSG_MOT_GET_MOVERELPARAMS 0x0447

Function: Used to set the relative move parameters for the specified motor channel. The only significant parameter at this time is the relative move distance itself. This gets stored by the controller and is used the next time a relative move is initiated.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
45	04	06	00	d|	s	Chan Ident		Relative Distance			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Relative Distance	The distance to move. This is a 4 byte signed integer that specifies the relative distance in position encoder counts. The scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the relative move distance for chan 2 to 10 mm:

TX 45, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00,

Header: 45, 04, 06, 00, A2, 01: SetMoveRelParams, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Rel Dist: *40, 0D, 03, 00:* Set relative move distance to 10 mm (10 x 20,000 encoder counts).

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
46	04	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
47	04	06	00	d|	s	Chan Ident		Relative Distance			

For structure see SET message above.

MGMSG_MOT_SET_MOVEABSPARAMS 0x0450
MGMSG_MOT_REQ_MOVEABSPARAMS 0x0451
MGMSG_MOT_GET_MOVEABSPARAMS 0x0452

Function: Used to set the absolute move parameters for the specified motor channel. The only significant parameter at this time is the absolute move position itself. This gets stored by the controller and is used the next time an absolute move is initiated.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
50	04	06	00	d|	s	Chan Ident		Absolute Position			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Absolute Position	The absolute position to move. This is a 4 byte signed integer that specifies the absolute position in position encoder counts. The scaling between real time values and this parameter is detailed in Section 8.	long

Example: MLS203 and BBD102: Set the absolute move position for chan 2 to 10 mm:

TX 50, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00,

Header: 50, 04, 06, 00, A2, 01: SetMoveAbsParams, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Abs Pos: *40, 0D, 03, 00:* Set absolute move position to 10 mm (200,000 encoder counts).

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
51	04	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
52	04	06	00	d|	s	Chan Ident		Absolute Position			

For structure see SET message above.

MGMSG_MOT_SET_HOMEPARAMS 0x0440
MGMSG_MOT_REQ_HOMEPARAMS 0x0441
MGMSG_MOT_GET_HOMEPARAMS 0x0442

Function: Used to set the home parameters for the specified motor channel. These parameters are stage specific and for the MLS203 stage implementation the only parameter that can be changed is the homing velocity.

SET:

Command structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
40	04	0E	00	d|	s	Chan Ident		Home Dir		Limit Switch	

12	13	14	15	16	17	18	19
Data							
Home Velocity				Offset Distance			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Home Direction	Ignored in this implementation. Homing direction is always positive.	word
Limit Switch	Ignored in this implementation. The limit switches are not used for homing.	word
Home Velocity	The homing velocity. A 4 byte unsigned long value. The scaling between real time values and this parameter is detailed in Section 8.	long
Offset Distance	Not used in this implementation.	long

Example: MLS203 and BBD102: Set the home parameters for chan 2 as follows:
Home Direction: Not used (always positive).
Limit Switch: Not used
Home Vel: 24 mm/sec
Offset Dist: Not used.

TX 40, 04, 0E, 00, A2, 01, 01, 00, 00, 00, 00, 00, 33. 33, 33, 00, 00, 00, 00, 00

Header: 40, 04, 0E, 00, A2, 01: SetHomeParams, 14 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Home Direction: *00, 00:* Not Applicable
Limit Switch: 00, 00: Not Applicable
Home Velocity: 33, 33, 33, 00: 24 mm/sec (3355443/134218)
Offset Distance: 00, 00, 00, 00: Not used

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	04	Chan Ident	00	d	s

GET:
Response structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
42	04	0E	00	d|	s	Chan Ident		Home Dir		Limit Switch	

12	13	14	15	16	17	18	19
Data							
Home Velocity				Offset Distance			

For structure see SET message above.

MGMSG_MOT_SET_LIMSWITCHPARAMS 0x0423
MGMSG_MOT_REQ_LIMSWITCHPARAMS 0x0424
MGMSG_MOT_GET_LIMSWITCHPARAMS 0x0425

These functions are not applicable to BBD10x units

Function: Used to set the limit switch parameters for the specified motor channel.

SET:
Command structure (22 bytes)
6 byte header followed by 16 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
23	04	10	00	d|	s	Chan Ident		CW Hardlimit		CCW Hardlimit	

12	13	14	15	16	17	18	19	20	21
Data									
CW Soft Limit				CCW Soft Limit				Limit Mode	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
CW Hard Limit	The operation of the Clockwise hardware limit switch when contact is made. 0x01 Ignore switch or switch not present. 0x02 Switch makes on contact. 0x03 Switch breaks on contact. 0x04 Switch makes on contact - only used for homes (e.g. limit switched rotation stages). 0x05 Switch breaks on contact - only used for homes (e.g. limit switched rotations stages). 0x06 For PMD based brushless servo controllers only - uses index mark for homing. Note. Set upper bit to swap CW and CCW limit switches in code. Both CWHardLimit and CCWHardLimit structure members will have the upper bit set when limit switches have been physically swapped. 0x80 // bitwise OR'd with one of the settings above.	word
CCW Hard Limit	The operation of the Counter Clockwise hardware limit switch when contact is made.	word
CW Soft Limit	Clockwise software limit in position steps. A 32 bit unsigned long value, the scaling factor between real time values and this parameter is 1 mm is equivalent to 134218. For example, to set the clockwise software limit switch to 100 mm, send a value of 13421800. **(Not applicable to TDC001 units)**	long
CCW Soft Limit	Counter Clockwise software limit in position steps (scaling as for CW limit). **(Not applicable to TDC001 units)**	long

Software Limit Mode	Software limit switch mode 0x01 Ignore Limit 0x02 Stop Immediate at Limit 0x03 Profiled Stop at limit 0x80 Rotation Stage Limit (bitwise OR'd with one of the settings above) **(Not applicable to TDC001 units)**	word

Example: Set the limit switch parameters for chan 2 as follows:
CW Hard Limit – switch makes.
CCW Hard Limit - switch makes
CW Soft Limit – set to 100 mm
CCW Soft Limit - .set to 0 mm
Software Limit Mode – Profiled Stop

TX 23, 04, 10, 00, A2, 01, 01, 00, 02, 00, 02, 00, E8. CC, CC, 00, 00, 00, 00, 00, 03, 00

Header: 23, 04, 10, 00, A2, 01: SetLimSwitchParams, 16 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
CW Hard Limit: *02, 00:* Switch Makes
CCW Hard Limit: 02, 00: Switch Makes
CW Soft Limit: E8, CC, CC, 00: 100 mm (13421800/134218)
CCW Soft Limit: 00, 00, 00, 00: 0 mm
Soft Limit Mode: 03, 00: Profiled Stop at Limit

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
24	04	Chan Ident	00	d	s

GET:
Response structure (20 bytes)
6 byte header followed by 16 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
25	04	10	00	d|	s	Chan Ident		CW Hardlimit		CCW Hardlimit	

12	13	14	15	16	17	18	19	20	21
Data									
CW Soft Limit				CCW Soft Limit				Limit Mode	

For structure see SET message above.

MGMSG_MOT_MOVE_HOME 0x0443
MGMSG_MOT_MOVE_HOMED 0x0444

Function: Sent to start a home move sequence on the specified motor channel (in accordance with the home parameters above).

TX structure (6 bytes):

0	1	2	3	4	5
header only					
43	04	Chan Ident	0x	d	s

Example: Home the motor channel in bay 2

TX 43, 04, 01, 00, 22, 01

HOMED:

Function: No response on initial message, but upon completion of home sequence controller sends a “homing completed” message:

RX structure (6 bytes):

0	1	2	3	4	5
header only					
44	04	Chan Ident	0x	d	s

Example: The motor channel in bay 2 has been homed

RX 44, 04, 01, 00, 01, 22

MGMSG_MOT_MOVE_RELATIVE 0x0448

Function: This command can be used to start a relative move on the specified motor channel (using the relative move distance parameter above). There are two versions of this command: a shorter (6-byte header only) version and a longer (6 byte header plus 6 data bytes) version. When the first one is used, the relative distance parameter used for the move will be the parameter sent previously by a MGMSG_MOT_SET_MOVERELPARAMS command. If the longer version of the command is used, the relative distance is encoded in the data packet that follows the header.

Short version:

TX structure (6 bytes):

0	1	2	3	4	5
header only					
48	04	Chan Ident	0x	d	s

Example: Move the motor associated with channel 2 by 10 mm. (10 mm was previously set in the MGMSG_ MOT_SET_MOVERELPARAMS method).

TX 48, 04, 01, 00, 22, 01

Long version:
The alternative way of using this command is by appending the relative move params structure (MOT_SET_MOVERELPARAMS) to this message header.

Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
48	04	06	00	d|	s	Chan Ident		Relative Distance			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	Word
Relative Distance	The distance to move. This is a 4 byte signed integer that specifies the relative distance in position encoder counts. In the BBD10X series controllers the encoder resolution is 20,000 counts per mm, therefore to set a relative move distance of 1 mm, set this parameter to 20,000 (twenty thousand).	Long

Example: Move the motor associated with chan 2 by 10 mm:

TX 48, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00,

Header: 45, 04, 06, 00, A2, 01: MoveRelative, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Rel Dist: *40, 0D, 03, 00:* Set absolute move distance to 10 mm (200,000 encoder counts).

Upon completion of the relative move the controller sends a Move Completed message as described following.

MGMSG_MOT_MOVE_COMPLETED 0x0464

Function: No response on initial message, but upon completion of the relative or absolute move sequence, the controller sends a “move completed” message:

RX structure (20 bytes):

0	1	2	3	4	5
header only					
64	04	Chan Ident	0x	d|	s

Followed by a 14-byte data packet described by the same status structures (i.e. MOTSTATUS and MOTDCSTATUS) described in the STATUS UPDATES section that follows.

MGMSG_MOT_MOVE_ABSOLUTE 0x0453

Function: Used to start an absolute move on the specified motor channel (using the absolute move position parameter above). As previously described in the "MOVE RELATIVE" command, there are two versions of this command: a shorter (6-byte header only) version and a longer (6 byte header plus 6 data bytes) version. When the first one is used, the absolute move position parameter used for the move will be the parameter sent previously by a MGMSG_MOT_SET_MOVEABSPARAMS command. If the longer version of the command is used, the absolute position is encoded in the data packet that follows the header.

Short version:

TX structure (6 bytes):

0	1	2	3	4	5
header only					
53	04	Chan Ident	0x	d	s

Example: Move the motor associated with channel 2 to 10 mm. (10 mm was previously set in the MGMSG_ MOT_SET_MOVEABSPARAMS method).

TX 53, 04, 01, 00, 22, 01

Long version:
The alternative way of using this command by appending the absolute move params structure (MOTABSMOVEPARAMS) to this message header.

Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
53	04	06	00	d|	s	Chan Ident		Absolute Distance			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	Word
Absolute Distance	The distance to move. This is a 4 byte signed integer that specifies the absolute distance in position encoder counts. In the BBD10X series controllers the encoder resolution is 20,000 counts per mm, therefore to set an absolute move distance of 100 mm, set this parameter to 2,000,000 (two million).	Long

Example: Move the motor associated with chan 2 to 10 mm:

TX 53, 04, 06, 00, A2, 01, 01, 00, 40, 0D, 03, 00,

Header: 45, 04, 06, 00, A2, 01: MoveAbsolute, 06 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Abs Dist: *40, 0D, 03, 00:* Set the absolute move distance to 10 mm (200,000 encoder counts).

Upon completion of the absolute move the controller sends a Move Completed message as previously described.

MGMSG_MOT_MOVE_JOG 0x046A

Function: Sent to start a jog move on the specified motor channel.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
6A	04	Chan Ident	Direction	d	s

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Direction	The direction to Jog. Set this byte to 0x01 to jog forward, or to 0x02 to jog in the reverse direction.	word

Upon completion of the jog move the controller sends a Move Completed message as previously described.

Note. The direction of the jog move is device dependent, i.e. on some devices jog forward may be towards the home position while on other devices it could be the opposite.

MGMSG_MOT_MOVE_VELOCITY 0x0457

Function: This command can be used to start a move on the specified motor channel.
When this method is called, the motor will move continuously in the specified direction, using the velocity parameters set in the MGMSG_MOT_SET_MOVEVELPARAMS command until either a stop command (either StopImmediate or StopProfiled) is called, or a limit switch is reached.

TX structure (6 bytes):

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="6">header only</td></tr>
<tr><td>57</td><td>04</td><td>Chan Ident</td><td>Direction</td><td>d</td><td>s</td></tr>
</table>

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Direction	The direction to Jog. Set this byte to 0x01 to move forward, or to 0x02 to move in the reverse direction.	word

Upon completion of the move the controller sends a Move Completed message as previously described.

Example: Move the motor associated with channel 2 forwards.

TX 57, 04, 01, 01, 22, 01

MGMSG_MOT_MOVE_STOP 0x0465

Function: Sent to stop any type of motor move (relative, absolute, homing or move at velocity) on the specified motor channel.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
65	04	Chan Ident	Stop Mode	d	s

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Stop Mode	The stop mode defines either an immediate (abrupt) or profiles tops. Set this byte to 0x01 to stop immediately, or to 0x02 to stop in a controller (profiled) manner.	word

Upon completion of the stop move the controller sends a Move Stopped message as described following

MGMSG_MOT_MOVE_STOPPED 0x0466

Function: No response on initial message, but upon completion of the stop move, the controller sends a “move stopped” message:

RX structure (20 bytes):

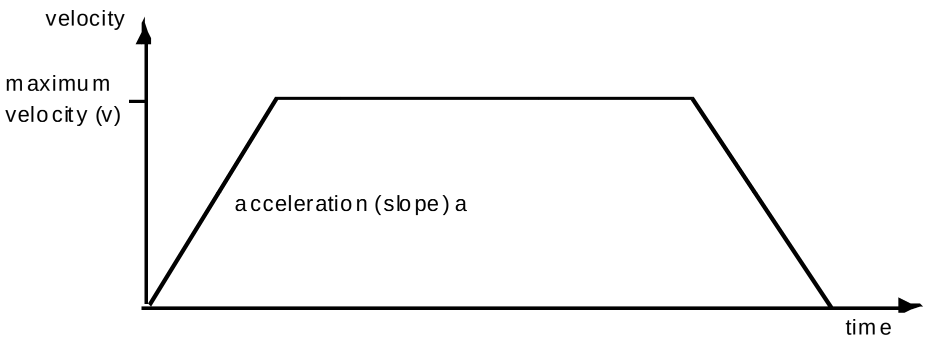
0	1	2	3	4	5
header only					
66	04	0E	0x	d|	s

Followed by a 14-byte data packet described by the same status structures (i.e. MOTSTATUS and MOTDCSTATUS) described in the STATUS UPDATES section that follows.

MGMSG_MOT_SET_BOWINDEX 0x04F4
MGMSG_MOT_REQ_BOWINDEX 0x04F5
MGMSG_MOT_GET_BOWINDEX 0x04F6

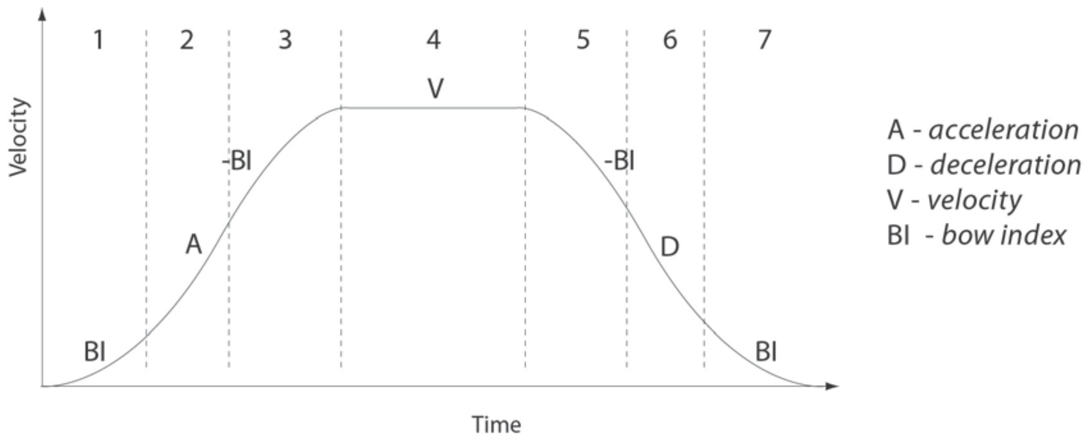
Function: To prevent the motor from stalling, it must be ramped up gradually to its maximum velocity. Certain limits to velocity and acceleration result from the torque and speed limits of the motor, and the inertia and friction of the parts it drives. The system incorporates a trajectory generator, which performs calculations to determine the instantaneous position, velocity and acceleration of each axis at any given moment. During a motion profile, these values will change continuously. Once the move is complete, these parameters will then remain unchanged until the next move begins. The specific move profile created by the system depends on several factors, such as the profile mode and profile parameters presently selected, and other conditions such as whether a motion stop has been requested.

The Bow Index parameter is used to set the profile mode to either Trapezoidal or S-curve. A Bow Index of '0' selects a trapezoidal profile. An index value of '1' to '18' selects an S-curve profile. In either case, the velocity and acceleration of the profile are specified using the Velocity Profile parameters on the Moves/Jogs tab. The Trapezoidal profile is a standard, symmetrical acceleration/deceleration motion curve, in which the start velocity is always zero. This profile is selected when the Bow Index field is set to '0'.



In a typical trapezoidal velocity profile, (see above), the stage is ramped at acceleration 'a' to a maximum velocity 'v'. As the destination is approached, the stage is decelerated at 'a' so that the final position is approached slowly in a controlled manner.

The S-curve profile is a trapezoidal curve with an additional 'Bow Value' parameter, which limits the rate of change of acceleration and smooths out the contours of the motion profile. The Bow Value is applied in mm/s^3 and is derived from the Bow Index as follows:
Bow Value = $2^{(\text{Bow Index} - 1)}$ within the range 1 to 262144 (Bow Index 1 to 18).
In this profile mode, the acceleration increases gradually from 0 to the specified acceleration value, then decreases at the same rate until it reaches 0 again at the specified velocity. The same sequence in reverse brings the axis to a stop at the programmed destination position.



Example

The figure above shows a typical S-curve profile. In segment (1), the S-curve profile drives the axis at the specified Bow Index (BI) until the maximum acceleration (A) is reached. The axis continues to accelerate linearly (Bow Index = 0) through segment (2). The profile then applies the negative value of Bow Index to reduce the acceleration to 0 during segment (3). The axis is now at the maximum velocity (V), at which it continues through segment (4). The profile then decelerates in a similar manner to the acceleration phase, using the Bow Index to reach the maximum deceleration (D) and then bring the axis to a stop at the destination.

Note

The higher the Bow Index, then the shorter the BI phases of the curve, and the steeper the acceleration and deceleration phases. High values of Bow Index may cause a move to overshoot.

SET:

Command structure (10 bytes)

6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
F4	04	04	00	d|	s	Chan Ident		Bow Index	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
BowIndex	This parameter is used to set the profile mode to either Trapezoidal or S-curve. A Bow Index of ‘0’ selects a trapezoidal profile. An index value of ‘1’ to ‘18’ selects an S-curve profile.	word

Example: Set the Bow Index to 18 for Channel 1 as follows:

TX F4, 04, 04, 00, A2, 01, 01, 00, 12, 00,

Header: F4, 04, 04, 00, A2, 01: Set_BowIndex, 04 byte data packet,
Chan Ident: 01, 00: Channel 1
Bow Index: *12, 00,:* Set the Bow Index to 18

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
F5	04	Chan Ident	00	d	s

GET:
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
F6	04	04	00	d|	s	Chan Ident		Bow Index	

For structure see SET message above.

MGMSG_MOT_SET_DCPIDPARAMS 0x04A0
MGMSG_MOT_REQ_DCPIDPARAMS 0x04A1
MGMSG_MOT_GET_DCPIDPARAMS 0x04A2

Function:

Used to set the position control loop parameters for the specified motor channel.

The motion processor within the controller uses a position control loop to determine the motor command output. The purpose of the position loop is to match the actual motor position and the demanded position. This is achieved by comparing the demanded position with the actual position to create a position error, which is then passed through a digital PID-type filter. The filtered value is the motor command output.

NOTE. These settings apply to LM628/629 based servo controllers (only TDC001 at this time). Refer to data sheet for National Semiconductor LM628/LM629 for further details on setting these PID related parameters.

SET:

Command structure (26 bytes)

6 byte header followed by 20 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
A0	04	14	00	d|	s	Chan Ident		Proportional			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Integral				Differential				Integral Limit			

24	25
Data	
FilterControl	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Proportional	The proportional gain. Together with the Integral and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767.	long
Integral	The integral gain. Together with the Proportional and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767.	long
Differential	The differential gain. Together with the Proportional and Integral, these terms determine the system response characteristics and accept values in the range 0 to 32767.	long
Integral Limit	The Integral Limit parameter is used to cap the value of the Integrator to prevent runaway of the integral sum at the output. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PID loop is ignored.	long
FilterControl	Identifies which of the above parameters are applied by	word

	setting the corresponding bit to '1'. By default, all parameters are applied, and this parameter is set to 0F (1111).	

Example: Set the PID parameters for TDC001 as follows:
Proportional: 65
Integral: 175
Differential: 600
Integral Limit: 20,000
FilCon: 15

TX A0, 04, 14, 00, D0, 01, 01, 00, 41, 00, AF, 00, 58, 02, 20, 4E, 00, 00, 0F, 00

Header: A0, 04, 14, 00, D0, 01: Set_DCPIDParams, 20 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Proportional: *41, 00,:* Set the proportional term to 65
Integral: *AF, 00,:* Set the integral term to 175
Differential: 58, 02,: Set the differential term to 600
Integral Limit: 20, 4E, 00, 00,: Set the integral limit to 20,000
FilterControl: 0F, 00: Set all terms to active.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
A0	04	Chan Ident	00	d	s

GET:
6 byte header followed by 20 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
A0	04	14	00	d|	s	Chan Ident		Proportional			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Integral				Differential				Integral Limit			

24	25
Data	
FilterControl	

For structure see Set message above.

MGMSG_MOT_SET_AVMODES 0x04B3
MGMSG_MOT_REQ_AVMODES 0x04B4
MGMSG_MOT_GET_AVMODES 0x04B5

Function: The LED on the control keypad can be configured to indicate certain driver states.
All modes are enabled by default. However, it is recognised that in a light sensitive environment, stray light from the LED could be undesirable. Therefore it is possible to enable selectively, one or all of the LED indicator modes described below by setting the appropriate value in the Mode Bits parameter.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
B3	04	04	00	d|	s	Chan Ident		ModeBits	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
ModeBits	The mode of operation for the LED is set according to the hex value entered in the mode bits. 1 LEDMODE_IDENT: The LED will flash when the 'Ident' message is sent. 2 LEDMODE_LIMITSWITCH: The LED will flash when the motor reaches a forward or reverse limit switch. 8 LEDMODE_MOVING: The LED is lit when the motor is moving.	word

Example: Set the LED to flash when the IDENT message is sent, and also when the motor is moving.

TX B3, 04, 04, 00, D0, 01, 01, 00, 09, 00,

Header: B3, 04, 04, 00, D0, 01: SetAVModes, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
ModeBits: 09, 00 (i.e. 1 + 8)

Similarly, if the ModeBits parameter is set to '11' (1 + 2 + 8) all modes will be enabled.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	04	Chan Ident	00	d	s

GET:

Response structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
B5	04	04	00	d|	s	Chan Ident		ModeBits	

For structure see SET message above.

MGMSG_MOT_SET_POTPARAMS 0x04B0
MGMSG_MOT_REQ_POTPARAMS 0x04B1
MGMSG_MOT_GET_POTPARAMS 0x04B2

Function: The potentiometer slider on the control panel panel is sprung, such that when released it returns to it's central position. In this central position the motor is stationary. As the slider is moved away from the center, the motor begins to move; the speed of this movement increases as the slider deflection is increased. Bidirectional control of motor moves is possible by moving the slider in both directions. The speed of the motor increases by discrete amounts rather than continuously, as a function of slider deflection. These speed settings are defined by 4 pairs of parameters. Each pair specifies a pot deflection value (in the range 0 to 127) together with an associated velocity (set in encoder counts/sec) to be applied at or beyond that deflection. As each successive deflection is reached by moving the pot slider, the next velocity value is applied. These settings are applicable in either direction of pot deflection, i.e. 4 possible velocity settings in the forward or reverse motion directions.
Note. The scaling factor between encoder counts and mm/sec depends on the specific stage/actuator being driven.

SET:
Command structure (32 bytes)
6 byte header followed by 26 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
B0	04	1A	00	d|	s	Chan Ident		ZeroWnd		Vel1	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Vel1		Wnd1		Vel2				Wnd2		Vel3	

24	25	26	27	28	29	30	31
Data							
Vel3		Wnd3		Vel4			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
ZeroWnd	The deflection from the mid position (in ADC counts 0 to 127) before motion can start	word
Vel1	The velocity (in encoder counts /sec) to move when between Wnd0 and PotDef1	long
Wnd1	The deflection from the mid position (in ADC counts, Wnd0 to 127) to apply Vel1	word
Vel2	The velocity (in encoder counts /sec) to move when between PotDef1 and PotDef2	long
Wnd2	The deflection from the mid position (in ADC counts, PotDef1 to 127) to apply Vel2	word

Vel3	The velocity (in encoder counts/sec) to move when between PotDef2 and PotDef3	long
Wnd3	The deflection from the mid position (in ADC counts PotDef2 to 127) to apply Vel3	word
Vel4	The velocity (in encoder counts /sec) to move when beyond PotDef3	long

Example: For the Z8 series motors, there are 512 encoder counts per revolution of the motor. The output shaft of the motor goes into a 67:1 planetary gear head. This requires the motor to rotate 67 times to rotate the 1.0 mm pitch lead screw one revolution. The end result is the lead screw advances by 1.0 mm.
Therefore, a 1 mm linear displacement of the actuator is given by

512 x 67 = 34,304 encoder counts

whereas the linear displacement of the lead screw per encoder count is given by

1.0 mm / 34,304 counts = 2.9 x 10-5 mm (29 nm).

Typical parameters settings Hex (decimal)

ZeroWnd – 14 (20)
Vel1 – 66, 0D,00,00 (3430)
Wnd1 – 32 (50)
Vel2 – CC, 1A, 00, 00 (6860)
Wnd2 – 50 (80)
Vel3 – 32, 28, 00, 00 (10290)
Wnd3 – 64 (100)
Vel4 – 00, 43, 00, 00 (17152)

Using the parameters above, no motion will start until the pot has been deflected to 20 (approx 1/6 full scale deflection), when the motor will start to move at 0.1mm/sec. At a deflection of 50 (approx 2/5 full scale deflection) the motor velocity will increase to 0.2mm/sec, and at 80, velocity will increase to 0.3 mm/sec. When the pot is deflected to 100 and beyond, the velocity will be 0.5 mm/sec.

Note. It is acceptable to set velocities equal to each other to reduce the number of speeds, however this is not allowed for the deflection settings, whereby the Wnd3 Pot Deflection value must be greater than Wnd2 Pot Deflection value.

TX *B0, 04, 1A, 00, D0, 01,* 01, 00, 01, 00, E8, 03, 00, 00, 00, 00, 00, 00, B0,35, 00, 00, CD, CC, CC, 00, 02, 00

Header: B0, 04, 1A, 00, D0, 01: Set Pot Params, 1AH (26) byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Wnd0: 14 (20 ADC Counts)
Vel1: 66, 0D,00,00 (3430 Encoder Counts/sec = 0.1 mm/sec)
PotDef1: 32 (50 ADC Counts)
Vel2: CC, 1A, 00, 00 (6860 Encoder Counts/sec = 0.2 mm/sec)
PotDef2: 50 (80 ADC Counts)

Vel3: 32, 28, 00, 00 (10290 Encoder Counts/sec = 0.3 mm/sec)
PotDef3: 64 (100 ADC Counts)
Vel4: 00, 43, 00, 00 (17152 Encoder Counts/sec = 0.5 mm/sec)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
17	04	Chan Ident	00	d	s

GET:
Response structure (28 bytes)
6 byte header followed by 22 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
B0	04	1A	00	d|	s	Chan Ident		ZeroWnd		Vel1	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Vel1		Wnd1		Vel2				Wnd2		Vel3	

24	25	26	27	28	29	30	31
Data							
Vel3		Wnd3		Vel4			

For structure see SET message above.

MGMSG_MOT_SET_BUTTONPARAMS 0x04B6
MGMSG_MOT_REQ_BUTTONPARAMS 0x04B7
MGMSG_MOT_GET_BUTTONPARAMS 0x04B8

Function: The control keypad can be used either to jog the motor, or to perform moves to absolute positions. This function is used to set the front panel button functionality.

SET:
Command structure (22 bytes)
6 byte header followed by 16 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
B6	04	10	00	d|	s	Chan Ident		Mode		Position1	

12	13	14	15	16	17	18	19	20	21
Data									
Position1		Position2				TimeOut		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Mode	The buttons on the keypad can be used either to jog the motor (jog mode), or to perform moves to absolute positions (go to position mode). If set to 0x01, the buttons are used to jog the motor. Once set to this mode, the move parameters for the buttons are taken from the 'Jog' parameters set via the 'Move/Jogs' settings tab or the SetJogParams methods. If set to 0x02, each button can be programmed with a different position value (as set in the Position 1 and Position 2 parameters), such that the controller will move the motor to that position when the specific button is pressed.	word
Position1	The position (in encoder counts) to which the motor will move when the top button is pressed. This parameter is applicable only if 'Go to Position is selected in the 'Mode' parameter.	long
Position2	The position (in encoder counts) to which the motor will move when the bottom button is pressed. This parameter is applicable only if 'Go to Position is selected in the 'Mode' parameter.	long
TimeOut	A 'Home' move or can be performed by pressing and holding both buttons. Furthermore, the present position can be entered into the Position 1 or Position 2 parameter by holding down the associated button. The Time Out parameter specifies the time in ms that the button(s) must be depressed. This function is independent of the 'Mode' setting and in normal circumstances should not require adjustment. **(Not applicable to TDC001 units)**	word
Not Used		word

Example: Set the button parameters for TDC001 as follows:
Mode: Go To Position
Position1: 0.5 mm
Position2: 1.2 mm
TimeOut: 2 secs

TX B6, 04, 10, 00, D0, 01, 01, 00, 02, 00, C0, 12, 00, 00, 00, 00, 00, 00, 00, 00

Header: B6, 04, 10, 00, D0, 01: SetButtonParams, 10H (16) byte data packet, Generic USB Device
Chan Ident: 01, 00: Channel 1 (always set to 1 for TDC001)
Mode: 02, 00 (i.e. Go to position)
Position1: 00, 43, 00, 00 (17152 Encoder Counts = 0.5 mm)
Position2: CC, A0, 00, 00 (41164 encoder counts = 1.2 mm):
TimeOut: D0, 07: (2 seconds)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
DB	04	Chan Ident	00	d	s

GET:
Response structure (20 bytes)
6 byte header followed by 16 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
B6	04	10	00	d|	s	Chan Ident		Mode		Position1	

12	13	14	15	16	17	18	19	20	21
Data									
Position1		Position2				TimeOut		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_EEPROMPARAMS 0x04B9

Function: Used to save the parameter settings for the specified message. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
B9	04	04	00	d|	s	Chan Ident		MsgID	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
MsgID	The message ID of the message containing the parameters to be saved.	word

Example:

TX B9, 04, 04, 00, D0, 01, 01, 00, B6, 04,

Header: B9, 04, 04, 00, D0, 01: Set_EEPROMPARAMS, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
MsgID: Save parameters specified by message 04B6 (SetButtonParams).

MGMSG_MOT_SET_PMDPOSITIONLOOPPARAMS 0x04D7
MGMSG_MOT_REQ_PMDPOSITIONLOOPPARAMS 0x04D8
MGMSG_MOT_GET_PMDPOSITIONLOOPPARAMS 0x04D9

Function: Used to set the position control loop parameters for the specified motor channel.
The motion processors within the BBD series controllers use a position control loop to determine the motor command output. The purpose of the position loop is to match the actual motor position and the demanded position. This is achieved by comparing the demanded position with the actual encoder position to create a position error, which is then passed through a digital PID-type filter. The filtered value is the motor command output.

SET:

Command structure (34 bytes)

6 byte header followed by 28 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D7	04	1C	00	d|	s	Chan Ident		Kp Pos		Integral	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
ILimPos				Differential		KdTimePos		KoutPos		KvffPos	

24	25	26	27	28	29	30	31	32	33
Data									
KaffPos		PosErrLim				N/A		N/A	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Kp Pos	The proportional gain. Together with the Integral and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767.	word
Integral	The integral gain. Together with the Proportional and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767.	word
ILimPos	The Integral Limit parameter is used to cap the value of the Integrator to prevent runaway of the integral sum at the output. It accepts values in the range 0 to 7FFFFFFF. If set to 0 then the integration term in the PID loop is ignored.	dword
Differential	The differential gain. Together with the Proportional and Integral, these terms determine the system response characteristics and accept values in the range 0 to 32767.	word
KdTimePos	Under normal circumstances, the derivative term of the PID loop is recalculated at every servo cycle. However, it may be desirable to reduce the sampling rate to a lower value, in order to increase stability or simplify tuning. The KdTimePos parameter is used to set the sampling rate. For example, if	word

	set to 10, the derivative term is calculated every 10 servo cycles. The value is set in cycles, in the range 1 to 32767.	
KoutPos	The KoutPos parameter is a scaling factor applied to the output of the PID loop. It accepts values in the range 0 to 65535, where 0 is 0% and 65535 is 100%.	word
KvffPos	The KvffPos and KaffPos parameters are velocity and acceleration feed-forward terms that are added to the output of the PID filter to assist in tuning the motor drive signal. They accept values in the range 0 to 32767.	word
KaffPos		word
PosErrLim	Under certain circumstances, the actual encoder position may differ from the demanded position by an excessive amount. Such a large position error is often indicative of a potentially dangerous condition such as motor failure, encoder failure or excessive mechanical friction. To warn of, and guard against this condition, a maximum position error can be set in the PosErrLim parameter, in the range 0 to 7FFFFFFF. The actual position error is continuously compared against the limit entered, and if exceeded, the Motion Error bit (bit 15) of the Status Register is set and the associated axis is stopped.	dword
Not Used		word
Not Used		word

Example: Set the PID parameters for chan 2 as follows:
Proportional: 65
Integral: 175
Integral Limit: 80,000
Differential: 600
KdTimePos: 5
KoutPos: 5%
KvffPos: 0
KaffPos: 1000
PosErrLim: 65535

TX D7, 04, 1C, 00, A2, 01, 01, 00, 41, 00, AF, 00, 80, 38, 01, 00, 58, 02, 05, 00, CD, 0C, 00, 00, E8, 03, FF, FF, 00, 00, 00, 00

Header: D7, 04, 1C, 00, A2, 01: Set_PMDPositionLoopParams, 28 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Proportional: *41, 00,:* Set the proportional term to 65
Integral: *AF, 00,:* Set the integral term to 175
Integral Limit: 80, 38, 01, 00,: Set the integral limit to 80,000
Differential: 58, 02,: Set the differential term to 600
KdTimePos: 05, 00,: Set the sampling rate to 5 cycles
KoutPos: CD, 0C,: Set the output scaling factor to 5% (i.e. 3277)
KvffPos: 00, 00,: Set the velocity feed forward value to zero
KaffPos: E8, 03,: Set the acceleration feed forward value to 1000
PosErrLim: FF, FF, 00, 00,: Set the position error limit to 65535.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
D8	04	Chan Ident	00	d	s

GET:
Response structure (34 bytes)
6 byte header followed by 28 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D9	04	1C	00	d	s	Chan Ident		Kp Pos		Integral	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
ILinPos				Differential		KdTimePos		KoutPos		KvffPos	

24	25	26	27	28	29	30	31	32	33
Data									
KaffPos		PosErrLim				N/A		N/A	

For structure see SET message above.

MGMSG_MOT_SET_PMDMOTOROUTPUTPARAMS 0x04DA
MGMSG_MOT_REQ_PMDMOTOROUTPUTPARAMS 0x04DB
MGMSG_MOT_GET_PMDMOTOROUTPUTPARAMS 0x04DC

Function: Used to set certain limits that can be applied to the motor drive signal. The individual limits are described below.

SET:

Command structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
DA	04	0E	00	d|	s	Chan Ident		Cont Current Lim		Energy Limit	

12	13	14	15	16	17	18	19
Data							
Motor Limit		Motor Bias		Not Used		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
ContCurrentLim	The system incorporates a current 'foldback' facility, whereby the continuous current level can be capped. The continuous current limit is set in the ContCurrentLim parameter, which accepts values as a percentage of maximum peak current, in the range 0 to 32767 (0 to 100%), which is the default maximum level set at the factory (this maximum value cannot be altered).	word
EnergyLim	When the current output of the drive exceeds the limit set in the ContCurrentLim parameter, accumulation of the excess current energy begins. The EnergyLim parameter specifies a limit for this accumulated energy, as a percentage of the factory set default maximum, in the range 0 to 32767 (0 to 100%). When the accumulated energy exceeds the value specified in the EnergyLim parameter, a 'current foldback' condition is said to exist, and the commanded current is limited to the value specified in the ContCurrentLim parameter. When this occurs, the Current Foldback status bit (bit 25) is set in the Status Register. When the accumulated energy above the ContCurrentLim value falls to 0, the limit is removed and the status bit is cleared.	word
MotorLim	The MotorLim parameter sets a limit for the motor drive signal and accepts values in the range 0 to 32767 (100%). If the system produces a value greater than the limit set, the motor command takes the limiting value. For example, if MotorLim is set to 30000 (91.6%), then signals greater than 30000 will be output as 30000 and values less than -30000 will be output as -30000.	word
MotorBias	When an axis is subject to a constant external force in one	word

	direction (such as a vertical axis pulled downwards by gravity) the servo filter can compensate by adding a constant DC bias to the output. This bias is set in the MotorBias parameter, which accepts values in the range -32767 to 32768. The default value is 0. Once set, the motor bias is applied while the position loop is enabled.	
Not Used		word
Not Used		word

Example: Set the motor output parameters for chan 2 as follows:
Continuous Current: 20%
Energy Limit: 14%
Motor Limit: 100%
Motor Bias: zero

TX DA, 04, 0E, 00, A2, 01, 01, 00, 99, 19, C0, 12, 00, 00, 00, 00, 00, 00, 00, 00

Header: DA, 04, 0E, 00, A2, 01: Set MotorOutputParams, 0EH (14) byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Cont Current Limit:
Energy Limit: 99, 19: Set the energy limit to 14%
Motor Limit: C0, 12: Set the motor limit to 100%
Motor Bias: 00, 00: Set the motor bias to zero

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
DB	04	Chan Ident	00	d	s

GET:
Response structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
DC	04	0E	00	d|	s	Chan Ident		Cont Current Lim		Energy Limit	

12	13	14	15	16	17	18	19
Data							
Motor Limit		Motor Bias		Not Used		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_PMDTRACKSETTLEPARAMS 0x04E0
MGMSG_MOT_REQ_PMDTRACKSETTLEPARAMS 0x04E1
MGMSG_MOT_GET_PMDTRACKSETTLEPARAMS 0x04E2

Function: Moves are generated by an internal profile generator, and are based on either a trapezoidal or S-curve trajectory. A move is considered complete when the profile generator has completed the calculated move and the axis has 'settled' at the demanded position. This command contains parameters which specify when the system is settled.

Further Information

The system incorporates a monitoring function, which continuously indicates whether or not the axis has 'settled'. The 'Settled' indicator is bit 14 in the Status Register and is set when the associated axis is settled. Note that the status bit is controlled by the processor, and cannot be set or cleared manually.

The axis is considered to be 'settled' when the following conditions are met:

* the axis is at rest (i.e. not performing a move),

* the error between the demanded position and the actual motor position is less than or equal to a specified number of encoder counts (0 to 65535) set in the *SettleWnd* parameter (Settle Window),

* the above two conditions have been met for a specified number of cycles (settle time, 1 cycle = 102.4 µs), set in the *SettleTime* parameter (range 0 to 32767).

The above settings are particularly important when performing a sequence of moves. If the PID parameters are set such that the settle window cannot be reached, the first move in the sequence will never complete, and the sequence will stall. The settle window and settle time values should be specified carefully, based on the required positional accuracy of the application. If positional accuracy is not a major concern, the settle time should be set to '0'. In this case, a move will complete when the motion calculated by the profile generator is completed, irrespective of the actual position attained, and the settle parameters described above will be ignored.

The processor also provides a 'tracking window', which is used to monitor servo performance outside the context of motion error. The tracking window is a programmable position error limit within which the axis must remain, but unlike the position error limit set in the SetDCPositionLoopParams method, the axis is not stopped if it moves outside the specified tracking window. This function is useful for processes that rely on the motor's correct tracking of a set trajectory within a specific range. The tracking window may also be used as an early warning for performance problems that do not yet qualify as motion error.

The size of the tracking window (i.e. the maximum allowable position error while remaining within the tracking window) is specified in the *TrackWnd* parameter, in the range 0 to 65535. If the position error of the axis exceeds this value, the Tracking Indicator status bit (bit 13) is set to 0 in the Status Register. When the position error returns to within the window boundary, the status bit is set to 1.

SET:

Command structure (18 bytes)
6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E0	04	0C	00	d|	s	Chan Ident		Time		Settle Window	

12	13	14	15	16	17
Data					
Track Window		Not Used		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Time	The time that the associated axis must be settled before the 'Settled' status bit is set. The time is set in cycles, in the range 0 to 32767, 1 cycle = 102.4 µs.	word
Settle Window	The position error is defined as the error between the demanded position and the actual motor position. This parameter specifies the number of encoder counts (in the range 0 to 65535) that the position error must be less than or equal to, before the axis is considered 'settled'.	word
Track Window	The maximum allowable position error (in the range 0 to 65535) whilst tracking .	word
Not Used		word
Not Used		word

Example: Set the track and settle parameters for chan 2 as follows:
Settle Time: 20%
Settle Window: 14%
Track Window: 100%

s
TX E0, 04, 0C, 00, A2, 01, 01, 00, 00, 00, 14, 00, 00, 00, 00, 00, 00, 00, 00, 00

Header: E0, 04, 0C, 00, A2, 01: Set MotorOutputParams, 0CH (12) byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Time: 00, 00: Set the Settle time to zero
Settle Window: 14, 00: Set the settle window to 20 encoder counts
Track Window: 00, 00: Set the track window to zero

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
E1	04	Chan Ident	00	d	s

GET:
Response structure (18 bytes)
6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E2	04	0C	00	d|	s	Chan Ident		Time		Settle Window	

12	13	14	15	16	17
Data					
Track Window		Not Used		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_PMDPROFILEMODEPARAMS 0x04E3
MGMSG_MOT_REQ_PMDPROFILEMODEPARAMS 0x04E4
MGMSG_MOT_GET_PMDPROFILEMODEPARAMS 0x04E5

Function: The system incorporates a trajectory generator, which performs calculations to determine the instantaneous position, velocity and acceleration of each axis at any given moment. During a motion profile, these values will change continuously. Once the move is complete, these parameters will then remain unchanged until the next move begins.

The specific move profile created by the system depends on several factors, such as the profile mode and profile parameters presently selected, and other conditions such as whether a motion stop has been requested. This method is used to set the profile mode to either 'Trapezoidal' or 'S-curve'.

SET:

Command structure (18 bytes)

6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E3	04	0C	00	d|	s	Chan Ident		Mode		Jerk	

12	13	14	15	16	17
Data					
Jerk		Not Used		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Mode	The move profile to be used: Trapezoidal: 0 S-Curve: 2 The Trapezoidal profile is a standard, symmetrical acceleration/deceleration motion curve, in which the start velocity is always zero. The S-curve profile is a trapezoidal curve with an additional 'Jerk' parameter, which limits the rate of change of acceleration and smooths out the contours of the motion profile. In this profile mode, the acceleration increases gradually from 0 to the specified acceleration value, then decreases at the same rate until it reaches 0 again at the specified velocity. The same sequence in reverse brings the axis to a stop at the programmed destination position.	word
Jerk	The Jerk value is specified in mm/s^3 in the Jerk parameter, and accepts values in the range 0 to 4294967295. It is used to specify the maximum rate of change in acceleration in a single cycle of the basic trapezoidal curve. 1.0 mm/s^3 is equal to 92.2337 jerk units.	dword
Not Used		word
Not Used		word

Example: Set the profile mode parameters for chan 2 as follows:
Profile Mode: S-curve
Jerk: 10,000 mm^3

TX E3, 04, 0C, 00, A2, 01, 01, 00, 02, 00, E1, 12, 0E, 00, 00, 00, 00, 00,

Header: E3, 04, 0C, 00, A2, 01: Set ProfileModeParams, 0CH (12) byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Profile Mode: 02, 00: Set the profile mode to S-Curve
Jerk: E1, 12,0E, 00: Set the jerk value to 10,000 mm/sec^3 (i.e. 922337)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
E4	04	Chan Ident	00	d	s

GET:
Response structure (18 bytes)
6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E5	04	0C	00	d|	s	Chan Ident		Mode		Jerk	

12	13	14	15	16	17
Data					
Jerk		Not Used		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_PMDJOYSTICKPARAMS 0x04E6
MGMSG_MOT_REQ_PMDJOYSTICKPARAMS 0x04E7
MGMSG_MOT_GET_PMDJOYSTICKPARAMS 0x04E8

Function: The MJC001 joystick console has been designed for use by microscopists to provide intuitive, tactile, manual positioning of the stage. The console consists of a two axis joystick for XY control which features both low and high gear modes. This message is used to set max velocity and acceleration values for these modes.

SET:

Command structure (26 bytes)

6 byte header followed by 20 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E6	04	14	00	d|	s	Chan Ident		JSGearLowMaxVel			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
JSGearHighMaxVel				JSGearHighLowAccn				JSGearHighHighAccn			

24	25
Data	
DirSense	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
JSGearLowMaxVel	Specifies the max velocity (in encoder counts/cycle) of a joystick move when low gear mode is selected. It accepts values in the range 0 to 4294967295. 1 mm / sec equals 134218 PMD units	long
JSGearHighMaxVel	Specifies the max velocity (in encoder counts/cycle) of a joystick move when high gear mode is selected. It accepts values in the range 0 to 4294967295. 1 mm / sec equals 134218 PMD units	long
JSGearLowAccn	Specifies the acceleration (in encoder counts/cycle) of a joystick move when low gear mode is selected. It accepts values in the range 0 to 4294967295. 1 mm /sec^2 equals 13.7439 PMD units.	long
JSGearHighAccn	Specifies the acceleration (in encoder counts/cycle) of a joystick move when high gear mode is selected. It accepts values in the range 0 to 4294967295. 1 mm /sec^2 equals 13.7439 PMD units.	long
DirSense	The actual direction sense of any joystick initiated move is dependent upon the application. This parameter can be used to reverse the sense of direction for a particular application and is useful when matching joystick direction sense to actual stage direction sense. DIRSENSE_POS 0X0001 Direction Positive DIRSENSE_NEG 0X0002 Direction Negative	word

Example: Set the joystick parameters for bay 2 as follows:
JSGearLowMaxVel: 1 mm/sec
JSGearHighMaxVel: 10 mm/sec
JSGearLowAccn: 0.5 mm /sec^2
JSGearHighAccn: 5.0 mm /sec^2
DirSens: Positive

TX E6, 04, 14, 00, A2, 01, 01, 00, 4A, 0C, 02, 00, E4, 7A, 14, 00, 07, 00, 00, 00, 46, 00, 00, 00, 01, 00

Header: E6, 04, 14, 00, A2, 01: SetPMDJoystickParams, 14H (20) byte data packet, bay 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
*JSGearLowMaxVel: 4A, 0C, 02, 00 (*134218)
JSGearHighMaxVel: E4, 7A, 14, 00 (1342180)
JSGearLowAccn: 07, 00, 00, 00 (7.0)
JSGearHighAccn: 46, 00, 00, 00 (70.0)
DirSens: *01, 00*

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
E7	04	Chan Ident	00	d	s

GET:
Response structure (26 bytes)
6 byte header followed by 20 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E8	04	14	00	d|	s	Chan Ident		JSGearLowMaxVel			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
JSGearHighMaxVel				JSGearHighLowAccn				JSGearHighHighAccn			

24	25
Data	
DirSense	

For structure see SET message above.

MGMSG_MOT_SET_PMDCURRENTLOOPPARAMS 0x04D4
MGMSG_MOT_REQ_PMDCURRENTLOOPPARAMS 0x04D5
MGMSG_MOT_GET_PMDCURRENTLOOPPARAMS 0x04D6

Function: Used to set the current control loop parameters for the specified motor channel.
The motion processors within the BBD series controllers use digital current control as a technique to control the current through each phase winding of the motors. In this way, response times are improved and motor efficiency is increased. This is achieved by comparing the required (demanded) current with the actual current to create a current error, which is then passed through a digital PI-type filter. The filtered current value is used to develop an output voltage for each motor coil.
This method sets various constants and limits for the current feedback loop.

SET:
Command structure (24 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D4	04	12	00	d|	s	Chan Ident		Phase		KpCurrent	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
KiCurrent		ILimCurrent		DeadBand		Kff		Not Used		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Phase	The current phase to set: PHASEA 0 PHASEB 1 PHASEA AND B 2	word
KpCurrent	The proportional gain. Together with the KiCurrent this term determines the system response characteristics and accept values in the range 0 to 32767.	word
KiCurrent	The integral gain. Together with the KpCurrent this term determines the system response characteristics and accept values in the range 0 to 32767.	word
ILimCurrent	The ILimCurrent parameter is used to cap the value of the Integrator to prevent runaway of the integral sum at the output. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PID loop is ignored.	word
IDeadBand	The IDeadBand parameter allows an integral dead band to be set, such that when the error is within this dead band, the integral action stops, and the move is completed using the proportional term only. It accepts values in the range 0	word

	to 32767.	
Kff	The Kff parameter is a feed-forward term that is added to the output of the PID filter to assist in tuning the motor drive signal. It accepts values in the range 0 to 32767.	word
Not Used		word
Not Used		word

Example: Set the limit switch parameters for chan 2 as follows:
Phase: A and B
KpCurrent: 35
KiCurrent: 80
ILimCurrent: 32,767
DeadBand: 50
Kff: 0

TX D4, 04, 12, 00, A2, 01, 01, 00, 02, 00, 23, 00, 50, 00, FF, 7F, 32, 00, 00, 00, 00, 00, 00, 00,

Header: D4, 04, 12, 00, A2, 01: Set_PMDCurrentLoopParams, 18 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Phase: 02, 00: Set Phase A and Phase B
KpCurrent: *23, 00,:* Set the proportional term to 35
KiCurrent: *50, 00,:* Set the integral term to 80
ILimCurrent: FF, 7F,: Set the integral limit to 32767
IDeadBand: 32, 00,: Set the deadband to 50
Kff: 00, 00: Set the feed forward value to zero

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
D8	04	Chan Ident	00	d	s

GET:
Command structure (24 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D6	04	12	00	d|	s	Chan Ident		Phase		KpCurrent	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
KiCurrent		ILimCurrent		DeadBand		Kff		Not Used		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_PMDSETTLEDCURRENTLOOPPARAMS 0x04E9
MGMSG_MOT_REQ_PMDSETTLEDCURRENTLOOPPARAMS 0x04EA
MGMSG_MOT_GET_PMDSETTLEDCURRENTLOOPPARAMS 0x04EB

Function: These commands assist in maintaining stable operation and reducing noise at the demanded position. They allow the system to be tuned such that errors caused by external vibration and manual handling (e.g. loading of samples) are minimized, and are applicable only when the stage is settled, i.e. the Axis Settled status bit (bit 14) is set.

SET:

Command structure (24 bytes)

6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E9	04	12	00	d|	s	Chan Ident		Phase		KpSettled	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
KiSettled		ILimSettled		DeadBandSet		KffSettled		Not Used		Not Used	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Phase	The current phase to set: PHASEA 0 PHASEB 1 PHASEA AND B 2	word
KpSettled	The proportional gain. Together with the KiSettled this term determines the system response characteristics and accept values in the range 0 to 32767.	word
KiSettled	The integral gain. Together with the KpSettled this term determines the system response characteristics and accept values in the range 0 to 32767.	word
ILimSettled	The ILimSettled parameter is used to cap the value of the Integrator to prevent runaway of the integral sum at the output. It accepts values in the range 0 to 32767. If set to 0 then the integration term in the PID loop is ignored.	word
IDeadBandSettled	The IDeadBandSettled parameter allows an integral dead band to be set, such that when the error is within this dead band, the integral action stops, and the move is completed using the proportional term only. It accepts values in the range 0 to 32767.	word
KffSettled	The KffSettled parameter is a feed-forward term that is added to the output of the PID filter to assist in tuning the motor drive signal. It accepts values in the range 0 to 32767.	word
Not Used		word
Not Used		word

Example: Set the limit switch parameters for chan 2 as follows:
Phase: A and B
KpSettled: 0
KiSettled: 40
ILimSettled: 30,000
DeadBandSettled: 50
KffSettled:500

TX E9, 04, 12, 00, A2, 01, 01, 00, 02, 00, 00, 00, 28, 00, 30, 75, 32, 00, F4, 01, 00, 00, 00, 00,

Header: D4, 04, 12, 00, A2, 01: Set_PMDSettledCurrentLoopParams, 18 byte data packet, Channel 2.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Phase: 02, 00: Set Phase A and Phase B
KpCurrent: *00, 00,:* Set the proportional term to zero
KiCurrent: *28, 00,:* Set the integral term to 40
ILimCurrent: 30, 75,: Set the integral limit to 30,000
IDeadBand: 32, 00,: Set the deadband to 50
Kff: F4, 01: Set the feed forward value to 500

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
D8	04	Chan Ident	00	d	s

GET:
Command structure (24 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
EB	04	12	00	d|	s	Chan Ident		Phase		KpSettled	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
KiSettled		ILimSettled		DeadBandSet		KffSettled		Not Used		Not Used	

For structure see SET message above.

MGMSG_MOT_SET_PMDSTAGEAXISPARAMS 0x04F0
MGMSG_MOT_REQ_PMDSTAGEAXISPARAMS 0x04F1
MGMSG_MOT_GET_PMDSTAGEAXISPARAMS 0x04F2

Function: The REQ and GET commands are used to obtain various parameters pertaining to the particular stage being driven. Most of these parameters are inherent in the design of the stage and cannot be altered. The SET command can only be used to increase the Minimum position value and decrease the Maximum position value, thereby reducing the overall travel of the stage.

SET:
Command structure (80 bytes)
6 byte header followed by 74 byte data packet – see Get for structure

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
F1	04	Chan Ident	00	d	s

GET:
Command structure (80 bytes)
6 byte header followed by 74 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
F2	04	4A	00	d|	s	Chan ID		Stage ID		Axis ID	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Part No/Axis											

24	25	26	27	28	29	30	31	32	33	34	35
Data											
Part No/Axis				Serial Number				Counts per Unit			

36	37	38	39	40	41	42	43	44	45	46	47
Data											
MinPos				Max Pos				Max Accn			

48	49	50	51	52	53	54	55	56	57	58	59
Data											
Max Dec				Max Vel				Reserved		Reserved	

60	61	62	63	64	65	66	67	68	69	70	71
Data											
Reserved		Reserved		Reserved				Reserved			

72	73	74	75	76	77	78	79
Data							
Reserved				Reserved			

Data Structure:

field	description	format
Stage ID	This 2 byte parameter identifies the stage and axis: 00, 10 - MLS203_X_AXIS 00, 11 - MLS203_Y_AXIS	word
AxisID	Not used for the BBD series controllers	word
PartNoAxis	A 16 byte character string used to identify the stage type and axis being driven.	char
SerialNum	The Serial number of the stage	dword
CntsPerUnit	The number of encoder counts per real world unit (either mm or degrees).	dword
MinPos	The minimum position of the stage, typically zero	long
MaxPos	The maximum position of the stage in encoder counts	long
MaxAccn	The maximum acceleration of the stage in encoder counts per cycle per cycle	long
MaxDec	The maximum deceleration of the stage in encoder counts per cycle per cycle	long
MaxVel	The maximum velocity of the stage in encoder counts per cycle.	long
Reserved		word
Reserved		word
Reserved		word
Reserved		word
Reserved		dword
Reserved		dword
Reserved		dword
Reserved		dword

Example: Get the stage and axis parameters for chan 2:

RX F2, 04, 4A, 00, 81, 22, 01, 00, 11, 00, 00, 00, 4D,4C, 53, 32, 30, 33, 20, 59, 20, 41, 78, 69, 73, 00, 00, 00, 81, 96, 98, 00, 20, 4E, 00, 00, 00, 00, 00, 00, 60, E3, 16, 00, 60, 6B, 00, 00, 60, 6B, 00, 00, 9A, 99, 99, 01, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00

Header: F2, 04, 4A, 00, 81, 22: Get_PMDStageAxisParams, 74 byte data packet,Bay 1.
Chan Ident: 01, 00: Channel 1 (always set to 1 for BBD202)
Stage ID: 11, 00: MLS203 Y Axis
Axis ID: *00, 00,:* Not used
PartNo Axis: *4D, 4C, 53, 32, 30, 33, 20, 59, 20, 41, 78, 69, 73, 00, 00, 00,:*
M L S 2 0 3 Y A X I S
SerialNum: 81, 96, 98, 00
CntsPerUnit 20, 4E, 00, 00: the encoder counts per unit is set to 20000
MinPos: 00, 00, 00, 00: the feed minimum position is set to zero
MaxPos: 60, E3, 16, 00: the maximum position is set to 1500000
MaxAccn: 60, 6B, 00, 00: the maximum acceleration is set to 27488
MaxDec: 60, 6B, 00, 00: the maximum deceleration is set to 27488
MaxVel: 9A, 99, 99, 01: the maximum velocity is set to 26843546

MGMSG_MOT_SET_TSTACTUATORTYPE 0x04FE

Function: This command is for use only with the TST101 driver, and is used to define an actuator type so that the TST driver knows the effective length of the stage. This information is used if a user wishes to home the stage to the far travel end. In this case, once the stage is homed the APT GUI count will be set to the far travel value. For example, in the case of a ZFS25 the user will see 25mm once homed. The TST holds this value as a number of Trinamic microsteps, which will be a function of the gearbox ratio, the lead screw pitch, and the motor type. So for example the number stored in the TST for the ZFS25 is 54613333.

SET:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
FE	04	Actuator Ident	00	d	s

Actuator Idents:

ZST_LEGACY_6MM	0x20
ZST_LEGACY_13MM	0x21
ZST_LEGACY_25MM	0x22
ZST_NEW_6MM	0x30
ZST_NEW_13MM	0x31
ZST_NEW_25MM	0x32
ZFS_NEW_6MM	0x40
ZFS_NEW_13MM	0x41
ZFS_NEW_25MM	0x42
DRV013_25MM	0x50
DRV014_50MM	0x51

Example: Set the actuator type to New ZFS 13 mm Travel:

Header: FE, 04, 31, 00, 50, 01:

MGMSG_MOT_GET_STATUSUPDATE 0x0481

Function: This message is returned when a status update is requested for the specified motor channel. This request can be used instead of enabling regular updates as described above.

GET:
Status update messages are received with the following format:-

Response structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
81	04	0E	00	d|	s	Chan Ident		Position			

12	13	14	15	16	17	18	19
Data							
EncCount				Status Bits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always P_MOD_CHAN1 (0x01) encoded as a 16-bit word (0x01 0x00)	word
Position	The position encoder count. In the APT Stepper Motor controllers the encoder resolution is 25,600 counts per mm, therefore a position change of 1 mm would be seen as this parameter changing by 25,600. The LONG variable is a 32 bit value, encoded in the data stream in the Intel format.	long
EncCount	For use with encoded stages only.	long
Status Bits	The meaning of individual bits in this 32-bit variable is described in the bit mask table below (1 = active, 0 = inactive).	dword

bit mask	meaning
0x00000001	forward (CW) hardware limit switch is active
0x00000002	reverse (CCW) hardware limit switch is active
0x00000004	forward (CW) software limit switch is active
0x00000008	reverse (CCW) software limit switch is active
0x00000010	in motion, moving forward (CW)
0x00000020	in motion, moving reverse (CCW)
0x00000040	in motion, jogging forward (CW)
0x00000080	in motion, jogging reverse (CCW)
0x00000100	motor connected
0x00000200	in motion, homing
0x00000400	homed (homing has been completed)
0x00001000	interlock state (1 = enabled)

This is not full list of all the bits but the remaining bits reflect information about the state of the hardware that in most cases does not affect motion.

MGMSG_MOT_REQ_STATUSUPDATE 0x0480

Function: Used to request a status update for the specified motor channel. This request can be used instead of enabling regular updates as described above.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
80	04	Chan Ident	00	d	s

GET:

See previous details on MGMSG_MOT_GET_STATUSUPDATE 0x0481.

MGMSG_MOT_GET_DCSTATUSUPDATE 0x0491

Function: This message is returned when a status update is requested for the specified motor channel. This request can be used instead of enabling regular updates as described above.

GET:
Status update messages are received with the following format:-

Response structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
91	04	0E	00	d|	s	Chan Ident		Position			

12	13	14	15	16	17	18	19
Data							
Velocity		Reserved		Status Bits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always P_MOD_CHAN1 (0x01) encoded as a 16-bit word (0x01 0x00)	word
Position	The position encoder count. In the BBD10X series controllers the encoder resolution is 20,000 counts per mm, therefore a position change of 1 mm would be seen as this parameter changing by 20,000 (twenty thousand). The LONG variable is a 32 bit value, encoded in the data stream in the Intel format, so for example a position of 1 million encoder counts (equivalent to 50 mm) would be sent as byte stream 0x40, 0x42, 0x0F, 0x00 since 1 million is hexadecimal 0xF4240.	long
Velocity	The actual velocity. Scaling is 204.8 per mm/sec, so a real-life measured speed of 100 mm/sec is read as 205. Again, the two-byte data stream will be encoded in the Intel format.	word
Reserved	Currently Not Used	Word
Status Bits	The meaning of individual bits in this 32-bit variable is described in the bit mask table below	dword

bit mask	meaning
0x00000001	forward hardware limit switch is active
0x00000002	reverse hardware limit switch is active
0x00000010	in motion, moving forward
0x00000020	in motion, moving reverse
0x00000040	in motion, jogging forward
0x00000080	in motion, jogging reverse
0x00000200	in motion, homing

0x00000400	homed (homing has been completed)
0x00001000	tracking
0x00002000	settled
0x00004000	motion error (excessive position error)
0x01000000	motor current limit reached
0x80000000	channel is enabled

This is not full list of all the bits but the remaining bits reflect information about the state of the hardware that in most cases does not affect motion.

MGMSG_MOT_REQ_DCSTATUSUPDATE 0x0490

Function: Used to request a status update for the specified motor channel. This request can be used instead of enabling regular updates as described above.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
90	04	Chan Ident	00	d	s

GET:

See previous details on MGMSG_MOT_GET_DCSTATUSUPDATE 0x0491.

MGMSG_MOT_ACK_DCSTATUSUPDATE 0x0492

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called “server alive” must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5
header only					
92	04	00	00	d	s

TX 92, 04, 00, 00, 21, 01

MGMSG_ MOT_REQ_STATUSBITS 0x0429
MGMSG_ MOT_GET_STATUSBITS 0x042A

Function: Used to request a "cut down" version of the status update message, only containing the status bits, without data about position and velocity.

SET: N/A

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
29	04	Chan Ident	00	d	s

GET:

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
2A	04	06	00	d|	s	Chan Ident		Status Bits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	Word
Status Bits	The status bits are assigned exactly as described in the section detailing the MGMSG_MOT_GET_DCSTATUSUPDATE command.	DWord

MGMSG_ MOT_SUSPEND_ENDOFMOVEMSGS 0x046B

Function: Sent to disable all unsolicited end of move messages and error messages returned by the controller, i.e.

MGMSG_MOT_MOVE_STOPPED
MGMSG_MOT_MOVE_COMPLETED
MGMSG_MOT_MOVE_HOMED

Command structure (6 bytes):

0	1	2	3	4	5
header only					
6B	04	00	00	d	s

MGMSG_ MOT_RESUME_ENDOFMOVEMSGS 0x046C

Function: Sent to resume all unsolicited end of move messages and error messages returned by the controller, i.e.

MGMSG_MOT_MOVE_STOPPED
MGMSG_MOT_MOVE_COMPLETED
MGMSG_MOT_MOVE_HOMED

The command also disables the error messages that the controller sends when an error conditions is detected:

MGMSG_HW_RESPONSE
MGMSG_HW_RICHRESPONSE

This is the default state when the controller is powered up.

Command structure (6 bytes):

0	1	2	3	4	5
header only					
6C	04	00	00	d	s

MGMSG_MOT_SET_TRIGGER 0x0500
MGMSG_MOT_REQ_TRIGGER 0x0501
MGMSG_MOT_GET_TRIGGER 0x0502

Function: This message is used to configure the Motor controller for triggered move operation. It is possible to configure a particular controller to respond to trigger inputs, generate trigger outputs or both respond to and generate a trigger output. When a trigger input is received, the unit can be set to initiate a move (relative, absolute or home). Similarly the unit can be set to generate a trigger output signal when a specified event (e.g move initiated) occurs. For those units configured for both input and output triggering, a move can be initiated via a trigger input while at the same time, a trigger output can be generated to initiate a move on another unit.
The trigger settings can be used to configure multiple units in a master – slave set up, thereby allowing multiple channels of motion to be synchronized. Multiple moves can then be initiated via a single software or hardware trigger command.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
00	05	Chan Ident	Mode	d	s

Note. This message operates differently when used with brushless DC controllers (e.g. BBD20x and TBD001) as opposed to other motor controllers as described in the following paragraphs.

All benchtop stepper controllers (BSC20x,)

field	description	format
Chan Ident	The channel being addressed	char
Mode	This parameter sets the trigger mode and move type to be initiated according to the numerical value entered in bits 0 to 7 as follows Bit 0 (0x01): TRIGIN_ENABLE set to enable physical trigger input Bit 1 (0x02): TRIGOUT_ENABLE set to enable trigger output function (mode set by BIT2 or BIT3 below) Bit 2 (0x04): TRIGOUT_MODEFOLLOW set to enable physical trigger output to mirror trig in Bit 3 (0x08): TRIGOUT_MODEMOVEEND set to enable physical trigger output, remains active (high) until move end Bit 4 (0x10): TRIG_RELMOVE set for relative move on trigger Bit 5 (0x20): TRIG_ABSMOVE set for absolute move on trigger Bit 6 (0x40): TRIG_HOMEMOVE set for home sequence on	char

	trigger Bit 7 (0x80): TRIGOUT_NOTRIGIN set to enable physical trigger output with no physical trigger in (i.e. sw initiated trigger)	

Brushless DC controllers only (BBD20x and TBD001)

field	description	format
Chan Ident	The channel being addressed	char
Mode	This parameter sets the trigger mode and move type according to the numerical value entered in bits 0 to 7 as follows Bit 0 (0x01): TRIGIN_HIGH The Trigger input can be configured to initiate a relative, absolute or homing home, either on the rising or falling edge of the signal driving it. As the trigger input is edge sensitive, it needs to see a logic LOW to HIGH transition ("rising edge") or a logic HIGH to LOW transition ("falling edge") for the move to be started. Additionally, the move parameters must be downloaded to the unit prior to the move using the relevant relative move or absolute move methods as described below. A move already in progress will not be interrupted; therefore external triggering will not work until the previous move has been completed. If this bit is set, the logic state is set HIGH. Bit 1 (0x02): TRIGIN_RELMOVE set to enable trigger in and initiate a relative move (specified using the latest MoveRelative or MoveRelativeEx settings) when a trigger input signal is received. Bit 2 (0x04): TRIGIN_ABSMOVE set to enable trigger in and initiate an absolute move (specified using the latest MoveAbsolute or MoveAbsoluteEx settings) when a trigger input signal is received. Bit 3 (0x08): TRIGIN_HOMEMOVE set to enable trigger in and initiate a home move (specified using the latest MoveHome settings) whan atrigger input signal is received. Bit 4 (0x10): TRIGOUT_HIGH The Trigger output can be configured to be asserted to either logic HIGH or LOW as a function of certain motion-related conditions, such as when a move is in progress (In Motion), complete (Move Complete) or reaches the constant velocity phase on its trajectory (Max Vel). The logic state of the output will remain the same for as long as the chosen condition is true. If this bit is set, the logic state is set HIGH when the following conditions are true. Bit 5 (0x20): TRIGOUT_INMOTION set to enable trigger out (triggered when in motion) Bit 6 (0x40): TRIGOUT_MOTIONCOMPLETE set to enable trigger out (triggered when motion complete) Bit 7 (0x80): TRIGOUT_MAXVELOCITY set to enable trigger out (triggered when axis at maximum velocity)	char

Example: Set the trigger mode for channel 1 of the BBD201 controller as follows:
Trigger Input Rising Edge (High)
Enable trigger input and initiate a Relative Move
Trigger Output Rising Edge (High)
Enable trigger output when move complete.

TX 00, 05, 01, 53, 50, 01

00,05 SET_TRIGGER
01, Channel 1
53, i.e. 01010011
50, destination Generic USB device
01, Source PC

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	05	Chan Ident	00	d	s

Example: Request the trigger mode

TX 01, 05, 01, 00, 50, 01

GET:
Response structure (6 bytes):

0	1	2	3	4	5
header only					
02	05	Chan Ident	Mode	d	s

For structure see SET message above.

Filter Flipper Control Messages

Introduction

The APT Filter Flipper drive uses the Motor server control instance control its functionality. The messages listed here provide the extra functionality required for a client application to control one or more of the Thorlabs series of MFF series flipper units.

MGMSG_MOT_SET_MFF_OPERPARAMS 0x0510
MGMSG_MOT_REQ_MFF_OPERPARAMS 0x0511
MGMSG_MOT_GET_MFF_OPERPARAMS 0x0512

Function: Used to set various operating parameters that dictate the function of the MFF series flipper unit.

SET:

Command structure (40 bytes)

6 byte header followed by 34 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
10	05	22	00	d|	s	Chan Ident		lTransitTime			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
lTransitTimeADC				OperMode1		SigMode1		PulseWidth1			

24	25	26	27	28	29	30	31	32	33	34	35
				Data							
OperMode2		SigMode2		PulseWidth2				Not Used			

36	37	38	39
Not Used			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
lTransitTime	The time taken (in milliseconds) for the flipper to move from position 1 to position 2 and vice versa. Values must be entered in the range 300 to 2800 ms.	long
lTransitTimeADC	The time taken (in ADC counts) for the flipper to move from position 1 to position 2 and vice versa. The number of ADC counts is calculated from an equation that relates actual time of flight in milli-seconds to the ADC value required by the flipper code. The equation relating the two variables is defined as follows TransitTimeADC = 10000000 x TransitTime$^{-1.591}$ Example A transit time of 500 ms would be calculated as TransitTimeADC = 10000000 x 500$^{-1.591}$ = 10000000 x 0.00005080877 = 508.0877 so a user requiring 500ms motion time needs to set 508 as the ADC value in the structure. This value is then used by the flipper to give a reasonable approximation for the actual time of flight.	long

wDigIO1OperMode	Specifies the operating mode of the DIG IO 1 input/output signal as follows: 01 Sets IO connector to input and 'toggle position' mode. In this mode, the input signal causes flipper to move to other position). 02 Sets IO connector to input and 'goto position' mode. In this mode, the input signal dictates flipper position, POS 1 or POS 2. as dictated by the Button Input or Button Input (Swap Pos) parameters set in the DigIOSigMode parameter below. 03 Sets IO connector to output mode, where the O/P signal indicates the flipper is 'at position'. 04 Sets IO connector to output mode, where the O/P signal indicates the flipper is in motion (i.e. between positions).	word
wDigIO1SigMode	Specifies the functionality of the input/output signal. as follows: 01 The connector can be short circuited (e.g. with button). If the Operating Mode is set to Input:Toggle Position then a short circuit causes the flipper to toggle position. If the Operating Mode is set to Input: Goto Position then a short circuit causes the flipper to move to Pos 1 and open circuit causes flipper to move to POS 02. The connector is set to logic input where a logic transition (edge) dictates flipper operation. If the Operating Mode above set to Input:Toggle Position, then a LO to HI edge causes flipper to toggle position. If the Operating Mode is set to Input: Goto Position, then a LO to HI edge causes the flipper to move to POS 1 and a HI to LO edge causes the flipper to move to POS 2. 04 This parameter can be 'Bitwise Ored' with either the button or the logic parameters above, such that the open circuit and short circuit or the edge functionality is swapped. 10 The connector is set to a logic output where the logic transition (edge) represents flipper position. If the Operating Mode above is set to Output: At Position, then a LO to HI edge (HI level) indicates flipper is at POS 1 and a HI to LO edge (LO level) indicates the flipper is at POS 2. If the Operating Mode above is set to Output: InMotion, then a LO to HI edge (HI level) indicates the flipper is moving between positions and a HI to LO edge (LO level) indicates the flipper has stopped moving. 20 MFFSIGMODE_OP_PULSE The connector is set to	word

	a logic output where a logic pulse indicates flipper operation. If the Operating Mode above is set to Output: At Position, then a logic HI pulse indicates flipper has reached a position. If the Operating Mode above is set to Output: InMotion, then a logic HI pulse indicates the flipper has started moving. The Pulse width is set in the Signal Width paramter below. 40 This parameter can be 'Bitwise Ored' with either the level (edge) or the pulse parameters above, such that the level or pulse functionality is swapped.	
lDigIO1PulseWidth	The pulse width in ms when the Digital Signal Mode described previously is set to Logic Pulse Output or Logic Pulse Output (Inverted). The pulse width is set within the range 10 to 200 ms.	long
wDigIO2OperMode	As DigIO1	word
wDigIO2SigMode	As DigIO1	word
lDigIO2PulseWidth	As DigIO1	long
Not Used		long
Not Used		dword

Example: Set the MFF parameters for chan 1 as follows:

TransitTime	500 ms
TransitTimeADC	508 counts
DigIO1OperMode	Toggle Position
DigIO1SigMode	Button Mode Input
DigIO1PulseWidth	200 ms
DigIO2OperMode	Toggle Position
DigIO2SigMode	Button Mode Input
DigIO2PulseWidth	200 ms
Not Used	
Not Used	

TX 10,05,22,00,D0,01,
01,00,F4,01,00,00,FC,01,00,00,01,00,01,00,C8,00,00,00,01,00,01,00,C8,00,00,00,00,00,00,00
,00,00,00,00

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	05	Chan Ident	00	d	s

Example: Request the MFF operating modes

TX 11, 05, 01, 00, 50, 01

GET:

Response structure (40 bytes):

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
10	05	22	00	d|	s	Chan Ident		lTransitTime			

12	13	14	15	16	17	18	19	20	21	22	23
Data											
lTransitTimeADC				OperMode1		SigMode1		PulseWidth1			

24	25	26	27	28	29	30	31	32	33	34	35
				Data							
OperMode2		SigMode2		PulseWidth2				Not Used			

36	37	38	39
Not Used			

See SET for structure

Solenoid Control Messages

Introduction

The APT Solenoid drive uses the Motor server control instance control its functionality. The messages listed here provide the extra functionality required for a client application to control one or more of the Thorlabs series of TSC001 T-Cube solenoid driver units.

MGMSG_MOT_SET_SOL_OPERATINGMODE 0x04C0
MGMSG_MOT_REQ_SOL_OPERATINGMODE 0x04C1
MGMSG_MOT_GET_SOL_OPERATINGMODE 0x04C2

Function: This message sets the operating mode of the solenoid driver.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C0	04	Chan Ident	Mode	d	s

Data Structure:

field	description	format
Chan Ident	The channel being addressed	char
Operating Mode	The operating mode of the unit as a 4 bit integer: 0x01 SOLENOID_MANUAL - In this mode, operation of the solenoid is via the front panel 'Enable' button, or by the 'Output' buttons on the GUI panel. 0x02 SOLENOID_SINGLE - In this mode, the solenoid will open and close each time the front panel 'Enable' button is pressed, or the 'Output ON' button on the GUI panel is clicked. The ON and OFF times are specified by calling the MGMSG_MOT_SET_SOL_CYCLEPARAMS message. 0x03 SOLENOID_AUTO - In this mode, the solenoid will open and close continuously after the front panel 'Enable' button is pressed, or the 'Output ON' button on the GUI panel is clicked. The ON and OFF times, and the number of cycles performed, are specified by calling the MGMSG_MOT_SET_SOL_CYCLEPARAMS message. 0x04 SOLENOID_TRIGGER - In Triggered mode, a rising edge on rear panel TRIG IN BNC input will start execution of the parameters programmed on the unit (On Time, Off Time, Num Cycles - see MGMSG_MOT_SET_SOL_CYCLEPARAMS message.). The unit must be primed (i.e. the ENABLE button pressed and the ENABLED LED lit) before the unit can respond to the external trigger.	char

Example: Set the control mode to 'Single'.

TX C0, 04, 01, 02, 50, 01

C0,04 SET_SOL_OPERATINGMODE
01, Channel 1
02, Set mode to 'Single'
50, destination Generic USB device
01, Source PC

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	04	Chan Ident	00	d	s

Example: Request the control mode

TX C1, 04, 01, 00, 50, 01

GET:
Response structure (6 bytes):

0	1	2	3	4	5
header only					
C2	04	Chan Ident	Mode	d	s

Example: Get the control mode currently set.

RX C2, 04, 01, 01, 01, 50

MGMSG_MOT_SET_SOL_CYCLEPARAMS 0x04C3
MGMSG_MOT_REQ_SOL_CYCLEPARAMS 0x04C4
MGMSG_MOT_GET_SOL_CYCLEPARAMS 0x04C5

Function: Used to set the cycle parameters that are applicable when the solenoid controller is operating in one of the non-manual modes.

SET:
Command structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C3	04	0E	00	d|	s	Chan Ident		OnTime			

12	13	14	15	16	17	18	19
Data							
OffTime				NumCycles			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
OnTime	The time which the solenoid is activated (100ms to 10,000s in 250 µs steps)	long
OffTime	The time which the solenoid is a de-activated (100ms to 10,000s in 250 µs steps)	long
NumCycles	If the unit is operating in 'Auto' mode, the number of Open/Close cycles to perform. (0 to 1,000,000) is specified in the NumCycles parameter. If set to '0' the unit cycles indefinitely. If the unit is not operating in 'Auto' mode, the NumCycles parameter is ignored.	long

Example: Set the cycle parameters parameters for chan 1 as follows:
OnTime: 1000ms
OffTime: 1000ms
NumCycles: 20

TX C3, 04, 0E, 00, D0, 01, 01, 00, A0, 0F, 00, 00, A0, 0F, 00, 00, 14, 00, 00, 00

Header: C3, 04, 0E, 00, D0, 01: Set Cycle Params, D0H (14) byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1 (always set to 1 for TSC001)
OnTime: *A0, 0F, 00, 00:* Set on time to 1000 ms (i.e. 4000 x 250 µs)
OffTime: *A0, 0F, 00, 00:* Set off time to 1000 ms (i.e. 4000 x 250 µs)
NumCycles: *14, 00, 00, 00:* Set number of cycles to 20

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
C4	04	Chan Ident	00	d	s

GET:

Response structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C5	04	0E	00	d|	s	Chan Ident		OnTime			

12	13	14	15	16	17	18	19
Data							
OffTime				NumCycles			

For structure see SET message above.

MGMSG_MOT_SET_SOL_INTERLOCKMODE 0x04C6
MGMSG_MOT_REQ_SOL_INTERLOCKMODE 0x04C7
MGMSG_MOT_GET_SOL_INTERLOCKMODE 0x04C8

Function: The solenoid unit features a hardware interlock jackplug. This message specifies whether the solenoid driver requires the hardware interlock to be fitted before it can operate.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C6	04	Chan Ident	Mode	d	s

Data Structure:

field	description	format
Chan Ident	The channel being addressed	char
Interlock Mode	The operating mode of the unit as a 4 bit integer: 0x01 SOLENOID_ENABLED – The hardware interlock must be fitted before the unit can be operated. 0x02 SOLENOID_DISABLED – The hardware interlock is not required.	char

Example: Set the interlock mode to 'Enabled'.

TX C6, 04, 01, 01, 50, 01

C0,06 SET_SOL_INTERLOCKMODE
01, Channel 1
01, Set mode to 'Enabled'
50, destination Generic USB device
01, Source PC

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C7	04	Chan Ident	00	d	s

Example: Request the control mode

TX C7, 04, 01, 00, 50, 01

GET:
Response structure (6 bytes):

0	1	2	3	4	5
header only					
C8	04	Chan Ident	Mode	d	s

Example: Get the control mode currently set.

RX C8, 04, 01, 01, 01, 50

MGMSG_MOT_SET_SOL_STATE 0x04CB
MGMSG_MOT_REQ_SOL_STATE 0x04CC
MGMSG_MOT_GET_SOL_STATE 0x04CD

Function: This message sets the output state of the solenoid unit, and overrides any existing settings. It can also be operated by the SET_CHANENABLESTATE message.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
CB	04	Chan Ident	State	d	s

Data Structure:

field	description	format
Chan Ident	The channel being addressed	char
Interlock Mode	The operating mode of the unit as a 4 bit integer: 0x01 SOLENOID_ON – The solenoid is active. 0x02 SOLENOID_OFF – The solenoid is de-activated.	char

Example: Set the solenoid to 'ON'.

TX CB, 04, 01, 01, 50, 01

CB,06 SET_SOL_STATE
01, Channel 1
01, Set state to 'ON'
50, destination Generic USB device
01, Source PC

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
CC	04	Chan Ident	00	d	s

Example: Request the control mode

TX CC, 04, 01, 00, 50, 01

GET:
Response structure (6 bytes):

0	1	2	3	4	5
header only					
CD	04	Chan Ident	Mode	d	s

Example: Get the control mode currently set.

RX CD, 04, 01, 01, 01, 50

Piezo Control Messages

Introduction

The 'Piezo' control messages provide the functionality required for a client application to control one or more of the Thorlabs series of piezo controller units. This range of controllers covers both open and closed loop piezo control in a variety of formats including compact Cube type controllers, benchtop units and 19" rack based modular drivers. **Note.** For ease of description, the TSG001 T-Cube Strain Gauge reader is considered here as a piezo controller. The list of controllers covered by the piezo messages includes:-

BPC001 – 1 Channel Benchtop Piezo Driver
BPC002 – 2 Channel Benchtop Piezo Driver
MPZ601 – 2 Channel Modular Piezo Driver
BPC101 – 1 Channel Benchtop Piezo Driver (2006 onwards)
BPC102 – 2 Channel Benchtop Piezo Driver (2006 onwards)
BPC103 – 3 Channel Benchtop Piezo Driver (2006 onwards)
BPC201 – 1 Channel Benchtop Piezo Driver (2007 onwards)
BPC202 – 2 Channel Benchtop Piezo Driver (2007 onwards)
BPC203 – 3 Channel Benchtop Piezo Driver (2007 onwards)
BPC301 – 1 Channel Benchtop Piezo Driver (2011 onwards)
BPC303 – 3 Channel Benchtop Piezo Driver (2012 onwards)
TPZ001 – 1 Channel T-Cube Piezo Driver
TSG001 – 1 Channel T-Cube Strain Gauge Reader

The piezo messages can be used to perform activities such as selecting output voltages, reading the strain gauge position feedback, operating open and closed loop modes and enabling force sensing mode. With a few exceptions, these messages are generic and apply equally to both single and dual channel units.

Where applicable, the target channel is identified in the lChanID parameter and on single channel units, this must be set to CHAN1_ID. On dual channel units, this can be set to CHAN1_ID, CHAN2_ID or CHANBOTH_ID as required.

For details on the operation of the Piezo Controller, and information on the principles of operation, refer to the handbook supplied with the unit.

MGMSG_PZ_SET_POSCONTROLMODE 0x0640
MGMSG_PZ_REQ_POSCONTROLMODE 0x0641
MGMSG_PZ_GET_POSCONTROLMODE 0x0642

Function: When in closed-loop mode, position is maintained by a feedback signal from the piezo actuator. This is only possible when using actuators equipped with position sensing.
This method sets the control loop status The Control Mode is specified in the Mode parameter as follows:

0x01 Open Loop (no feedback)
0x02 Closed Loop (feedback employed)
0x03 Open Loop Smooth
0x04 Closed Loop Smooth

If set to Open Loop Smooth or Closed Loop Smooth is selected, the feedback status is the same as above however the transition from open to closed loop (or vise versa) is achieved over a longer period in order to minimize voltage transients (spikes).

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
40	06	Chan Ident	Mode	d	s

Example: Set the control mode to closed loop.

TX 40, 06, 01, 02, 50, 01

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	06	Chan Ident	00	d	s

Example: Request the control mode

TX 41, 06, 01, 00, 50, 01

GET:

Response structure (6 bytes):

0	1	2	3	4	5
header only					
42	06	Chan Ident	Mode	d	s

Example: Get the control mode currently set.

RX 42, 06, 01, 02, 01, 50

MGMSG_PZ_SET_OUTPUTVOLTS 0x0643
MGMSG_PZ_REQ_OUTPUTVOLTS 0x0644
MGMSG_PZ_GET_OUTPUTVOLTS 0x0645

Function: Used to set the output voltage applied to the piezo actuator. This command is applicable only in Open Loop mode. If called when in Closed Loop mode it is ignored.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
43	06	04	00	d|	s	Chan Ident		Voltage	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Voltage	The output voltage applied to the piezo when operating in open loop mode. The voltage is set in the range -32768 to 32767 (-7FFF to 7FFF) to which corresponds to -100% to 100% of the maximum output voltage as set using the TPZ_IOSETTINGS command.	short

Example: Set the drive voltage to 70V

TX 43, 06, 04, 00, D0, 01, 01, 00, 77, 77,

Header: 43, 06, 04, 00, D0, 01: SetPZOutputVolts, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
Voltage: *77, 77:* corresponds to 70 V (30583) for a max 75 V unit

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
44	6	Chan Ident	00	d	s

GET:
Response structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
45	06	04	00	d|	s	Chan Ident		Voltage	

For structure see SET message above.

MGMSG_PZ_SET_OUTPUTPOS 0x0646
MGMSG_PZ_REQ_OUTPUTPOS 0x0647
MGMSG_PZ_GET_OUTPUTPOS 0x0648

Function: Used to set the output position of piezo actuator. This command is applicable only in Closed Loop mode. If called when in Open Loop mode it is ignored. The position of the actuator is relative to the datum set for the arrangement using the ZeroPosition method.

SET:

Command structure (10 bytes)

6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
46	06	04	00	d|	s	Chan Ident		PositionSW	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
PositionSW	The output position of the piezo relative to the zero position. The voltage is set in the range 0 to 32767 (0 to 7FFF) or 0 to 65535 (0 to FFFF) depending on the unit. This corresponds to 0 to 100% of the maximum piezo extension.	word

Example: Set the drive position to 15 µm (when total travel = 100 µm).

TX 46, 06, 04, 00, D0, 01, 01, 00, 66, 26,

Header: 46, 06, 04, 00, D0, 01: SetPZOutputPos, 04 byte data packet, Generic USB Device.

Chan Ident: 01, 00: Channel 1

PositionSW: *33, 13:* corresponds to 15 µm for a max 100 µm unit

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
47	06	Chan Ident	00	d	s

GET:

Response structure (10 bytes)

6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
48	06	04	00	d|	s	Chan Ident		PositionSW	

For structure see SET message above.

MGMSG_PZ_SET_INPUTVOLTSSRC 0x0652
MGMSG_PZ_REQ_INPUTVOLTSSRC 0x0653
MGMSG_PZ_GET_INPUTVOLTSSRC 0x0654

Function: Used to set the input source(s) which controls the output from the HV amplifier circuit (i.e. the drive to the piezo actuators).

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
52	06	04	00	d|	s	Chan Ident		VoltSrc	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
VoltSrc	The following values are entered into the VoltSrc parameter to select the various analog sources. *0x00 Software Only*: Unit responds only to software inputs and the HV amp output is that set using the SetVoltOutput method or via the GUI panel. *0x01 External Signal*: Unit sums the differential signal on the rear panel EXT IN (+) and EXT IN (-)connectors with the voltage set using the SetVoltOutput method *0x02 Potentiometer*: The HV amp output is controlled by a potentiometer input (either on the control panel, or connected to the rear panel User I/O D-type connector) summed with the voltage set using the SetVoltOutput method. The values can be 'bitwise ord' to sum the software source with either or both of the other source options.	word

Example: Set the input source to software and potentiometer.

TX 52, 06, 04, 00, D0, 01, 01, 00, 02, 00,

Header: 52, 06, 04, 00, D0, 01: SetVoltsSrc, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
VoltSrc: *02, 00:* selects software and potentiometer inputs

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
53	06	Chan Ident	00	d	s

GET:
Response structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
54	06	04	00	d|	s	Chan Ident		VoltsSrc	

For structure see SET message above.

MGMSG_PZ_SET_PICONSTS 0x0655
MGMSG_PZ_REQ_PICONSTS 0x0656
MGMSG_PZ_GET_PICONSTS 0x0657

Function: Used to set the proportional and integration feedback loop constants. These parameters determine the response characteristics when operating in closed loop mode.
The processors within the controller compare the required (demanded) position with the actual position to create an error, which is then passed through a digital PI-type filter. The filtered value is used to develop an output voltage to drive the piezo.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
55	06	06	00	d|	s	Chan Ident		PropConst		IntConst	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
PropConst	The value of the proportional term in the range 0 to 255.	word
IntConst	The value of the Integral term.in the range 0 to 255	word

Example: Set the PI constants for a TPZ001 unit.

TX 55, 06, 06, 00, D0, 01, 01, 00, 64, 00, 0F, 00

Header: 55, 06, 05, 00, D0, 01: SetPIConsts, 06 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
PropConst: *64, 00:* sets the proportional constant to 100
IntConst: *0F, 00:* sets the integral constant to15

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
56	06	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
57	06	06	00	d|	s	Chan Ident		PropConst		IntConst	

For structure see SET message above.

MGMSG_PZ_REQ_PZSTATUSBITS 0x065B
MGMSG_PZ_GET_PZSTATUSBITS 0x065C

Function: Returns a number of status flags pertaining to the operation of the piezo controller channel specified in the Chan Ident parameter. These flags are returned in a single 32 bit integer parameter and can provide additional useful status information for client application development. The individual bits (flags) of the 32 bit integer value are described in the following tables.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
5B	06	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
5C	06	06	00	d|	s	Chan Ident		StatusBits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
StatusBits	The status bits for the associated controller channel. The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword

TPZ001 controller

Hex Value	Bit Number	Description
0x00000001	1	Piezo actuator connected (1 - connected, 0 - not connected).
	2 to 4	For Future Use
0x00000010	5	Piezo channel has been zero'd (1 - zero'd, 0 not zero'd).
0x00000020	6	Piezo channel is zeroing (1 - zeroing, 0 - not zeroing).
0x00000040	7 to 8	For Future Use
0x00000100	9	Strain gauge feedback connected (1 - connected, 0 - not connected).
	10	For Future Use
0x00000400	11	Position control mode (1 - closed loop, 0 - open loop).
	12 to 20	For Future Use

BPC series controllers

Hex Value	Bit Number	Description
0x00000001	1	Piezo actuator connected (1 - connected, 0 - not connected).
	2 to 4	For Future Use
0x00000010	5	Piezo channel has been zero'd (1 - zero'd, 0 not zero'd).
0x00000020	6	Piezo channel is zeroing (1 - zeroing, 0 - not zeroing).
0x00000040	7 to 8	For Future Use
0x00000100	9	Strain gauge feedback connected (1 - connected, 0 - not connected).
	10	For Future Use
0x00000400	11	Position control mode (1 - closed loop, 0 - open loop).
	12	For Future Use
Note. Bits 13, 14 and 15 are applicable only to BPC30x series controllers.		
0x00001000	13	Hardware set to 75 V max output voltage
0x00002000	14	Hardware set to 100 V max output voltage
0x00004000	15	Hardware set to 150 V max output voltage
	16 to 20	For Future Use
Note. Bits 21 to 28 (Digital Input States) are only applicable if the associated digital input is fitted to your controller – see the relevant handbook for more details		
0x00100000	21	Digital input 1 state (1 - logic high, 0 - logic low).
0x00200000	22	Digital input 2 state (1 - logic high, 0 - logic low).
0x00400000	23	Digital input 3 state (1 - logic high, 0 - logic low).
0x00800000	24	Digital input 4 state (1 - logic high, 0 - logic low).
0x01000000	25	Digital input 5 state (1 - logic high, 0 - logic low).
0x02000000	26	Digital input 6 state (1 - logic high, 0 - logic low).
0x04000000	27	Digital input 7 state (1 - logic high, 0 - logic low).
0x08000000	28	Digital input 8 state (1 - logic high, 0 - logic low).
	29	For Future Use
0x20000000	30	Active (1 – indicates unit is active, 0 – not active)
0x40000000	31	For Future Use
0x80000000	32	Channel enabled (1 – enabled, 0- disabled)

MGMSG_PZ_GET_PZSTATUSUPDATE 0x0661

Function: This function is used in applications where spontaneous status messages (i.e. messages sent using the START_STATUSUPDATES command) must be avoided. There is no REQ message.
Status update messages contain information about the position and status of the controller (for example position and O/P voltage). The messages will be sent by the controller each time the function is called.

NOTE. This message is also returned by the NanoTrak control when it is operating in piezo mode.

GET:
Status update messages are received with the following format:-

Response structure (16 bytes)
6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
61	06	0A	00	d|	s	Chan Ident		OPVoltage		Position	

12	13	14	15
Status Bits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always P_MOD_CHAN1 (0x01) encoded as a 16-bit word (0x01 0x00)	word
OPVoltage	The output voltage applied to the piezo. The voltage is returned in the range -32768 to 32767 (-7FFF to 7FFF) which corresponds to -100% to 100% of the maximum output voltage as set using the TPZ_IOSETTINGS command.	short
Position	The position of the piezo. The position is returned in the range 0 to 32767 (0 to 7FFF) which corresponds to 0 to 100% of the maximum position.	short
Status Bits	The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword

TPZ001 controller

Hex Value	Bit Number	Description
0x00000001	1	Piezo actuator connected (1 - connected, 0 - not connected).
	2 to 4	For Future Use
0x00000010	5	Piezo channel has been zero'd (1 - zero'd, 0 not zero'd).
0x00000020	6	Piezo channel is zeroing (1 - zeroing, 0 - not zeroing).
0x00000040	7 to 8	For Future Use
0x00000100	9	Strain gauge feedback connected (1 - connected, 0 - not connected).
	10	For Future Use
0x00000400	11	Position control mode (1 - closed loop, 0 - open loop).
	12 to 20	For Future Use

BPC series controllers

Hex Value	Bit Number	Description
0x00000001	1	Piezo actuator connected (1 - connected, 0 - not connected).
	2 to 4	For Future Use
0x00000010	5	Piezo channel has been zero'd (1 - zero'd, 0 not zero'd).
0x00000020	6	Piezo channel is zeroing (1 - zeroing, 0 - not zeroing).
0x00000040	7 to 8	For Future Use
0x00000100	9	Strain gauge feedback connected (1 - connected, 0 - not connected).
	10	For Future Use
0x00000400	11	Position control mode (1 - closed loop, 0 - open loop).
	12 to 20	For Future Use
Note. Bits 21 to 28 (Digital Input States) are only applicable if the associated digital input is fitted to your controller – see the relevant handbook for more details		
0x00100000	21	Digital input 1 state (1 - logic high, 0 - logic low).
0x00200000	22	Digital input 2 state (1 - logic high, 0 - logic low).
0x00400000	23	Digital input 3 state (1 - logic high, 0 - logic low).
0x00800000	24	Digital input 4 state (1 - logic high, 0 - logic low).
0x01000000	25	Digital input 5 state (1 - logic high, 0 - logic low).
0x02000000	26	Digital input 6 state (1 - logic high, 0 - logic low).
0x04000000	27	Digital input 7 state (1 - logic high, 0 - logic low).
0x08000000	28	Digital input 8 state (1 - logic high, 0 - logic low).
	29	For Future Use
0x20000000	30	Active (1 – indicates unit is active, 0 – not active)
0x40000000	31	For Future Use
0x80000000	32	Channel enabled (1 – enabled, 0- disabled)

MGMSG_PZ_ACK_PZSTATUSUPDATE 0x0662

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called "server alive" must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5
header only					
62	06	00	00	d	s

TX 62, 06, 00, 00, 50, 01

MGMSG_PZ_SET_OUTPUTLUT 0x0700
MGMSG_PZ_REQ_OUTPUTLUT 0x0701
MGMSG_PZ_GET_OUTPUTLUT 0x0702

Function:

It is possible to use the controller in an arbitrary Waveform Generator Mode (WGM). Rather than the unit outputting an adjustable but static voltage or position, the WGM allows the user to define a voltage or position sequence to be output, either periodically or a fixed number of times, with a selectable interval between adjacent samples.

This waveform generation function is particularly useful for operations such as scanning over a particular area, or in any other application that requires a predefined movement sequence.

The waveform is stored as values in an array, with a maximum of 8000 samples per channel. The samples can have the meaning of voltage or position; if open loop operation is specified when the samples are output, then their meaning is voltage and vice versa, if the channel is set to closed loop operation, the samples are interpreted as position values. If the waveform to be output requires less than 8000 samples, it is sufficient to download the desired number of samples.

This function is used to load the LUT array with the required output waveform. The applicable channel is specified by the Chan Ident parameter

If only a sub set of the array is being used (as specified by the cyclelength parameter of the SetOutputLUTParams function), then only the first cyclelength values need to be set. In this manner, any arbitrary voltage waveform can be programmed into the LUT.

Note. The LUT values are output by the system at a maximum bandwidth of 7KHz, e.g.500 LUT values will take approximately 71 ms to be clocked out and the full 8000 LUT values will take approximately 1.14 secs.

SET:

Command structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
00	07	06	00	d|	s	Chan Ident		Index		Output	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Index	The position in the array of the value to be set (0 to 7999 for BPC, 0 to 512 for TPZ).	word
Output	The voltage value to be set. Values are set in the range -32768 to 32767 which corresponds to -100% to 100% of the max HV output (piezo drive voltage).	short

Example: Set output LUT value of 10V (for 150V piezo) in array position 2.

TX 00, 07, 06, 00, D0, 01, 01, 00, 02, 00, 88, 08

Header: 00, 07, 06, 00, D0, 01: SETOUTPUTLUT, 06 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
Index: *02, 00:* sets the value of array position 2
IntConst: *88, 08:* sets the value to 10V. (i.e. 150/10=15, 32767/15=2184, 2184=0888H)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	07	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
02	07	06	00	d|	s	Chan Ident		Index		Output	

For structure see SET message above.

MGMSG_PZ_SET_OUTPUTLUTPARAMS 0x0703
MGMSG_PZ_REQ_OUTPUTLUTPARAMS 0x0704
MGMSG_PZ_GET_OUTPUTLUTPARAMS 0x0705

Function: It is possible to use the controller in an arbitrary Waveform Generator Mode (WGM). Rather than the unit outputting an adjustable but static voltage or position, the WGM allows the user to define a voltage or position sequence to be output, either periodically or a fixed number of times, with a selectable interval between adjacent samples.
This waveform generation function is particularly useful for operations such as scanning over a particular area, or in any other application that requires a predefined movement sequence.
This function is used to set parameters which control the output of the LUT array.

SET:
Command structure (36 bytes)
6 byte header followed by 30 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
03	07	1E	00	d|	s	Chan Ident		Mode		CycleLength	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
NumCycles				DelayTime				PreCycleRest			

24	25	26	27	28	29	30	31	32	33	34	35
Data											
PostCycleRest				OPTrigStart		OPTrigWidth				TrigRepCycle	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Mode	Specifies the output mode of the LUT waveform as follows. Values can be 'bitwise or'd together as required. 0x01 - OUTPUTLUT_CONTINUOUS – The waveform is output continuously (i.e. until a StopOPLUT command is received). 0x02 - OUTPUTLUT_FIXED – A fixed number of waveform cycles are output (as specified in the NumCycles parameter). The following values are not applicable to the TPZ001 unit because it has no triggering functionality. 0x04 - OUTPUTLUT_OUTPUTTRIG – Enables Output Triggering. With OP Triggering enabled, the system can be configured to generate one or more hardware trigger pulses during a LUT (waveform) cycle output, as specified in the OPTrigStart parameter below.	word

	0x08 - OUTPUTLUT_INPUTTRIG –Enables Input Triggering. With INPUTTRIG set to 'False', the waveform generator will start as soon as it receives a StartOPLUT command. If however, INPUTTRIG is set to 'True, waveform generation will only start if a software command is received AND the trigger input is in its active state. In most cases, the trigger input will be used to synchronize waveform generation to an external event. In this case, the StartOPLUT command can be viewed as a command to "arm" the waveform generator and the waveform will start as soon as the input becomes active. The trigger input can be used to trigger a single channel or multiple channels. In this latter case ensure that input triggering is enabled on all the desired channels. Using the trigger input for multiple channels is particularly useful to synchronize all channels to the same event. 0x10 - OUTPUTLUT_OUTPUTTRIG_SENSE_HI – determines the voltage sense and edge of the O/P trigger. If this bit is set, the units responds to a rising edge (OV to 5V) trigger. If not set it responds to a falling edge (5V to 0V). 0x20 - OUTPUTLUT_INPUTTRIG_SENSE_HI – determines the voltage sense and edge of the I/P trigger. If this bit is set, the units responds to a rising edge (OV to 5V) trigger. If not set it responds to a falling edge (5V to 0V). 0x40 - OUTPUTLUT_LUTGATED – If set to '1' the trigger acts as a gate, if set to '0' acts as trigger. 0x80 - OUTPUTLUT_OUTPUTTRIG_REPEAT – This parameter is a flag which determines if repeated O/P triggering is enabled. If set, the output trigger is repeated by the interval set in the TrigRepeatCycle parameter. This is useful for multiple triggering during a single voltage O/P sweep.	
CycleLength	Specifies how many samples will be output in each cycle of the waveform. It can be set in the range 0 to 7999 for BPC and MPZ units, and 0 to 512 for TPZ units. It must be less than or equal to the total number of samples that were loaded. (To set the LUT array values for a particular channel, see the SetOutputLUT function).	word
NumCycles	Specifies the number of cycles (1 to 2147483648) to be output when the Mode parameter is set to fixed. If Mode is set to Continuous, the NumCycles parameter is ignored. In both cases, the waveform is not output until a StartOPLUT command is received.	long
DelayTime	Specifies the delay (in sample intervals) that the system waits after setting each LUT output value. By default, the time the system takes to output LUT values (sampling interval) is set at the maximum bandwidth possible, i.e. 7KHz (0.14 ms) for MPZ models, 1kHz(1.0 ms) for BPC and 4 kHz (0.25 ms) for TPZ units. The DelayTime parameter specifies the time interval between neighbouring samples, i.e. for how long the	long

	sample will remain at its present value. To increase the time between samples, set the DelayTime parameter to the required additional delay (1 to 2147483648 sample intervals). In this way, the user can stretch or shrink the waveform without affecting its overall shape.	
PreCycleRest	In some applications, during waveform generation the first and the last samples may need to be handled differently from the rest of the waveform. For example, in a positioning system it may be necessary to start the movement by staying at a certain position for a specified length of time, then perform a movement, then remain at the last position for another specified length of time. This is the purpose of PreCycleRest and PostCycleRest parameters, i.e. they specify the length of time that the first and last samples are output for, independently of the DelayTime parameter. The PreCycleRest parameter allows a delay time to be set before the system starts to clock out the LUT values. The delay can be set between 0 and 2147483648 sample intervals. The system then outputs the first value in the LUT until the PreCycleRest time has expired.	long
PostCycleRest	In a similar way to PreCycleRest, the PostCycleRest parameter specifies the delay imposed by the system after a LUT table has been output. The delay can be set between 0 and 2147483648 sample intervals. The system then outputs the last value in the cycle until the PostCycleRest time has expired.	long
OPTrigStart	Output triggering is enabled by setting the value 0x04 in the MODE parameter. With Op Triggering enabled, the system can be configured to generate one or more hardware trigger pulses during a LUT (waveform) cycle output. The OPTrigStart parameter specifies the LUT value (position in the LUT array) at which to initiate an output trigger. In this way, it is possible to synchronize an output trigger with the output of a particular voltage value. Values are set in the range 1 to 8000 but must also be less than the CycleLength parameter.	word
OPTrigWidth	sets the width of the output trigger. Values are entered in 1ms increments for BPC20x models.	long
TrigRepeatCycle	specifies the repeat interval between O/P triggers when OUTPUTTRIG_REPEAT is set to True. This parameter is specified in the number of LUT values between triggers (0 to 7999 for MPZ and BPC units, 0 to 512 for TPZ units). If this value is greater than the lCycleLength parameter (set in the SetOPLUTParams method) then by definition, a repeated trigger will not occur during a single waveform cycle output.	word

Example: Set output LUT parameters as follows:
Channel: 1
Mode: OUTPUTLUT continuous
CycleLength: 40
NumCycles: 20
DelayTime: 10
PreCycleRest: 10
PostCycleRest: 10
OPTrigStart: 0
OPTrigWidth: 1
TrigRepeatCycle: 100
TX 03, 07, 1E, 00, D0, 01, 01, 00, 01, 00, 28, 00, 14, 00, 00, 00, 0A, 00, 00, 00, 0A, 00, 00, 00, 0A, 00, 00, 00, 00, 00, 01, 00, 00, 00, 64, 00

Header: 03, 07, 06, 00, D0, 01: SETOUTPUTLUTPARAMS, 30 byte data packet, Generic USB Device.
Channel: 1
Mode: OUTPUTLUT continuous
CycleLength: 00, 28
NumCycles: 00, 00, 00, 14
DelayTime: 00, 00, 00, 0A
PreCycleRest: 00, 00, 00, 0A
PostCycleRest: 00, 00, 00, 0A
OPTrigStart: 00, 00
OPTrigWidth: 00, 00, 00, 01
TrigRepeatCycle: 00, 64

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
04	07	Chan Ident	00	d	s

GET:
Response structure (36 bytes)
6 byte header followed by 30 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
03	07	1E	00	d|	s	Chan Ident		Mode		CycleLength	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
NumCycles				DelayTime				PreCycleRest			

24	25	26	27	28	29	30	31	32	33	34	35
Data											
PostCycleRest				OPTrigStart		OPTrigWidth				TrigRepCycle	

For structure see SET message above.

MGMSG_PZ_START_LUTOUTPUT 0x0706

Function: This function is used to start the voltage waveform (LUT) outputs. Note. If the IPTrig flag of the SetOPLUTTrigParams function is set to false, this method initiates the waveform immediately. If the IPTrig flag is set to true, then this method 'arms' the system, in readiness for receipt of an input trigger.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
06	07	Chan Ident	00	d	s

MGMSG_PZ_STOP_LUTOUTPUT 0x0707

Function: This function is used to stop the voltage waveform (LUT) outputs.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
07	07	Chan Ident	00	d	s

MGMSG_PZ_SET_EEPROMPARAMS 0x07D0

Function: Used to save the parameter settings for the specified message. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
D0	07	04	00	d|	s	Chan Ident		MsgID	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
MsgID	The message ID of the message containing the parameters to be saved.	word

Example:

TX D0, 07, 04, 00, D0, 01, 01, 00, 03, 07,

Header: D0, 07, 04, 00, D0, 01: Set_EEPROMPARAMS, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
MsgID: Save parameters specified by message 0703 (SetOutputLUTParams).

MGMSG_PZ_SET_TPZ_DISPSETTINGS 0x07D1
MGMSG_PZ_REQ_TPZ_DISPSETTINGS 0x07D2
MGMSG_PZ_GET_TPZ_DISPSETTINGS 0x07D3

Function: Used to set the intensity of the LED display on the front of the TPZ unit.

SET:
Command structure (8 bytes)
6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
D1	07	02	00	d|	s	DispIntensity	

Data Structure:

field	description	format
DispIntensity	The intensity is set as a value from 0 (Off) to 255 (brightest).	word

Example: Set the input source to software and potentiometer.

TX D1, 07, 02, 00, D0, 01, 64, 00,

Header: D1, 07, 02, 00, D0, 01: Set_DISPSETTINGS, 02 byte data packet, Generic USB Device.
DispIntensity: 64, 00: Sets the display brightness to 100 (40%)

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
D2	07	01	00	d	s

Example: Request the display intensity

TX D2, 07, 01, 00, 50, 01

GET:
Command structure (8 bytes)
6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
D3	07	02	00	d|	s	DispIntensity	

See SET for data structure.

MGMSG_PZ_SET_TPZ_IOSETTINGS 0x07D4
MGMSG_PZ_REQ_TPZ_IOSETTINGS 0x07D5
MGMSG_PZ_GET_TPZ_IOSETTINGS 0x07D6

Function: This function is used to set various I/O settings as described below. The settings can be saved (persisted) to the EEPROM by calling the MGMSG_PZ_SET_EEPROMPARAMS function.

SET:
Command structure (16 bytes)
6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D4	07	0A	00	d|	s	Chan Ident		VoltageLimit		HubAnalogIP	

12	13	14	15
Data			
Future Use		Future Use	

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always P_MOD_CHAN1 (0x01) encoded as a 16-bit word (0x01 0x00)	word
VoltageLimit	The piezo actuator connected to the T-Cube has a specific maximum operating voltage range. This parameter sets the maximum output to the value specified as follows: 0x01 VOLTAGELIMIT_75V 75V limit 0x02 VOLTAGELIMIT_100V 100V limit 0x03 VOLTAGELIMIT_150V 150V limit	word
HubAnalogInput	When the T-Cube Piezo Driver unit is used in conjunction with the T-Cube Strain Gauge Reader (TSG001) on the T-Cube Controller Hub (TCH001), a feedback signal can be passed from the Strain Gauge Reader to the Piezo unit. High precision closed loop operation is then possible using our complete range of feedback-equipped piezo actuators. This parameter is used to select the way in which the feedback signal is routed to the Piezo unit as follows: 0x01 HUB_ANALOGUEIN_A the feedback signals run through all T-Cube bays. 0x02 HUB_ANALOGUEIN_B the feedback signals run between adjacent pairs of T-Cube bays (i.e. 1&2, 3&4, 5&6). This setting is useful when several pairs of Strain Gauge/Piezo Driver cubes are being used on the same hub. 0x03 EXTSIG_SMA the feedback signals run through the rear panel SMA connectors.	word

REQ:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
D5	07	01	00	d	s

GET:

Response structure (16 bytes)

6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D4	07	0A	00	d|	s	Chan Ident		VoltageLimit		HubAnalogIP	

12	13	14	15
Data			
Future Use		Future Us	

See SET message for structure.

MGMSG_PZ_SET_ZERO 0x0658

Function: This function applies a voltage of zero volts to the actuator associated with the channel specified by the lChanID parameter, and then reads the position. This reading is then taken to be the zero reference for all subsequent position readings. This routine is typically called during the initialisation or re-initialisation of the piezo arrangement.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
58	06	Chan Ident	00	d	s

MGMSG_PZ_REQ_MAXTRAVEL 0x0650
MGMSG_PZ_GET_MAXTRAVEL 0x0651

Function: In the case of actuators with built in position sensing, the Piezoelectric Control Unit can detect the range of travel of the actuator since this information is programmed in the electronic circuit inside the actuator. This function retrieves the maximum travel for the piezo actuator associated with the channel specified by the Chan Ident parameter, and returns a value (in microns) in the Travel parameter.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
50	06	01	00	d	s

Example: Request the max travel of the actuator associated with Channel 1, bay 2 (0x22)

TX 50, 06, 01, 00, 22, 01

GET:
Response structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
51	06	04	00	d|	s	Chan ID		Travel	

Data Structure:

field	description	format
Chan Ident	The channel being addressed.	word
Travel	The max travel of the actuator associated with the specified channel in the range 0 to 65535 (0 to FFFF). The travel is read from a calibration resistor and is returned in real world units, steps of 100nm.	

Example: Get the maximum travel.

TX 51, 06, 04, 00, 01, A2, 01, 00, C8, 00

Header: 51, 06, 04, 00, A2, 01: Get_Max Travel, 04 byte data packet, d=A2 (i.e. 22 ORed with 80), s=01 (PC).
Channel 1*: 01, 00*:
Travel: 00C8 (200 i.e. 20 µm)

MGMSG_PZ_SET_IOSETTINGS 0x0670
MGMSG_PZ_REQ_IOSETTINGS 0x0671
MGMSG_PZ_GET_IOSETTINGS 0x0672

Function: This function is used to set various I/O settings as described below. The settings can be saved (persisted) to the EEPROM by calling the MGMSG_PZ_SET_EEPROMPARAMS function.

SET:
Command structure (16 bytes)
6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
70	06	0A	00	d|	s	Chan Ident		AmpCurrentLim		AmpLPFilter	

12	13	14	15
Data			
FeedbackSig		BNCTrigORLVOut	

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always P_MOD_CHAN1 (0x01) encoded as a 16-bit word (0x01 0x00)	word
AmpCurrentLim	This parameter sets the maximum current output for the HV amplifier circuit as follows: CURRENTLIMIT_100MA 0x00 CURRENTLIMIT_250MA 0x01 CURRENTLIMIT_500MA 0x02	word
AmpLPFilter	This parameter sets the value of the hardware low pass filter applied to the HV amplifier output channels. It can be used to improve stability and reduce noise on the HV outputs. It is not channel specific and the Chan Ident parameter is ignored for this particular setting. Values are set as follows: OUTPUTLPFILTER_10HZ 0x00 OUTPUTLPFILTER_100HZ 0x01 OUTPUTLPFILTER_5KHZ 0x02 OUTPUTLPFILTER_NONE 0x03	word
FeedbackSig	For future use. The feedback signal type is locked at AC (strain gauge) and cannot be changed at this time.	
BNCTrigORLVOut	The Control IO BNC connectors on the rear panel are dual function. When set to Low Voltage (LV) outputs they mirror the voltage on the Piezo drive HV connectors and can be connected to an oscilloscope for monitoring purposes. When set to Trigger mode they provide the trigger input and output connections. This function is used to set the mode of the rear panel BNC connectors as follows: BNCMODE_TRIG Trigger Output 0x0000 BNCMODE_LVOUT LV Output 0xFFFF	

REQ:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	06	01	00	d	s

GET:

Response structure (16 bytes)

6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
72	06	0A	00	d|	s	Chan Ident		AmpCurrentLim		AmpLPFilter	

12	13	14	15
Data			
FeedbackSig		BNCTrigORLVOut	

See SET message for structure.

MGMSG_PZ_SET_OUTPUTMAXVOLTS 0x0680
MGMSG_PZ_REQ_OUTPUTMAXVOLTS 0x0681
MGMSG_PZ_GET_OUTPUTMAXVOLTS 0x0682

Function: The piezo actuator connected to the unit has a specific maximum operating voltage range: 75, 100 or 150 V. This function sets the maximum voltage for the piezo actuator associated with the specified channel.

SET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
80	06	06	00	d|	s	Chan Ident		Voltage		Flags	

Data Structure:

field	description	format
Chan Ident	The channel being addressed.	word
Voltage	This parameter sets the maximum output to the value specified, in 1/10 volt steps between 0 and 1500 (i.e. 0 to 150 V).	word
Flags	These flags tell the APT server certain parameters relating to the stage and controller combination. They are not relevant to the SET command and are only used in the GET_OUTPUTMAXVOLTS message	word

Note. When the SET_OUTPUTMAXVOLTS message is sent, a GET_OUTPUTMAXVOLTS message is automatically returned. This is to inform the server that the max output voltage has changed. Similarly, a GET_MAXTRAVEL message is also returned to tell the server the new max travel value.

Example: Set the max output voltage to 100V.

TX 80, 06, 06, 00, D0, 01, 01, 00, E8, 03, 08, 00

Header: 80, 06, 06, 00, D0, 01: Set_OutputMaxVolts, 06 byte data packet, d=D0 (i.e. 50 ORed with 80 i.e. generic USB device), s=01 (PC).
Channel 1*: 01, 00*:
Voltage: 03E8 (1000 i.e. 100V)
Flags: N/A

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
81	06	01	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
82	06	06	00	d|	s	Chan Ident		Voltage		Flags	

Data Structure:

field	description	format
Chan Ident	The channel being addressed.	word
Voltage	This parameter sets the maximum output to the value specified,either 750, 1000 or 1500 (i.e. 75, 100 or 150 V).	word
Flags	These flags tell the APT server certain parameters relating to the stage and controller combination. The meaning of the individual bits (flags) of the 16 bit integer value is as follows: 0x01 For Future Use 0x02 VOLTAGELIMIT_75V 75V limit 0x04 VOLTAGELIMIT_100V 100V limit 0x05 VOLTAGELIMIT_150V 150V limit	word

Example: Set the max output voltage to 100V.

TX 82, 06, 06, 00, D0, 01, 01, 00, E8, 03, 08, 00

Header: 80, 06, 06, 00, D0, 01: Get_MaxOutputVolts, 06 byte data packet, d=D0 (i.e. 50 ORed with 80 i.e. generic USB device), s=01 (PC).
Channel 1*: 01, 00*:
Voltage: 03E8 (1000 i.e. 100V)
Flags: 08, 00: 150 V max voltage

MGMSG_PZ_SET_TPZ_SLEWRATES 0x0683
MGMSG_PZ_REQ_TPZ_SLEWRATES 0x0684
MGMSG_PZ_GET_TPZ_SLEWRATES 0x0685

Function: When stages with delicate internal mechanisms are being driven, it is possible that sudden large changes to the drive voltage could cause damage. This function is used to limit the rate of change of the drive voltage. Different limits may be set for open loop and closed loop operating modes.
Note. The controller is loaded at the factory with default values suitable for driving legacy piezo stages. For newer generation stages, the slew rate is read in automatically. Consequently, these parameters should not require adjustment under normal operating conditions.

SET:
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
83	06	06	00	d|	s	Chan Ident		SlewOpen		SlewClosed	

Data Structure:

field	description	format
Chan Ident	The channel being addressed.	word
SlewOpen	This parameter sets the maximum slew rate when operating in open loop mode. Values are set in the range 0 to 32767, where 0 disables the limit, and 1 is the slowest rate. Values are calculated in V/ms as follows: Slew Rate = $\frac{\text{Value x Max Voltage (i.e. 75, 100 or 150 V)}}{19000}$	word
SlewClosed	This parameter sets the maximum slew rate when operating in closed loop mode. Values are calculated as above	word

Example: Set the open and closed max slew rates to 10V/ms for a 150V piezo.

TX 83, 06, 06, 00, D0, 01, 01, 00, F2, 04, F2, 04

Header: 80, 06, 06, 00, D0, 01: Set_SlewRates, 06 byte data packet, d=D0 (i.e. 50 ORed with 80 i.e. generic USB device), s=01 (PC).
Channel 1*: 01, 00*:
SlewOpen: F2, 04 (10V/ms i.e. 1266 x 150 / 19000)
SlewClosed: F2, 04

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
84	06	01	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
85	06	06	00	d|	s	Chan Ident		SlewOpen		SlewClosed	

See SET message for structure.

MGMSG_MOT_SET_PZSTAGEPARAMDEFAULTS 0x0686

Function: If the system has become unstable, possibly due to multiple changes to parameter values, this message can be sent to the controller in order to reset parameters to the default values stored in the EEPROM.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
86	06	Chan Ident	00	d	s

MGMSG_PZ_SET_LUTVALUETYPE: 0x0708

Function: It is possible to use the controller in an arbitrary Waveform Generator Mode (WGM). Rather than the unit outputting an adjustable but static voltage or position, the WGM allows the user to define a voltage or position sequence to be output, either periodically or a fixed number of times, with a selectable interval between adjacent samples. This waveform generation function is particularly useful for operations such as scanning over a particular area, or in any other application that requires a predefined movement sequence.

The waveform is stored as values in an array, with a maximum of 8000 samples per channel. The samples can have the meaning of voltage or position; if open loop operation is specified when the samples are output, then their meaning is voltage and vice versa, if the channel is set to closed loop operation, the samples are interpreted as position values. If the waveform to be output requires less than 8000 samples, it is sufficient to download the desired number of samples.

This message specifies whether the samples output from the LUT are voltage or position values.

TX structure (6 bytes):

0	1	2	3	4	5
header only					
08	07	LUTType	00	d	s

Data Structure:

field	description	format
LUTType	The LUT value type: 0x01 LUT values are Voltage 0x02 LUT values are position	char

Example: Set the LUT value type to Volts.

TX, 08,07,01,00,50,01

Notes on using this message.

This method must be called BEFORE the LUT values are downloaded.

The LUT values are scaled to either voltage or position while the LUT is being downloaded. If the value type needs to be changed during operation (e.g. the system was in open loop with volts type selected, but now needs to change to closed loop with position type) the message must be called again, and the LUT values downloaded again.

MGMSG_PZ_SET_TSG_IOSETTINGS 0x07DA
MGMSG_PZ_REQ_TSG_IOSETTINGS 0x07DB
MGMSG_PZ_GET_TSG_IOSETTINGS 0x07DC

Function: When the T-Cube Strain Gauge Reader is used in conjunction with the T-Cube Piezo Driver unit (TPZ001) on the T-Cube Controller Hub (TCH001), a feedback signal can be passed from the Strain Gauge Reader to the Piezo unit. High precision closed loop operation is then possible using our complete range of feedback-equipped piezo actuators.
This method is used to select the way in which the feedback signal is routed back to the Piezo unit.

SET:
Command structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
DA	07	0E	00	d|	s	Chan Ident		HubAnalogOP		DisplayMode	

12	13	14	15	16	17	18	19
Data							
ForceCalib				Future Use		Future Use	

Data Structure:

field	description	format
Chan Ident	The channel being addressed is always (e.g. 0x01) encoded as a 16-bit word (0x01 0x00)	word
HubAnalogueOutput	When the T-Cube Strain Gauge Reader is used in conjunction with the T-Cube Piezo Driver unit (TPZ001) on the T-Cube Controller Hub (TCH001), a feedback signal can be passed from the Strain Gauge Reader to the Piezo unit. High precision closed loop operation is then possible using our complete range of feedback-equipped piezo actuators. This message is used to select the way in which the feedback signal is routed back to the Piezo unit If set to 0x01 HUB_ANALOGUEOUT_1, the feedback signals run through all T-Cube bays. If set to 0x02 HUB_ANALOGUEOUT_2,the feedback signals run between adjacent pairs of T-Cube bays (i.e. 1&2, 3&4, 5&6). This setting is useful when several pairs of Strain Gauge/Piezo Driver cubes are being used on the same hub.	word

Display Mode	The LED display window on the front of the unit (and the display on the GUI panel) can be set to display the strain gauge signal as a position (microns), a voltage (Volts) or as a force (Newtons). This parameter sets the display mode as follows If set to 0x01 DISPUNITS_POSITION, the display shows the strain gauge signal as a position in microns. If set to 0x02 DISPUNITS_VOLTAGE, the display shows the strain gauge signal as a voltage. If set to 0x03 DISPUNITS_FORCE, the display shows the strain gauge signal as a force	word
ForceCalib	If using a force sensor with the TSG001 unit, the Force Sensor has a specific maximum operating force. This parameter sets the force calibration factor in steps of 0.001 N between 1 and 1000. The default setting for this parameter is H7530 (30,000), to be compatible with our FSC102 force sensor, which is specified to read forces up to 30N.	word

Example: Set the IO settings as follows.

TX DA, 07, 0E, 00, D0, 01, 01, 00, 01, 00, 02, 00, 30, 75, 00, 00, 00, 00, 00, 00

Header: DA, 07, 0E, 00, D0, 01: Set_TSG_IOSettings, 14 byte data packet, d=D0 (i.e. 50 ORed with 80 i.e. generic USB device), s=01 (PC).
Channel 1*: 01, 00*:
HubAnalogueOutput: 01, 00 (Hub Analogue Output A)
Display Mode: 02, 00 (Display Voltage
Force Calibration: 30, 75 30,000 x 0.001 = 30 N

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
DB	07	01	00	d	s

GET:
Response structure (16 bytes)
6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
DC	07	0E	00	d|	s	Chan Ident		HubAnalogOP		DisplayMode	

12	13	14	15	16	17	18	19
Data							
ForceCalib				Future Use		Future Use	

See SET message for structure.

MGMSG_PZ_REQ_TSG_READING 0x07DD
MGMSG_PZ_GET_TSG_READING 0x07DE

Function: This message returns the current reading of the strain gauge The units applicable are dependent on the current operating mode (set using the DisplayMode parameter of the SET_TSG_IOSETTINGS message.

REQUEST:

Command structure (6 bytes)

0	1	2	3	4	5
header only					
DD	07	Chan Ident	00	d	s

GET:

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
DE	07	06	00	d|	s	Chan Ident		Reading		Smoothed	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
Reading	The current reading of the strain gauge unit. If the unit is operating in Position mode, then the returned value is a position in microns. If the unit is in Voltage mode, then the returned reading is a Voltage. If the controller is in 'Force Sensing Mode' then the parameter returns a force value in Newtons. Values are returned in the range -32767 to 32768, which corresponds to -100% to 100% of the maximum voltage, travel or force. The returned data values are sampled at 500Hz. This is particularly useful in touch probe or force sensing applications where rapid polling of the force reading is important. Display mode and Max Force are described in the MGMSG_PZ_GET_TSG_IOSETTINGS message. Max Travel is described in the MGMSG_PZ_GET_MAXTRAVEL message.	short
Smoothed		word

Example: Get the readings for channel 1.

RX DE, 07, 06, 00, 81, 50, 01, 00, 52, 00, 50, 00,

Header: DE, 07, 06, 00, 81, 50: Get_TSG_Readings, 6 byte data packet, d=D0 (i.e. 01 ORed with 80 i.e. PC), s=50 (Generic USB device).
Channel 1: 01, 00
Reading: 52, 00 (i.e. 82)
Smoothed: 52, 00

NanoTrak Control Messages

Introduction

The 'NanoTrak' ActiveX Control provides the functionality required for a client application to control one or more NanoTrak auto-alignment controller products. The NanoTrak system comes in benchtop (BNT001), T-Cube (TNA001) and 19" rack modular (MNA601) formats, all of which are covered by the NanoTrak ActiveX Control.
The messages of the NanoTraks object can then be used to perform activities such as latching/unlatching, reading power levels, obtaining/setting circle size and position and determining if 'NanoTracking' is currently taking place.
For details on the use of the NanoTrak controller, and information on the principles of operation, refer to the NanoTrak Operating Guide.

NOTE. The NanoTrak can be set to operate as a piezo amplifier. When operated in this mode, some piezo control messages may also be sent or returned.

MGMSG_PZ_SET_NTMODE 0x0603

Function: The NanoTrak unit can be used as a standard piezo amplifier, or as a NanoTrak Auto-alignment unit. This message sets the unit to piezo operation, or one of the NanoTrak operating modes as described below. The mode of operation is set in byte 2 of the message as follows:

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
03	06	State	00	d	s

Data Structure:

field	description	format
State	01 Sets the unit to Piezo mode. **Note**. The hardware unit must be rebooted before changes to operating mode can take effect. **Note**. When the HW operating mode of a NanoTrak unit has been changed to Piezo operation, then the Piezo ActiveX control must be used to communicate with the unit. Use the same serial number as used on the NanoTrak control in order to establish communication with the unit. 02 Latch mode. In this mode, scanning is disabled and the piezo drives are held at the present position. 03 Track mode. In this mode, the NanoTrak detects any drop in signal strength resulting from misalignment of the input and output devices, and makes vertical and horizontal positional adjustments to maintain the maximum throughput. 04 Horizontal Track mode. In this mode, the NanoTrak detects any drop in signal strength resulting from misalignment of the input and output devices, and makes horizontal positional adjustments to maintain the maximum throughput. 05 Vertical Track mode. In this mode, the NanoTrak detects any drop in signal strength resulting from misalignment of the input and output devices, and makes vertical positional adjustments to maintain the maximum throughput.	short

Example: Set the tracking mode to Latch

TX 03, 06, 02, 00, 50, 01,

MGMSG_PZ_REQ_NTMODE 0x0604
MGMSG_PZ_GET_NTMODE 0x0605

Function: The NanoTrak unit can be used as a standard piezo amplifier, or as a NanoTrak Auto-alignment unit. This message gets the present operating mode of the unit as described below. The mode of operation is returned in byte 2 of the message as follows:

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
04	06	00	00	d	s

GET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
05	06	State	Mode	d	s

Data Structure:

field	description	format
State	The Tracking state 01 NanoTracking off. The unit is in Piezo mode. 02 Latch mode. In this mode, scanning is disabled and the piezo drives are held at the present position. 03 Tracking ON No Signal. In this mode, the NanoTrak is tracking but the signal power is below the threshold power set by the user in the Set_NTTrackThreshold message. 04 Tracking ON, Signal Attained. In this mode, the threshold power has been detected and the NanoTrak is tracking normally.	short
Mode	The Tracking Mode. 01 Dual axis (X and Y) tracking. 02 Horizontal (X) axis tracking. 03 Vertical (Y) axis tracking.	

Example

TX 05, 06, 04, 01, 01, 50
Mode is Tracking Signal (0x04) and dual axis (Both X and Y tracking) (0x01)

MGMSG_PZ_SET_NTTRACKTHRESHOLD 0x0606
MGMSG_PZ_REQ_NTTRACKTHRESHOLD 0x0607
MGMSG_PZ_GET_NTTRACKTHRESHOLD 0x0608

Function: This message sets the tracking threshold of the NanoTrak. The value is set in Amps, and is dependent upon the application. Typically, the value is set to lie above the 'noise floor' of the particular physical arrangement. When the input signal level exceeds this value, the tracking LED is lit on the GUI panel. Note there is no guarantee that tracking is taking place if this threshold value is set inappropriately. E.g. if the tracking threshold is set to below the noise floor, then the GUI will show a lit tracking LED even though no tracking is taking place.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
06	06	04	00	d|	s	ThresholdAbsReading			

Data Structure:

field	description	format
ThresholdAbsReading	The tracking threshold of the NanoTrak. This is the absolute TIA reading (PIN current). The value set in Amps as a 4-byte floating point number in the range 1 x 10^{-9} to 1 x 10^{-3} (i.e. 1 nA to 1 mA).	Float

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
07	06	00	00	d	s

GET:
Command structure (10 bytes):

0	1	2	3	4	5	6	7	8	9
header						*Data*			
08	06	04	00	d|	s	ThresholdAbsReading			

See SET for structure.

MGMSG_PZ_SET_NTCIRCHOMEPOS 0x0609
MGMSG_PZ_REQ_NTCIRCHOMEPOS 0x0610
MGMSG_PZ_GET_NTCIRCHOMEPOS 0x0611

Function: This message sets the circle home position to the horizontal and vertical coordinates specified in the CircHomePosA and CircHomePosB parameters respectively.
The home position is used when the Move_NTCircToHomePos message is called

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
06	06	04	00	d|	s	CircHomePosA		CircHomePosB	

Data Structure:

field	description	format
CircHomePosA	The horizontal co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word
CircHomePosB	The vertical co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word

Example: Set the NanoTrak circle home position to be screen centre.

TX 09 06, 04, 00, D0, 01, FF, 7F, FF, 7F,

Header: 09, 06, 04, 00, D0, 01: Set_NTCircHomePos, 04 byte data packet, Generic USB Device.
CircHomePosA: FF, 7F: Sets the horizontal co-ordinate to 32767 (i.e. 50% of O/P Voltage or 5 NT units)
CircHomePosB: FF, 7F: Sets the vertical co-ordinate to 32767 (i.e. 50% of O/P Voltage or 5 NT units)

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
10	06	00	00	d	s

GET:
Command structure (10 bytes):

0	1	2	3	4	5	6	7	8	9
header						*Data*			
11	06	04	00	d|	s	CircHomePosA		CircHomePosB	

See SET for structure.

MGMSG_PZ_MOVE_NTCIRCTOHOMEPOS 0x0612

Function: This message moves the circle to the 'Home' position as set by the Set_NTCircHomePos message

SET:
Command structure (6 bytes)

0	1	2	3	4	5
header					
12	06	00	00	d	s

Example: Move the NanoTrak circle to the home position.

TX, 12, 06, 00, 00, 50, 01,

MGMSG_PZ_REQ_NTCIRCCENTREPOS 0x0613
MGMSG_PZ_GET_NTCIRCCENTREPOS 0x0614

Function: This message obtains the current horizontal and vertical position of the circle, together with other signal and range parameters relating to NanoTrak operation as described below.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
13	06	01	00	d	s

GET:

Command structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
06	06	0E	00	d|	s	CircPosA		CircPosB	

10	11	12	13	14	15	16	17	18	19
Data									
AbsReading				RelReading		Range		UnderOverRead	

Data Structure:

field	description	format
CircPosA	The horizontal co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word
CircPosB	The vertical co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word
AbsReading	The absolute TIA (PIN) current or BNC voltage value at the current position. The value is returned as a 4 byte floating point value in the range 1 x 10^{-9} to 1 x 10^{-3} (i.e. 1 nA to 1 mA or 1 to 10 V). The input source, TIA or BNC is set in the Set_NTFeedbackSRC message.	float
RelReading	The relative signal strength at the current position, in the range 0 to 32767 (i.e. 0 to 100% of the range currently selected). This value matches the length of the input signal bargraph on the GUI panel. (e.g. if the 3 µA range is currently selected, then a RelReading value of 16384 (50%) equates to 1.5 µA).	word
Range	The NanoTrak unit is equipped with an internal trans-impedance amplifier (TIS) circuit (and associated range/power level displays and control buttons in the GUI). This amplifier operates when an external input signal is connected to the Optical/PIN connector on the rear panel. There are 14 range settings (1 - 14) that can be used to select the best range to measure the input signal	word

	(displayed on the GUI panel relative input signal bar and display). **Note**. Range 1 and 2 (3 nA and 10 nA) are not applicable to TNA001 T-Cube units. This parameter returns the input signal range currently selected, defined as follows: Range 1 3 nA 0x03 Range 2 10 nA 0x04 Range 3 30 nA 0x05 Range 4 100 nA 0x06 Range 5 300 nA 0x07 Range 6 1 µA 0x08 Range 7 3 µA 0x09 Range 8 10 µA 0x0A Range 9 30 µA 0x0B Range 10 100 µA 0x0C Range 11 300 µA 0x0D Range 12 1 mA 0x0E Range 13 3 mA 0x0F Range 14 10 mA 0x10	
UnderOverRead	This parameter returns a value that identifies whether the unit is under reading or over reading the input signal as follows: 0x01 power signal is within current TIA range 0x02 power signal is under-reading for current TIA 0x03 power signal is over-reading for current TIA range e.g. if a user specified range of 3 µA is currently applied, this parameter returns '0x03' (Over read)' for input signals greater than 3 µA.	word

Example:

RX 14, 06, 0E, 00, 81, 50, 73, 63, 2A, F3, 00, 00, 00, 00, 00, 00, 05, 00, 02, 00

Header: 14, 06, 0E, 00, 81, 50: Get_NTCircCentrePos, 14 byte data packet, Generic USB Device.

CircPosA;	0x6373	25459 (25459/65535 = 39%)
CircPosB;	0xF32A	62250 (62250/65535 = 95%)
AbsReading;	0x00000000	0V
RelReading;	0x0000	0V
Range;	0x0005	Range 3 (i.e. 30 nA)
UnderOverRead;	0x0002	Signal is under reading for range.

MGMSG_PZ_SET_NTCIRCPARAMS 0x0618
MGMSG_PZ_REQ_NTCIRCPARAMS 0x0619
MGMSG_PZ_GET_NTCIRCPARAMS 0x0620

Function: This message obtains sets various scanning circle parameters as described below.

SET:
Command structure (18 bytes)
6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
18	06	0C	00	d|	s	CircDiaMode		CircDiaSW	

10	11	12	13	14	15	16	17
Data							
CircOscFreq		AbsPwrMinCircDia		AbsPwrMaxCircDia		AbsPwrAdjustType	

Data Structure:

field	description	format
CircDiaMode	This parameter allows the different modes of circle diameter adjustment to be enabled and disabled as follows: 0x01 NTCIRCDIA_SW the circle diameter remains at the value set using the CircDiaSW parameter below. 0x02 NTCIRCDIA_ABSPWR the circle diameter is set by absolute power input value (depending on adjustment algorithm selected in the AbsPwrAdjustType parameter - see below) 0x03 NTCIRCDIA_LUT the circle diameter is adjusted automatically, using a table of TIA range dependent values (set using the SetCircDiaLUT message.	word
CircDiaSW	This parameter sets the NT circle diameter if NTCIRCDIA_SW (0x01) is selected in the CircDiaMode parameter above. The diameter is set in the range 0 to 65535, which relates to 0% to 100% output voltage –(i.e. 0 to 10 NT units).	word
CircOscFreq	This parameter contains the number of samples taken in one revolution of the scanning circle and is used to set the scanning frequency of the NanoTrak circle. The circle scanning frequency lies in the range 17.5 Hz to 87.5 Hz for TNA001 and 20 Hz to 190 Hz for the BNT001. The factory default setting for the scanning frequency is 43.75Hz. This means that a stage driven by the NanoTrak makes 43.75 circular movements per second. Different frequency settings allow more than one NanoTrak to be used in the same alignment scenario. The scanning frequency is derived from the NanoTrak sampling frequency of 7000 Hz and the CircOscFreq	word

	value which is calculated as follows: CircOscFreq = 7000 / scanning frequency **Note**. The CircOscFreq parameter must be entered as a multiple of '4'.	
AbsPwrMinCircDia	The minimum circle diameter. Applicable only if the CircDiaMode parameter above is set to NTCIRCDIA_ABSPWR (0x02). The diameter is set in the range 0 to 32767, which relates to 0% to 50% output voltage –(i.e. 0 to 5 NT units).	word
AbsPwrMaxCircDia	The maximum circle diameter. Applicable only if the CircDiaMode parameter above is set to NTCIRCDIA_ABSPWR (0x02). The diameter is set in the range 0 to 32767, which relates to 0% to 50% output voltage –(i.e. 0 to 5 NT units).	word
AbsPwrAdjustType	This parameter sets the adjustment type and is applicable only if CircDiaMode parameter above is set to NTCIRCDIA_ABSPWR (0x02). 0x01 NTABSPWRCIRCADJUST_LIN inverse linear adjustment 0x02 NTABSPWRCIRCADJUST_LOG inverse log adjustment 0x03 NTABSPWRCIRCADJUST_X2 inverse square adjustment 0x04 NTABSPWRCIRCADJUST_X3 inverse cube adjustment	word

Example

TX 18, 06, 0C, 00, D0, 01, 01, 00, 9A, 19, A0, 00, CC, 0C, 99, 19, 01, 00

Header: 18, 06, 0C, 00, D0, 01: Set_NTCircParams, 12 byte data packet, Generic USB Device.
CircDiaMode; 0x0001 Software setting mode
CircDiaSW; 0x199A 6554 6554/65535 = 10% of O/P voltage (1 NT unit)
CircOscFreq; 0x00A0 160 7000/160 = 43.75 Hz
AbsPwrMinCircDia; 0x0CCC 3276 5% or 0.5 NT units
AbsPwrMaxCircDia; 0x1999 6553 10% or 1 NT unit
AbsPwrAdjustType; 0x0001 inverse linear adjust type.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
19	06	01	00	d	s

GET:

Command structure (18 bytes)

6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
20	06	0C	00	d|	s	CircDiaMode		CircDiaSW	

10	11	12	13	14	15	16	17
Data							
CircOscFreq		AbsPwrMinCircDia		AbsPwrMaxCircDia		AbsPwrAdjustType	

See SET for structure

MGMSG_PZ_SET_NTCIRCDIA 0x061A

Function: This message sets the NT circle diameter and can be used as an alternative to the Set_NTCircParams message described previously. The diameter is set in the range 0 to 65535, which relates to 0% to 100% output voltage (i.e. 0 to 10 NT units).

SET:

Command structure (6 bytes)

0	1	2	3	4	5
header					
1A	06	CircDia	00	d	s

Example: Set the NanoTrak circle diameter to 10% (i.e. 1 NT unit).

TX, 1A, 06, 99, 19, 50, 01,

H1999 = 6553 6553/65535 = 10%

MGMSG_PZ_SET_NTCIRCDIALUT 0x0621
MGMSG_PZ_REQ_NTCIRCDIALUT 0x0622
MGMSG_PZ_GET_NTCIRCDIALUT 0x0623

Function: This message enables a look up table (LUT) of circle diameter values to be specified as a function of input range. When automatic LUT diameter adjustment mode is enabled (using the CircDiaMode parameter in the Set_NTCircParams message), the system uses values in this LUT to modify circle diameter in relation to the input range currently selected.
This LUT diameter adjustment mode allows appropriate circle diameters to be applied on an application specific basis.

SET:
Command structure (38 bytes)
6 byte header followed by 32 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
21	06	20	00	d|	s	LUTVal		LUTVal		LUTVal	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal	

24	25	26	27	28	29	30	31	32	33	34	35	36	36
Data													
LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal	

Data Structure:

field	description	format
CircDias	This parameter contains the circle diameter values for each range of the NanoTrak. The values are entered in range order in a 32 byte array. **Note**. On the BNT001 unit bytes 1 through 4 of the array are ignored and Range 1 starts in Byte 5. **Note**. On the TNA001 unit bytes 1 through 8 of the array are ignored and Range 1 starts in Byte 9. The diameters are entered in the range 0 to 65535 (0 to FFFF), which relates to 0% to 100% output voltage (i.e. 0 to 10 NT units).	array

Example: Enter the NanoTrak cirle diameter LUT values.

TX 21, 06, 20, 00, D0, 01, 00, 00, 00, 00, 34, 33, A4, 30, 16, 2E, 86, 2B, F6, 28, 68, 26, D8, 23, 48, 21, B8, 1E, 2A, 1C, 9A, 19, 0A, 17, 7C, 14, EC, 11

Header: 21, 06, 20, 00, D0, 01: Set_NTCircHomePos, 32 byte data packet, Generic USB Device.
CircDias: The various range related LUT values entered in range order)

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
22	06	00	00	d	s

GET:

Command structure (38 bytes)

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
23	06	20	00	d|	s	Not Used		Not Used		LUTVal	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal	

24	25	26	27	28	29	30	31	32	33	34	35	36	36
Data													
LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal		LUTVal	

See SET for structure.

MGMSG_PZ_SET_NTPHASECOMPPARAMS 0x0626
MGMSG_PZ_REQ_NTPHASECOMPPARAMS 0x0627
MGMSG_PZ_GET_NTPHASECOMPPARAMS 0x0628

Function: The feedback loop scenario in a typical NanoTrak application can involve the operation of various electronic and electromechanical components (e.g. power meters and piezo actuators) that could introduce phase shifts around the loop and thereby affect tracking efficiency and stability. These phase shifts can be cancelled by setting the 'Phase Compensation' factors.
This message sets the phase compensation for the horizontal and vertical components of the circle path in the range 0 to 360 degrees. Typically both phase offsets will be set the same, although some electromechanical systems may exhibit different phase lags in the different components of travel and so require different values.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
26	06	06	00	d|	s	PhaseCompMode		PhaseCompASW		PhaseCompBSW	

Data Structure:

field	description	format
PhaseCompMode	Currently, the phase compensation mode is not adjustable, and is locked at manual (software) adjustment.	word
PhaseCompASW	The horizontal axis phase compensation value, entered in real world units and calculated as follows:- value = (phase angle [degrees] / 360) * CircOscFreq See the PZ_SET_NTCIRCPARAMS message for details on the CircOscFreq parameter **Note**. Negative phase values must be made positive by subtraction from 360 before the calculation is made.	short
PhaseCompBSW	The vertical axis phase compensation value, entered in real world units and calculated as follows:- value = (phase angle [degrees] / 360) * CircOscFreq See the PZ_SET_NTCIRCPARAMS message for details on the CircOscFreq parameter **Note**. Negative phase values must be made positive by subtraction from 360 before the calculation is made.	short

Example: Set the NanoTrak circle home position to be screen centre.

TX 26, 06, 06, 00, D0, 01, 02, 00, 93, 00, 93, 00

Header: 26, 06, 06, 00, D0, 01: Set_NTPhaseCompParams, 06 byte data packet, Generic USB Device.

PhaseCompMode; 0x0002 Locked at Software Adjustment mode.
PhaseCompASW; 0x0093 147

Therefore, for circle scanning freq of 44, Phase Angle = 147/(7000/44) x 360 = -30°

PhaseCompBSW 0x0093

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
27	06	00	00	d	s

GET:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
28	06	06	00	d|	s	PhaseCompMode		PhaseCompASW		PhaseCompBSW	

See SET for structure.

MGMSG_PZ_SET_NTTIARANGEPARAMS 0x0630
MGMSG_PZ_REQ_NTTIARANGEPARAMS 0x0631
MGMSG_PZ_GET_NTTIARANGEPARAMS 0x0632

Function: This message is used to select manual (software) or auto ranging, and to modify the ranging characteristics in each case.

SET:

Command structure (18 bytes)

6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
30	06	0C	00	d|	s	RangeMode		RangeUpLimit	

10	11	12	13	14	15	16	17
RangeDownLimit		SettleSamples		RangeChangeType		RangeSW	

Data Structure:

field	description	format
RangeMode	This parameter specifies the ranging mode of the unit as follows: 0x01 RANGE_AUTO change to Auto ranging at the range currently selected 0x02 RANGE_SW change to manual ranging at the range currently selected 0x03 RANGE_SWSET change to manual ranging at the range set in the SetRange method (or the 'Settings' panel) 0x04 RANGE_AUTOSET change to Auto ranging at the range set in the RangeSW parameter below.	word
RangeUpLimit	Only applicable if Auto Ranging is selected in the RangeMode parameter above. This parameter sets the upper range limit as a percentage of the present range, 0 to 1000 = 0 to 100%. When autoranging, the NanoTrak unit adjusts continually the TIA range as appropriate for the input signal level. When the relative signal rises above the limit specified in this parameter, the unit increments the range to the next higher setting. The relative signal is displayed on the NanoTrak GUI panel by a green horizontal bar.	short
RangeDownLimit	Only applicable if Auto Ranging is selected in the RangeMode parameter above. This parameter sets the lower range limit as a percentage of the present range, 0 to 1000 = 0 to 100%. Similarly to RangeUpLimit, when the relative signal on a particular range drifts below the limit set in this parameter, the NanoTrak unit decrements the range to the next lower setting.	short

	The relative signal is displayed on the NanoTrak GUI panel by a green horizontal bar.	
SettleSamples	Only applicable if Auto Ranging is selected in the RangeMode parameter above. This parameter determines the amount of averaging applied to the signal before autoranging takes place. Higher SettleSamples values improve the signal to noise ratio when dealing with noisy feedback signals. However, higher SettleSamples values also slow down the autoranging response. In a particular application, the SettleSamples value should be adjusted to obtain the best autoranging response combined with a noise free signal. Values are set in real world units, from ‘2’ to ‘32’, with a default setting value of ‘4’.	short
RangeChangeType	Only applicable if Auto Ranging is selected in the RangeMode parameter above. This parameter specifies how range changes are implemented by the system. `0x01` `AUTORANGE_ALL` the unit visits all ranges when ranging between two input signal levels. `0x02` `AUTORANGE_ODD` only the odd numbered ranges between the two input signals levels will be visited. `0x03` `AUTORANGE_EVEN` only the even numbered ranges between the two input signals levels will be visited. These latter two modes are useful when large rapid input signal fluctuations are anticipated, because the number of ranges visited is halved to give a more rapid response.	word
RangeSW	Only applicable if Manual (SW) Ranging is selected in the RangeMode parameter above. The NanoTrak unit is equipped with an internal trans-impedance amplifier (TIA) circuit (and associated range/power level displays and control buttons in the GUI). This amplifier operates when an external input signal is connected to the Optical/PIN connector on the rear panel. There are 14 range settings (1 - 14) that can be used to select the best range to measure the input signal (displayed on the GUI panel relative input signal bar and display). **Note**. Range 1 and 2 (3 nA and 10 nA) are not applicable to TNA001 T-Cube units. This parameter returns the input signal range currently selected, defined as follows: Range 1 3 nA 0x03 Range 2 10 nA 0x04 Range 3 30 nA 0x05 Range 4 100 nA 0x06 Range 5 300 nA 0x07	word

	Range 6	1 µA	0x08	
	Range 7	3 µA	0x09	
	Range 8	10 µA	0x0A	
	Range 9	30 µA	0x0B	
	Range 10	100 µA	0x0C	
	Range 11	300 µA	0x0D	
	Range 12	1 mA	0x0E	
	Range 13	3 mA	0x0F	
	Range 14	10 mA	0x10	

Example

TX 30, 06, 0C, 00, D0, 01, 01, 00, 52, 03, 96, 00, 04, 00, 01, 00, 05, 00

Header: 30, 06, 0C, 00, D0, 01: Set_NTTIARangeParams, 12 byte data packet, Generic USB Device.

wRangeMode;	0x0001	Auto Ranging mode
sRangeUpLimit;	0x0352	850 == 85%
sRangeDownLimit;	0x0096	150 == 15%
wSettleSamples;	0x0004	4
wRangeChangeType;	0x0001	Auto range through all ranges
wRangeSW;	0x0005	P_PZ_NTTIA_RANGE30NANO

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
31	06	01	00	d	s

GET:

Command structure (18 bytes)

6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
32	06	0C	00	d|	s	RangeMode		RangeUpLimit	

10	11	12	13	14	15	16	17
RangeDownLimit		SettleSamples		RangeChangeType		RangeSW	

See SET for structure

MGMSG_PZ_SET_NTGAINPARAMS 0x0633
MGMSG_PZ_REQ_NTGAINPARAMS 0x0634
MGMSG_PZ_GET_NTGAINPARAMS 0x0635

Function: This message sets the gain level of the NanoTrak control loop, and is used to ensure that the DC level of the input (feedback loop) signal lies within the dynamic range of the input. Increasing this value can lead to a more responsive NanoTrak behaviour as the signal variation around the circular path is enhanced. However, for a particular set up, if this value is too high, then unstable NanoTrak operation (indicated by a fluctuating circle) can result.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
33	06	04	00	d|	s	GainCtrlMode		NTGainSW	

Data Structure:

field	description	format
GainCtrlMode	This parameter is currently locked and cannot be changed: 0x02 GAIN_SW software setting gain control mode	word
NTGainSW	This parameter sets the loop gain, as a function of TIA range setting. The value is set between 100 and 10000 with a default value of 600. It is not normally necessary for anything other than minor adjustment from this default value.	short

Example: Set the NanoTrak circle home position to be screen centre.

TX 33, 06, 04, 00, D0, 01, 02, 00, 58, 02

Header: 33, 06, 04, 00, D0, 01: Set_NTGainParams, 04 byte data packet, Generic USB Device.
GainCtrlMode 0x0002: Software Setting
NTGainSW 0x0258: 600

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
34	06	00	00	d	s

GET:
Command structure (10 bytes):

0	1	2	3	4	5	6	7	8	9
header						*Data*			
35	06	04	00	d|	s	GainCtrlMode		NTGainSW	

See SET for structure.

MGMSG_PZ_SET_NTTIALPFILTERPARAMS 0x0636
MGMSG_PZ_REQ_NTTIALPFILTERPARAMS 0x0637
MGMSG_PZ_GET_NTTIALPFILTERPARAMS 0x0638

Function: This message specifies the cut off frequency of the digital low pass (LP) filter applied to output readings of the internal amplifier (TIA) circuitry. If the readings displayed or returned are unstable, this setting can be used to remove any unwanted high frequency components and improve input signal stability.

SET:

Command structure (26 bytes)

6 byte header followed by 20 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
36	06	14	00	d|	s	Param1				Param2			

14	15	16	17	18	19	20	21	22	23	24	25
Data											
Param3				Param4				Param5			

Data Structure:

field	description	format
FilterParams	This parameter contains low pass filter values which can be applied to the OUTPUT from the TIA, i.e. is applied to those reading params sent to the PC. It does NOT operate on the input to the TIA and does not operate on reading values used by the NanoTrak algorythms (these use a bandpass filter, effectively negating the need for a LP filter). The filter can be used to smooth out readings displayed in the GUI. It can also be used by client applications without affecting operation of the NanoTrak. **Note**. Although there are 5 parameters available, only the first parameter is used at this time. The filter can be set to OFF, or one of 5 frequency values as follows: Note. Only the first parameter is used at this time. 0 LP_NONE Low pass filter inactive 1 LP_1HZ Cut off all signals above 1Hz 2 LP_3HZ Cut off all signals above 3Hz 3 LP_10HZ Cut off all signals above 10Hz 4 LP_30HZ Cut off all signals above 30Hz 5 LP_100HZ Cut off all signals above 100Hz	long

Example: Set the LP filter to 1 Hz.

TX 36, 06, 14, 00, D0, 01, 05, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00, 00

Header: 36, 06, 14, 00, D0, 01: Set_NTTIALPFilterParams, 20 byte data packet, Generic USB Device.
FilterParams: 05 LP_100HZ Cut off all signals above 100Hz

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
37	06	00	00	d	s

GET:
Command structure (26 bytes)

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
38	06	14	00	d|	s	Param1				Param2			

14	15	16	17	18	19	20	21	22	23	24	25
Data											
Param3				Param4				Param5			

See SET for structure.

MGMSG_PZ_REQ_NTTIAREADING 0x0639
MGMSG_PZ_GET_NTTIAREADING 0x063A

Function: This message obtains the absolute signal value at the current position, in units as displayed on the GUI panel.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
39	06	00	00	d	s

GET:

Command structure (16 bytes)

6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
3A	06	0A	00	d|	s	AbsReading				RelReading	

12	13	14	15
Data			
Range		UnderOverRead	

Data Structure:

field	description	format
AbsReading	This parameter returns the absolute TIA (PIN) current or BNC voltage value at the current position. The value is returned as a 4 byte floating point value in the range 1 x 10^{-9} to 1 x 10^{-3} (i.e. 1 nA to 1 mA or 1 to 10 V). The input source, TIA or BNC is set in the Set_NTFeedbackSRC message.	float
RelReading	The relative signal strength at the current position, in the range 0 to 32767 (i.e. 0 to 100% of the range currently selected). This value matches the length of the input signal bargraph on the GUI panel. (e.g. if the 3 µA range is currently selected, then a RelReading value of 16384 (50%) equates to 1.5 µA).).	word
Range	This parameter returns the input signal range currently selected. There are 14 range settings (1 - 14) that can be used to select the best range to measure the input signal (displayed on the GUI panel relative input signal bar and display). **Note**. Range 1 and 2 (3 nA and 10 nA) are not applicable to TNA001 T-Cube units. This parameter returns the input signal range currently selected, defined as follows: Range 1 3 nA 0x03 Range 2 10 nA 0x04	word

	Range 3 30 nA 0x05 Range 4 100 nA 0x06 Range 5 300 nA 0x07 Range 6 1 µA 0x08 Range 7 3 µA 0x09 Range 8 10 µA 0x0A Range 9 30 µA 0x0B Range 10 100 µA 0x0C Range 11 300 µA 0x0D Range 12 1 mA 0x0E Range 13 3 mA 0x0F Range 14 10 mA 0x10	
UnderOverRead	This parameter returns a value that identifies whether the unit is under reading or over reading the input signal as follows: 0x01 power signal is within current TIA range 0x02 power signal is under-reading for current TIA 0x03 power signal is over-reading for current TIA range e.g. if a user specified range of 3 µA is currently applied, this parameter returns '0x03' (Over read)' for input signals greater than 3 µA.	word

Example: Get the NanoTrak reading.

RX 3A, 06, 0A, 00, D0, 01, 00, 00, 00, 00, 00, 00, 05, 00, 01, 00

Header: 3A, 06, 0A, 00, D0, 01: Get_NTTIAReading, 10 byte data packet, Generic USB Device.

AbsReading	00, 00, 00, 00:		i.e. 20 nA
RelReading	00, 40:	16384,	i.e. 50%
Range	05, 00	Range 3,	i.e. 30 nA
UnderOverRead	01, 00	Within Range	

MGMSG_PZ_SET_NTFEEDBACKSRC 0x063B
MGMSG_PZ_REQ_NTFEEDBACKSRC 0x063C
MGMSG_PZ_GET_NTFEEDBACKSRC 0x063D

Function:

This message sets the input source of the NanoTrak.
The INPUT_BNC settings are used when NanoTraking to optimise a voltage feedback signal. Typically, these inputs are selected when an external power meter which generates a voltage output, is connected to the rear panel SIG IN connector.

Note. In this case the internal amplifier circuit is bypassed and the 'Range' bar on the GUI panel is switched off (autoranging functionality is not required). Furthermore, although tracking occurs as normal, the tracking indicator on the GUI panel is inoperative.

The INPUT_TIA setting is used when NanoTraking to optimise a PIN current feedback signal. The TIA (trans impedence amplifier) input source should be selected when using the rear panel OPTICAL/PIN I/P connector with either an integral detector, or an external detector head connected to the optional SMB adapter. This option uses the internal amplifier circuit and associated functionality (e.g. autoranging).

SET:
Command structure (6 bytes)

0	1	2	3	4	5
header					
3B	06	00	00	d	s

The input source is set in byte 2 as follows:

P_PZ_NTFBTIA	0x01	TIA input
P_PZ_NTFBBNC1V	0x02	BNC input (1V range)
P_PZ_NTFBBNC2V	0x03	BNC input (2V range)
P_PZ_NTFBBNC5V	0x04	BNC input (5V range)
P_PZ_NTFBBNC10V	0x05	BNC input (10V range)

Example: Set the input source to TIA input.

TX, 3B, 06, 01, 00, 50, 01,

REQ:
Command structure (6 bytes)

0	1	2	3	4	5
header					
3C	06	00	00	d	s

GET:
Command structure (6 bytes)

0	1	2	3	4	5
header					
3D	06	00	00	d	s

See SET command for structure

MGMSG_PZ_REQ_NTSTATUSBITS 0x063E
MGMSG_PZ_GET_NTSTATUSBITS 0x063F

Function: Returns a number of status flags pertaining to the operation of the NanoTrak controller channel specified in the Chan Ident parameter. These flags are returned in a single 32 bit integer parameter and can provide additional useful status information for client application development. The individual bits (flags) of the 32 bit integer value are described in the following tables.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
3E	06	Chan Ident	00	d	s

GET:
Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
3F	06	0A	00	d|	s	StatusBits					

Data Structure:

field	description	format
StatusBits	The status bits for the associated controller channel. The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword

TNA001 controller

Hex Value	Bit Number	Description
0x00000001	1	Tracking (1 - tracking, 0 - latched).
0x00000002	2	Tracking with Signal (1 – with signal, 0 – no signal)
0x00000004	3	Tracking Channel A (1 – Chan A only, 0 – Both channels)
0x00000008	4	T racking Channel B (1 – Chan B only, 0 – Both channels)
0x00000010	5	Auto-ranging (1 – auto ranging, 0 manual ranging).
0x00000020	6	Under Read (1 – under reading, 0 – reading within range).
0x00000040	7	Over Read (1 – over reading, 0 – reading within range).
	8 to 16	For future use
0x00010000	17	Channel A Connected (1 – Connected, 0 – Not Connected)
0x00020000	18	Channel B Connected (1 – Connected, 0 – Not Connected)
0x00040000	19	Channel A Enabled (1 – Enabled, 0 – Disabled)
0x00080000	20	Channel B Enabled (1 – Enabled, 0 – Disabled)
0x00100000	21	Channel A Control Mode (1 – Closed Loop, 0 – Open Loop)
0x00200000	22	Channel B Control Mode (1 – Closed Loop, 0 – Open Loop)
	23 to 32	For future use

BNT series controllers

Hex Value	Bit Number	Description
0x00000001	1	Tracking (1 - tracking, 0 - latched).
0x00000002	2	Tracking with Signal (1 – with signal, 0 – no signal)
0x00000004	3	Tracking Channel A (1 – Chan A only, 0 – Both channels)
0x00000008	4	T racking Channel B (1 – Chan B only, 0 – Both channels)
0x00000010	5	Auto-ranging (1 – auto ranging, 0 manual ranging).
0x00000020	6	Under Read (1 – under reading, 0 – reading within range).
0x00000040	7	Over Read (1 – over reading, 0 – reading within range).
	8 to 16	For future use
0x00010000	17	Channel A Connected (1 – Connected, 0 – Not Connected)
0x00020000		
0x00040000	19	Channel A Enabled (1 – Enabled, 0 – Disabled)
0x00080000	20	Channel B Enabled (1 – Enabled, 0 – Disabled)
0x00100000	21	Channel A Control Mode (1 – Closed Loop, 0 – Open Loop)
0x00200000	22	Channel B Control Mode (1 – Closed Loop, 0 – Open Loop)
Note. Bits 23 to 32 (Digital Input States) are only applicable if the associated digital input is fitted to your controller – see the relevant handbook for more details		
0x00100000	21	Digital input 1 state (1 - logic high, 0 - logic low).
0x00200000	22	Digital input 2 state (1 - logic high, 0 - logic low).
0x00400000	23	Digital input 3 state (1 - logic high, 0 - logic low).
0x00800000	24	Digital input 4 state (1 - logic high, 0 - logic low).
0x01000000	25	Digital input 5 state (1 - logic high, 0 - logic low).
0x02000000	26	Digital input 6 state (1 - logic high, 0 - logic low).
0x04000000	27	Digital input 7 state (1 - logic high, 0 - logic low).
0x08000000	28	Digital input 8 state (1 - logic high, 0 - logic low).
	29	For Future Use
0x20000000	30	Active (1 – indicates unit is active, 0 – not active)
0x40000000	31	For Future Use
0x80000000	32	Channel enabled (1 – enabled, 0- disabled)

MGMSG_PZ_REQ_NTSTATUSUPDATE 0x0664
MGMSG_PZ_GET_NTSTATUSUPDATE 0x0665

Function: This function is used in applications where spontaneous status messages (i.e. messages sent using the START_STATUSUPDATES command) must be avoided.
Status update messages contain information about the position and status of the controller (for example position and O/P voltage). The response will be sent by the controller each time the function is requested.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
64	06	Chan Ident	00	d	s

GET:

Status update messages are received with the following format:-

Response structure (32 bytes)

6 byte header followed by 26 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
65	06	1A	00	d|	s	CircPosA		CircPosB		CircDia	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
AbsReading				RelReading		Range		UnderOverRead		StatusBits	

24	25	26	27	28	29	30	31
Data							
StatusBits		NTGain		PhaseCompA		PhaseCompB	

Data Structure:

field	description	format
CircPosA	The horizontal co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word
CircPosB	The vertical co-ordinate of the circle home position, in the range 0 to 65535 (0 to 100% of output voltage or 0 to 10 NanoTrak units).	word
CircDia	This NanoTrak scanning circle diameter. The diameter is returned in the range 0 to 65535, which relates to 0% to 100% output voltage –(i.e. 0 to 10 NT units).	word
AbsReading	The absolute TIA (PIN) current or BNC voltage value at the current position. The value is returned as a 4 byte floating point value in the range 1 x 10^{-9} to 1 x 10^{-3} (i.e. 1 nA to 1 mA or 1 to 10 V). The input source, TIA or BNC is set in the	float

	Set_NTFeedbackSRC message.	
RelReading	The relative signal strength at the current position, in the range 0 to 32767 (i.e. 0 to 100% of the range currently selected). This value matches the length of the input signal bargraph on the GUI panel. (e.g. if the 3 µA range is currently selected, then a RelReading value of 16384 (50%) equates to 1.5 µA).	word
Range	The NanoTrak unit is equipped with an internal trans-impedance amplifier (TIS) circuit (and associated range/power level displays and control buttons in the GUI). This amplifier operates when an external input signal is connected to the Optical/PIN connector on the rear panel. There are 14 range settings (1 - 14) that can be used to select the best range to measure the input signal (displayed on the GUI panel relative input signal bar and display). **Note**. Range 1 and 2 (3 nA and 10 nA) are not applicable to TNA001 T-Cube units. This parameter returns the input signal range currently selected, defined as follows: Range 1 3 nA 0x03 Range 2 10 nA 0x04 Range 3 30 nA 0x05 Range 4 100 nA 0x06 Range 5 300 nA 0x07 Range 6 1 µA 0x08 Range 7 3 µA 0x09 Range 8 10 µA 0x0A Range 9 30 µA 0x0B Range 10 100 µA 0x0C Range 11 300 µA 0x0D Range 12 1 mA 0x0E Range 13 3 mA 0x0F Range 14 10 mA 0x10	word
UnderOverRead	This parameter returns a value that identifies whether the unit is under reading or over reading the input signal as follows: 0x01 power signal is within current TIA range 0x02 power signal is under-reading for current TIA 0x03 power signal is over-reading for current TIA range e.g. if a user specified range of 3 µA is currently applied, this parameter returns '0x03' (Over read)' for input signals greater than 3 µA.	word
StatusBits	The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword
NTGain	This parameter returns the loop gain, as a function of TIA range setting. The value is returned between 100 and 10000 (default value of 600).	short
PhaseCompA	The horizontal axis phase compensation value, returned in real world units as follows:-	short

	value = (phase angle [degrees] / 360) * CircOscFreq See the PZ_SET_NTCIRCPARAMS message for details on the CircOscFreq parameter **Note**. Negative phase values must be made positive by subtraction from 360 before the calculation is made.	
PhaseCompB	The vertical axis phase compensation value, returned in real world units as follows:- value = (phase angle [degrees] / 360) * CircOscFreq See the PZ_SET_NTCIRCPARAMS message for details on the CircOscFreq parameter **Note**. Negative phase values must be made positive by subtraction from 360 before the calculation is made.	short

TNA001 controller

Hex Value	Bit Number	Description
0x00000001	1	Tracking (1 - tracking, 0 - latched).
0x00000002	2	Tracking with Signal (1 – with signal, 0 – no signal)
0x00000004	3	Tracking Channel A (1 – Chan A only, 0 – Both channels)
0x00000008	4	T racking Channel B (1 – Chan B only, 0 – Both channels)
0x00000010	5	Auto-ranging (1 – auto ranging, 0 manual ranging).
0x00000020	6	Under Read (1 – under reading, 0 – reading within range).
0x00000040	7	Over Read (1 – over reading, 0 – reading within range).
	8 to 16	For future use
0x00010000	17	Channel A Connected (1 – Connected, 0 – Not Connected)
0x00020000	18	Channel B Connected (1 – Connected, 0 – Not Connected)
0x00040000	19	Channel A Enabled (1 – Enabled, 0 – Disabled)
0x00080000	20	Channel B Enabled (1 – Enabled, 0 – Disabled)
0x00100000	21	Channel A Control Mode (1 – Closed Loop, 0 – Open Loop)
0x00200000	22	Channel B Control Mode (1 – Closed Loop, 0 – Open Loop)
	23 to 32	For future use

BPC series controllers

Hex Value	Bit Number	Description
0x00000001	1	Piezo actuator connected (1 - connected, 0 - not connected).
	2 to 4	For Future Use
0x00000010	5	Piezo channel has been zero'd (1 - zero'd, 0 not zero'd).
0x00000020	6	Piezo channel is zeroing (1 - zeroing, 0 - not zeroing).
0x00000040	7 to 8	For Future Use
0x00000100	9	Strain gauge feedback connected (1 - connected, 0 - not connected).
	10	For Future Use
0x00000400	11	Position control mode (1 - closed loop, 0 - open loop).
	12 to 20	For Future Use
Note. Bits 21 to 28 (Digital Input States) are only applicable if the associated digital input is fitted to your controller – see the relevant handbook for more details		
0x00100000	21	Digital input 1 state (1 - logic high, 0 - logic low).
0x00200000	22	Digital input 2 state (1 - logic high, 0 - logic low).
0x00400000	23	Digital input 3 state (1 - logic high, 0 - logic low).
0x00800000	24	Digital input 4 state (1 - logic high, 0 - logic low).

0x01000000	25	Digital input 5 state (1 - logic high, 0 - logic low).
0x02000000	26	Digital input 6 state (1 - logic high, 0 - logic low).
0x04000000	27	Digital input 7 state (1 - logic high, 0 - logic low).
0x08000000	28	Digital input 8 state (1 - logic high, 0 - logic low).
	29	For Future Use
0x20000000	30	Active (1 – indicates unit is active, 0 – not active)
0x40000000	31	For Future Use
0x80000000	32	Channel enabled (1 – enabled, 0- disabled)

MGMSG_PZ_ACK_NTSTATUSUPDATE 0x0666

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called “server alive” must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5
header only					
66	06	00	00	d	s

TX 66, 06, 00, 00, 50, 01

MGMSG_NT_SET_EEPROMPARAMS 0x07E7

Function: Used to save the parameter settings for the specified message. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
E7	07	04	00	d|	s	Chan Ident		MsgID	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
MsgID	The message ID of the message containing the parameters to be saved.	word

Example:

TX E7, 07, 04, 00, D0, 01, 01, 00, 18, 06,

Header: E7, 07, 04, 00, D0, 01: Set_EEPROMPARAMS, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
MsgID: Save parameters specified by message 0618 (SetNTCircParams).

MGMSG_NT_SET_TNA_DISPSETTINGS 0x07E8
MGMSG_NT_REQ_TNA_DISPSETTINGS 0x07E9
MGMSG_NT_GET_TNA_DISPSETTINGS 0x07EA

Function: Used to set the intensity of the LED display on the front of the TNA unit.

SET:
Command structure (8 bytes)
6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
E8	07	02	00	d|	s	DispIntensity	

Data Structure:

field	description	format
DispIntensity	The intensity is set as a value from 0 (Off) to 255 (brightest).	word

Example: Set the input source to software and potentiometer.

TX E8, 07, 02, 00, D0, 01, 64, 00,

Header: E8, 07, 02, 00, D0, 01: Set_DISPSETTINGS, 02 byte data packet, Generic USB Device.
DispIntensity: 64, 00: Sets the display brightness to 100 (40%)

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
E9	07	01	00	d	s

Example: Request the display intensity

TX E9, 07, 01, 00, 50, 01

GET:
Command structure (8 bytes)
6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
EA	07	02	00	d|	s	DispIntensity	

See SET for data structure.

MGMSG_NT_SET_TNAIOSETTINGS 0x07EB
MGMSG_NT_REQ_TNAIOSETTINGS 0x07EC
MGMSG_NT_GET_TNAIOSETTINGS 0x07ED

Function: This message is used to set parameters which control the NanoTrak output signal ranges and the way in which these signals are routed to the associated piezo drivers.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
EB	07	04	00	d|	s	LVOutRange		LVOutRoute		Not Used		Not Used	

Data Structure:

field	description	format
LVOutRange	The output signals from the NanoTrak T-Cube are routed to the piezo drivers to position the piezo actuators. Earlier piezo T-cubes accept a 5V input while later cubes accept a 10V input. Other piezo amplifiers with 5V or 10V input ranges may be driven from the NanoTrak T-Cube. This parameter sets the LV output range as follows: 0x01 0 to 5V Output Range 0x02 0 to 10V Output Range	word
LVOutRoute	This parameter sets the way the signals are routed to the piezo T-Cubes as follows: 0x01 Rear panel SMA connectors only 0x02 Rear panel SMA connectors and Hub routing	word
Not Used		
Not Used		

Example

Tx EB,07,08,00,D0,01,01,00,01,00,00,00,00,00

Header: EB, 07, 08, 00, D0, 01: Set_TNAIOSettings, 08 byte data packet, Generic USB Device.
LVOutRange: 01, 00: 0 to 5V range
LVOutRoute: 01, 00: Signal routing via rear panel SMA connectors.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
EC	07	Chan Ident	00	d	s

GET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
ED	07	04	00	d|	s	LVOutRange		LVOutRoute		Not Used		Not Used	

See SET for structure.

Laser Control Messages

Introduction

The ‘Laser’ ActiveX Control provides the functionality required for a client application to control one or more T-Cube Laser Sources.

The methods of the Laser Control Object can then be used to control the T-Cube Laser Source and Laser Driver units, and activities such as switching between display modes, setting the laser power set point, reading the laser power or current and setting the LED display intensity can be performed.

For details on the use of the Laser Source, refer to the handbook supplied with the unit.

MGMSG_LA_SET_PARAMS 0x0800
MGMSG_LA_REQ_PARAMS 0x0801
MGMSG_LA_GET_PARAMS 0x0802

Function: This generic parameter set/request message is used to control all the functionality of the TLS001. The specific parameters to control are identified by the use of sub-messages. These sub messages comply with the general format of the APT message protocol but rather than having a unique first and second byte in the header carrying the “message identifier” information, the first and second byte remain the same.
Instead, for the SET and GET messages, the message identifier is carried in the first two bytes in the data packet part of the message, whilst for the REQ message it is encoded as the third byte of the header.
Likewise, when the TLS001 responds, the first two bytes of the response remain the same and the first two bytes of the data packet identify the sub-message to which the information returned in the remaining part of the data packet relates.
The following sub messages are applicable to the TLS001:

Set/Request/Get Laser Power Setpoint (sub-message ID = 1)
Request/Get Laser Current and Power (sub-message ID = 3)
Set/Request/Get Laser Power Control Source (sub-message ID = 5)
Request/Get Status Bits (sub-message ID = 7)
Request/Get Maximum Limits (sub-message ID = 9)
Set/Request/Get Display Settings (sub-message ID = 11)

To explain the principle, the following examples describe the first of these messages in more detail.

Example - Set/Request/Get Laser Power Setpoint (sub-message ID = 1)
This sub-command is used to set / read the laser power setpoint. The setpoint is the required laser power that the TLS001 will attempt to maintain. This is not necessarily the same as the actual laser power because if the current limit for the laser diode is exceeded, the setpoint will not be reached.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
00	08	04	00	d|	s	MsgID		SetPoint	

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
SetPoint	The Laser power setpoint (0 to 32767 -> 0% to 100% power).to be saved.	word

Example: Set the laser power setpoint to be set to 5% of the maximum power

TX 00, 08, 04, 00, D0, 01, 01, 00, 66, 06,

Header: 00, 08, 04, 00, D0, 01: Set_PARAMS, 04 byte data packet, Generic USB Device.
MsgID: 01, 00: Set Laser Power Setpoint
SetPoint:.66, 06: the laser power setpoint, 0x0666 (1638 decimal), which is 5 % of the full power.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	01	00	d	s

TX 01, 08, 01, 00, 50, 01,

GET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
02	08	04	00	d|	s	MsgID		SetPoint	

See SET message for data structure

Example - Request/Get Laser Current and Power (sub-message ID = 3)
This sub-command is used to read the actual laser power and the laser current. Note that there is no SET message as only the setpoint power can be set, not the actual power or current.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	03	00	d	s

TX 01, 08, 03, 00, 50, 01,

GET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
02	08	06	00	d|	s	MsgID		LaserCurrent		LaserPower	

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
LaserCurrent	The Laser current (0 to 32767 -> 0 to max current in mA)	word
LaserPower	The Laser power (0 to 32767 -> 0% to 100% power)	word

Example: Get the laser current and power

RX 02, 08, 06, 00, D0, 01, 03, 00, 66, 06, 66, 06

Header: 00, 08, 06, 00, D0, 01: Set_PARAMS, 06 byte data packet, Generic USB Device.
MsgID: 03, 00: Get Laser Current and Power
LaserCurrent:.66, 06: the laser current, 0x0666 (1638 decimal), which is 5 mA for a 100 mA max current laser.
LaserPower:.66, 06: the laser power, 0x0666 (1638 decimal), which is 5% of the full power.

Example - Set/Request/Get the Laser Power Control Source (sub-message ID = 5)
This sub-command is used to set / read the laser power control source. The laser power can be controlled by APT commands, the potentiometer on the top of the unit or the external SMA input. Only one control source can be active at any time, the options are mutually exclusive.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
00	08	04	00	d|	s	MsgID		LaserSource	

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
LaserSource	The Laser power source. This can be one of the following three options: 0 = SW control; 1 = external SMA input; 4 = potentiometer.	word

Example: Set the laser power source to be external SMA input

TX 00, 08, 04, 00, D0, 01, 05, 00, 01, 00

Header: 00, 08, 04, 00, D0, 01: Set_PARAMS, 04 byte data packet, Generic USB Device.
MsgID: 05, 00: Set Laser Power Source
LaserSource:.01, 00: the laser power source is the external SMA input.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	05	00	d	s

TX 01, 08, 01, 00, 50, 01,

GET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
02	08	04	00	d|	s	MsgID		LaserSource	

See SET message for data structure

Request/Get Status Bits (sub-message ID = 7)
This sub command can be used to request the TLS001 status bits. The message only has a request/ get part.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	07	00	d	s

TX 01, 08, 07, 00, 50, 01,

GET:
Status update messages are received with the following format:-

Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
02	08	06	00	d|	s	MsgID		StatusBits			

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
StatusBits	The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword

TLS001 controller

Hex Value	Bit Number	Description
0x00000001	1	Laser output enabled state (1 - enabled, 0 - disabled).
0x00000002	2	Keyswitch enabled state (1 - enabled, 0 – disabled)
0x00000004	3	Laser control mode (1 - power [closed loop], 0 - current [open loop])
0x00000008	4	Safety interlock, (1 - enabled, 0 – disabled)
0x00000010	5	Units mode (1 - mA, else 0).
0x00000020	6	Units mode (1 - mW, else 0).
0x00000040	7	Units mode (1 - dBm, else 0)
	8	For Future Use

Example

RX 02, 08, 06, 00, 81, 50, 07, 00, 2B, 00, 00, 00

Header: 02, 08, 06, 00, 81, 50: LA_Get_Params, 06 byte data packet, Generic USB Device.
MsgID: 07, 00: Get Status Bits
StatusBits: 2B,00,00,00, i.e. 00101011 the display shows mW units, the safety interlock is enabled, the keyswitch is enabled and the output is enabled.

Request/Get Maximum Limits (sub-message ID = 9)
This sub command can be used to request the TLS001 maximum limits, such as maximum current, maximum power and the wavelength of the laser diode. The message only has a request/ get part.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	09	00	d	s

TX 01, 08, 09, 00, 50, 01,

GET:
Status update messages are received with the following format:-

Response structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
02	08	08	00	d|	s	MsgID		MaxCurrent		MaxPower		Wavelength	

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
MaxCurrent	The Laser max current (0 to 65535 -> 0 to655.35 mA)	word
MaxPower	The Laser max power (0 to 65535 -> 0 to 6.5535 mW)	word
WaveLength	The Laser wavelength in nm (635 or 1550)	word

Example – Get Laser Limits
RX 02, 08, 08, 00, D0, 01, 09, 00, C8, 00, 05, 00, 0E, 06

Header: 00, 08, 06, 00, D0, 01: Set_PARAMS, 06 byte data packet, Generic USB Device.
MsgID: 09, 00: Get Laser Max Limits
MaxCurrent:.C8, 00:, 0x00C8 i.e. 200mA max current.
MaxPower:.05, 00:, 0x0005 i.e. 5 mW max power.
Wavelength:.0E, 06: the laser power, 0x060E (1550 decimal), wavelength 1550 nm.

Set/Request/Get Display Settings (sub-message ID = 11)

This message can be used to adjust or read the front panel LED display brightness and the display units.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
00	08	08	00	d|	s	MsgID		DispIntensity		DispUnits		Unused	

Data Structure:

field	description	format
MsgID	The message ID of the message containing the parameters	word
DispIntensity	The intensity is set as a value from 0 (Off) to 255 (brightest).	word
DispUnits	The LED display window on the front of the unit can be set to display the laser output in mA, mW or dBm as follows. 1 display shows laser current in mA. 2 display shows laser power in mW. 3 display shows laser power in dBm (relative to 1 mW)	word
Unused	N/A	word

Example: Set the display to show the laser current in Amps and at max brightness:

TX 00, 08, 08, 00, D0, 01, 0B, 00, FF, 00, 01, 00, 00, 00

Header: 00, 08, 08, 00, D0, 01: Set_Params, 08 byte data packet, Generic USB Device.
MsgID: 0B, 00: Set Display Settings
DispIntensity: FF, 00: Sets the display brightness to 255 (100%)
DispUnits: 01, 00: Sets the display units to mA

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
01	08	0B	00	d	s

Example: TX 01, 08, 0B, 00, 50, 01

GET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
00	08	08	00	d|	s	MsgID		DispIntensity		DispUnits		Unused	

See SET for data structure.

MGMSG_LA_SET_EEPROMPARAMS 0x0810

Function: Used to save the parameter settings for the specified message. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
10	08	04	00	d|	s	Chan Ident		MsgID	

Data Structure:

field	description	format
Chan Ident	The channel being addressed	word
MsgID	The message ID of the message containing the parameters to be saved.	word

Example:

TX 10, 08, 04, 00, D0, 01, 01, 00, 18, 06,

Header: 10, 08, 04, 00, D0, 01: Set_EEPROMPARAMS, 04 byte data packet, Generic USB Device.
Chan Ident: 01, 00: Channel 1
MsgID: Save parameters specified by message 0821 (GetStatusUpdate).

MGMSG_LA_ENABLEOUTPUT 0x0811
MGMSG_LA_DISABLEOUTPUT 0x0812

Function These messages are sent to enable or disable the Laser output.
The 3rd and 4th bytes in the command header are unused and set to 0x00.

SET:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
11	08	00	00	d	s

Example: Enable the laser output

TX 11, 08, 00, 00, 50, 01

Disable the laser output

TX 12, 08, 00, 00, 50, 01

MGMSG_LA_REQ_STATUSUPDATE 0x0820
MGMSG_LA_GET_STATUSUPDATE 0x0821

Function: This function is used in applications where spontaneous status messages (i.e. messages sent using the START_STATUSUPDATES command) must be avoided.
Status update messages contain information about the position and status of the controller (for example position and O/P voltage). The response will be sent by the controller each time the function is requested.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
20	08	00	00	d	s

GET:

Status update messages are received with the following format:-

Response structure (14 bytes)

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
21	08	08	00	d|	s	LaserCurrent		LaserPower		StatusBits			

Data Structure:

field	description	format
LaserCurrent	The laser current, in the range 0 to 32760 – (i.e. 0 to max current in mA)	word
LaserPower	The.laser power, in the range 0 to 32760 – (i.e. 0 to 100% of max power)	word
StatusBits	The meaning of the individual bits (flags) of the 32 bit integer value will depend on the controller and are described in the following tables.	dword

TLS001 controller

Hex Value	Bit Number	Description
0x00000001	1	Laser output enabled state (1 - enabled, 0 - disabled).
0x00000002	2	Keyswitch enabled state (1 - enabled, 0 – disabled)
0x00000004	3	Laser control mode (1 - power [closed loop], 0 - current [open loop])
0x00000008	4	Safety interlock, (1 - enabled, 0 – disabled)
0x00000010	5	Units mode (1 - mA, else 0).
0x00000020	6	Units mode (1 - mW, else 0).
0x00000040	7	Units mode (1 - dBm, else 0)
	8	For Future Use

Example

RX 21, 08, 08, 00, 81, 50, 90, 19, 90, 19, 2B, 00, 00, 00

Header: 21, 08, 08, 00, 81, 50: LA_Get_StatusUpdate, 08 byte data packet, Generic USB Device.
LaserCurrent: 90, 19: 6544 = 20 % of the maximum current;
LaserPower: *90, 19*: 6544 = 20 % of the maximum power;
StatusBits: 2B,00,00,00, i.e. 00101011 the display shows mW units, the safety interlock is enabled, the keyswitch is enabled and the output is enabled.

MGMSG_LA_ACK_STATUSUPDATE 0x0822

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called "server alive" must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5
header only					
22	08	00	00	d	s

TX 22, 08, 00, 00, 50, 01

Quad Control Messages

Introduction

The ‘Quad’ ActiveX Control provides the functionality required for a client application to control one or more T-Cube Quad Detector Readers or Position Aligners.
The methods of the Quad Control Object can then be used to control the TQD001 T-Cube Quad Reader and the TPA101 T-Cube Position Aligner, and activities such as switching between Monitor, Open Loop and Closed Loop operating modes, setting the position demand parameters, reading the present beam position and setting the LED display intensity.
For details on the use of the T-Cubes, refer to the handbook supplied for the unit.

MGMSG_QUAD_SET_PARAMS 0x0870
MGMSG_QUAD_REQ_PARAMS 0x0871
MGMSG_QUAD_GET_PARAMS 0x0872

Function: This generic parameter set/request message is used to control the functionality of the TQD001 or TPA101. The specific parameters to control are identified by the use of sub-messages. These sub messages comply with the general format of the APT message protocol but rather than having a unique first and second byte in the header carrying the "message identifier" information, the first and second byte remain the same.
Instead, for the SET and GET messages, the message identifier is carried in the first two bytes in the data packet part of the message, whilst for the REQ message it is encoded as the third byte of the header.
Likewise, when the TQD001 or TPA101 responds, the first two bytes of the response remain the same and the first two bytes of the data packet identify the sub-message to which the information returned in the remaining part of the data packet relates.

The following sub messages are applicable to the TQD001 and TPA101:

Set/Request/Get Quad_LoopParams (sub-message ID = 01)
Request/Get Quad_Readings (sub-message ID = 03)
Set/Request/Get Quad Position Demand Params (sub-message ID = 05)
Set/Request/Get Quad Operating Mode (sub-message ID = 07)
Request/Get Quad Status Bits (sub-message ID = 09)
Set/Request/Get Quad Display Settings (sub-message ID = 0B)
Set/Request/Get Quad Position Demand Outputs (sub-message ID = 0D)

The following sub message is applicable only to the TPA101:

Set/Request/Get Quad_LoopParams2 (sub-message ID = 0E)

To explain the principle, the following examples describe these messages in more detail.

Set/Request/Get Quad_LoopParams (sub-message ID = 01)
Used to set the proportional, integration and differential feedback loop constants to the value specified in the PGain, IGain and DGain parameters respectively. They apply when the quad detector unit is operated in closed loop mode, and position demand signals are generated at the rear panel SMA connectors by the feedback loops. These position demand voltages act to move the beam steering elements (e.g. a piezo driven mirror) in order to centralize a beam at the centre of the PSD head.
When operating in closed loop mode, the proportional, integral and differential (PID) constants can be used to fine tune the behaviour of the dual feedback loops to adjust the response of the position demand output voltages. The feedback loop parameters need to be adjusted to suit the different types of sensor that can be connected to the system. The default values have been optimized for the PDQ80A sensor.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
70	08	08	00	d|	s	SubMsgID		PGain		IGain		DGain	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0100) of the message containing the parameters	word
PGain	The proportional gain. This term provides the force used to drive the piezo to the demand position, reducing the positional error. Together with the Integral and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767 (i.e. 0 to 100 in APT User GUI).	word
IGain	The integral gain. This term provides the 'restoring' force that grows with time, ensuring that the positional error is eventually reduced to zero. Together with the Proportional and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767 (i.e. 0 to 100 in APT User GUI).	word
DGain	The differential gain. This term provides the 'damping' force proportional to the rate of change of the position. Together with the Proportional and Integral, these terms determine the system response characteristics and accept values in the range 0 to 32767 (i.e. 0 to 100 in APT User GUI).	word

Example: Set the PID parameters for TQD001 or TPA101 as follows:
Proportional: 65
Integral: 80
Differential: 60

TX 70, 08, 08, 00, D0, 01, 01, 00, 41, 00, 50, 00, 3C, 00,

Header: 70, 08, 08, 00, D0, 01: Quad_SetParams, 8 byte data packet, Generic USB Device.
SubMsgID: 01, 00 SetQuadControlLoopParams)
PGain: *32, 53,(32767x65/100):* Set the proportional term to 65
IGain: *65, 66, (32767x80/100)*: Set the integral term to 80
DGain: CC, 4C, *(32767x60/100)*: Set the differential term to 60

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	01	00	d	s

GET:

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
72	08	08	00	d|	s	SubMsgID		PGain		IGain		DGain	

For structure see Set message above.

Request/Get Quad_Readings (sub-message ID = 3)

The TQD001 Quad Detector T-Cube has been designed to operate with the PDQ80A Quad Detector. The detector consists of a 4-segment photodiode sensor array, which provides 'Bottom minus Top' (YDIFF) and 'Left minus Right' (XDIFF) difference signals, together with the SUM of the signals (total beam power) from all four quadrants of the photodiode array. This sub-message is used to read the actual SUM, XDIFF and YDIFF signals from the detector. Whether these signals are routed to the LV OUT/XDIFF and LV OUT/YDIFF SMA connectors on the rear panel depends on the operating mode selected (see the Quad_OperMode message) as follows.

In 'Closed Loop' mode, the signal from the detector is interpreted by the unit, and the feedback circuit sends position demand signals (XOut and YOut) to the rear panel LV OUT/XDIFF and LV OUT/YDIFF connectors, which can be used to drive a pair of positioning elements (e.g. piezo controllers) in order to position the light beam within the center of the detector array. This submessage is then used to read the actual values for the XPos and YPos position demand signals (-10 V to +10V). Note that in closed loop mode, with the beam central, the X and Y axis difference outputs from the photodiode array are zero. However, the position demand signals on the rear panel LV OUT XDIFF and YDIFF SMA connectors are whatever value is necessary to drive the positioning elements to centre the beam.

When the Quad Detector T-Cube is operated in 'open loop' mode, the signals on the rear panel LV OUT/XDIFF and LV OUT/YDIFF connectors are constant. They are either fixed at zero (0V), or held at the last Closed Loop value (depending on the 'QuadPosDemandParams' message. This is useful when the system is being adjusted manually, to position the light beam within the detector array.

When operating in 'Monitor' mode, the X axis (XDIFF) and Y axis (YDIFF) difference signals from the detector, are fed through to the rear panel SMA connectors for use in a monitoring application.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	03	00	d	s

TX 71, 08, 03, 00, 50, 01,

GET:

Command structure (18 bytes)

6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
72	08	0C	00	d|	s	SubMsgID		XDiff		YDiff	

12	13	14	15	16	17
Data					
Sum		XPos		YPos	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0300) of the message containing the parameters	word
XDiff	The present X axis difference (XDIFF) signal from the detector head. (-10V to 10V in the range -32768 to 32767)	short
YDiff	The present Y axis difference (YDIFF) signal value from the detector head. (-10V to 10V in the range -32768 to 32767)	short
Sum	The present Sum signal value from the detector head (0V to 10V in the range 0 to 65535)	word
XPos	The X axis position output value on the rear panel XDiff SMA connector (-10V to 10V in the range -32768 to 32767)	short
YPos	The Y axis position output value on the rear panel YDiff SMA connector (-10V to 10V in the range -32768 to 32767)	short

Example: Get the Quad Detector T-Cube readings (T-Cube in open loop mode)

RX 72, 08, 0C, 00, D0, 01, 03, 00, FF, 3F, FF, 3F, FF, 7F, 00, 00, 00, 00

Header: 72, 08, 0C, 00, D0, 01: Quad_GetPARAMS, 12 byte data packet, Generic USB Device.
MsgID: 03, 00: Get Quad Readings
XDiff:.FF, 3F: 0x3FFF (16383 decimal), i.e. 5 V.
YDiff:. FF, 3F: 0x3FFF (16383 decimal), i.e. 5 V.
Sum: FF, FF: 0x7FFF (65535 decimal), i.e. 10 V.
XPos: 00, 00 i.e. Zero
YPos: 00, 00 i.e. Zero

Set/Request/Get Quad_PosDemandParams (sub-message ID = 5)

The TQD001 or TPA101 Quad Detector T-Cube has been designed to operate with the PDQ80A Quad Detector. The detector consists of a 4-segment photodiode sensor array, which provides ‘Bottom minus Top’ (YDIFF) and ‘Left minus Right’ (XDIFF) difference signals, together with the SUM of the signals (total beam power) from all four quadrants of the photodiode array. Whether these signals are routed to the LV OUT/XDIFF and LV OUT/YDIFF SMA connectors on the rear panel depends on the operating mode selected – see the Quad_OperMode message.

This sub-message is used to control the signals on the rear panel LV OUT/XDIFF and LV OUT/YDIFF connectors.

SET:

Command structure (24 bytes)

6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
70	08	12	00	d|	s	SubMsgID		XPosDemMin		YPosDemMin	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
XPosDemMax		YPosDemMax		LVOutRoute		OLPosDem		XPosFBSense		YPosFBSense	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0500) of the message containing the parameters	word
XPosDemandMin	The following four parameters are applicable only when operating in closed loop mode. The XOut and YOut values are the low voltage signals sent to the LV OUT/XDIFF and LV OUT/YDIFF connectors, which are then used to drive the positioning mechanism in order to keep the beam central in the detector. Under normal operating conditions, these values are between -10 V and +10 V, however some applications may require the limits to be less than this. The XPosDemandMin parameter is used to set the min limit for the XOut value, between -10V and +10V. (i.e. -32768 to 32767)	short
YPosDemandMin	As above. The YPosDemandMin parameter is used to set the min limit for the YOut value, between -10V and +10V. (i.e. -32768 to 32767)	short
XPosDemandMax	As above. The XPosDemandMax parameter is used to set the max limit for the XOut value, between -10V and +10V. (-32768 to 32767)	short
YPosDemandMax	As above. The YPosDemandMax parameter is used to set the max limit for the YOut value, between -10V and +10V. (-32768 to 32767)	short
LVOutRoute	When operating in closed loop mode, the Quad Detector position control signals are always output on the external SMA connectors (LV OUT XDiff and LV	word

	OUT YDiff). In addition, they can also be routed to the TCH002 hub, which eliminates the need for external SMA to SMA cables. This parameter is used to set the LV Out signal routing as follows: 1 SMA Only 2 SMA + Hub	
OpenLoopPosDemands	When the Quad Detector T-Cube is operated in ‘open loop’ mode, the position demand signals (on the XDIFF and YDIFF connectors) can either be set to zero, or held at their last closed loop value, according to the value entered in this parameter as follows: 1 OpenLoopPosDemandsZero - the output is set to zero (0V). 2 OpenLoopPosDemandsHeld = the outputs are fixed at the values present when the unit is switched to open loop.	word
XPosDemandFBSense	Due to the choice of piezo amplifier/driver or the configuration of mirrors (or other optical components) it is possible that certain application set ups may require the sense of the X and Y axis position demand signals to be inverted. This parameter sets the signal sense and gain for the X axis output as follows: If XPosDemandFBSense is set to '10' (32767) the signals are positive when the beam is in the left hand quadrants of the detector array, and negative when in the right hand quadrants. The gain of the system is set to '1'. If XPosDemandFBSense is set to '-7' (-22938) the signals are positive when the beam is in the right hand quadrants of the detector array, and negative when in the left hand quadrants. The gain of the system is set to '0.7'.	short
YPosDemandFBSense	Similarly to the XPosDemandFBSense described above, this parameter sets the signal sense and gain for the Y axis output as follows: If YPosDemandFBSense is set to '10' (32767) the signals are positive when the beam is in the top quadrants of the detector array, and negative when in the bottom quadrants. The gain of the system is set to '1'. If YPosDemandFBSense is set to '-3' (-9830) the signals are positive when the beam is in the bottom quadrants of the detector array, and negative when in the top quadrants. The gain of the system is set to '0.3'.	short

Example: Set the Quad Pos Demand Params

RX 70, 08, 12, 00, D0, 01, 05, 00, 01, 80, 01, 80, FF, 7F, FF, 7F, 02, 00, 01, 00, 0A, 00, 0A, 00

Header: 70, 08, 12, 00, D0, 01: Quad_SetPARAMS, 18 byte data packet, Generic USB Device.
SubMsgID: 05, 00: Set Quad PosDemandParams
XPosDemandMin:.01, 80: 0x8001 (-32767 decimal), i.e. -10 V.
YPosDemandMin:. 01, 80: 0x8001 (-32767 decimal), i.e. -10 V.
XPosDemandMax: FF, 7F: 0x7FFF (32767 decimal), i.e. 10 V.
YPosDemandMax: FF, 7F: 0x7FFF (32767 decimal), i.e. 10 V.
LVOutRoute: 02, 00 i.e. SMA + Hub
OpenLoopPosDemand:.01, 00: i.e. Zero.
XPosDemandFBSense:. FF, 7F: i.e. Positive sense, gain = 1.
YPosDemandFBSense: 9A, D9: i.e. Positive sense, gain = 0.3.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	05	00	d	s

TX 71, 08, 05, 00, 50, 01,

GET:
Command structure (22 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
72	08	12	00	d|	s	SubMsgID		XPosDemMin		YPosDemMin	

12	13	14	15	16	17						
Data											
XPosDemMax		YPosDemMax		LVOutRoute		OLPosDem		XPosFBSense		YPosFBSense	

See Set message for structure

Set/Request/Get Quad_OperMode (sub-message ID = 07)
Used to set the operating mode of the TQD001 Quad Detector T-Cube to either Monitor, Open Loop or Closed Loop mode as described below.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
70	08	08	00	d|	s	SubMsgID		Mode	

Data Structure:

field	description	format
SubMsg ID	The message ID (i.e. 0700) of the message containing the parameters	word
Mode	The operating mode of the unit. When operating in 'Monitor' mode, the X axis (XDIFF) and Y axis (YDIFF) difference signals from the detector, are fed through to the rear panel SMA connectors for use in a monitoring application. When in ‘Open Loop’ mode, the signals at the rear panel are fixed at zero (0V), or held at the last closed loop value, depending on the setting of the ‘OpenLoopPosDemands parameter in the QuadPosDemandParams message. This is useful when the system is being adjusted manually, to position the light beam within the detector array. In ‘Closed Loop’ mode, the feedback circuit sends position demand signals (XOut & YOut) to the rear panel XDIFF and YDIFF connectors, which can be used to drive a pair of positioning elements (e.g. piezo drivers) in order to position the light beam within the center of the detector array. The mode is set as follows: 1 Monitor Mode 2 OpenLoop 3 ClosedLoop	word

Example: Set the operating mode to closed loop

TX 70, 08, 04, 00, D0, 01, 07, 00, 03, 00,

Header: 70, 08, 04, 00, D0, 01: Quad_SetPARAMS, 04 byte data packet, Generic USB Device.
SubMsgID: 07, 00: SetQuadOperMode
Mode: *03, 00,:* Set closed loop mode

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	Msg Ident	00	d	s

GET:
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
70	08	08	00	d|	s	SubMsgID		Mode	

For structure see Set message above.

Request/Get Quad_Status Bits (sub-message ID = 9)
This sub command can be used to request the TQD001 or TPA101 status bits. The message only has a request/ get part.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	09	00	d	s

TX 71, 08, 09, 00, 50, 01,

GET:
Status update messages are received with the following format:-

Response structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
72	08	06	00	d|	s	SubMsgID		StatusBits			

Data Structure:

field	description	format
MsgID	The message ID (0900) of the message containing the parameters	word
StatusBits	The individual bits (flags) of the 32 bit integer value are described in the following table.	dword

TQD001 or TPA101 controller

Hex Value	Bit Number	Description
0x00000001	1	Position Monitoring Mode (1 - enabled, 0 - disabled).
0x00000002	2	Open Loop Operating Mode (1 - enabled, 0 – disabled)
0x00000004	3	Closed Loop Operating Mode (1 - enabled, 0 – disabled)
0x00000008	4 to 32	For Future Use

Example

RX 72, 08, 06, 00, D0, 50, 09, 00, 2B, 00, 00, 00

Header: 02, 08, 06, 00, D0, 50: Quad_Get_Params, 06 byte data packet, Generic USB Device.
MsgID: 09, 00: Get Status Bits
StatusBits: 04,00,00,00, i.e. 100 Closed Loop operating mode is enabled.

Set/Request/Get Quad Display Settings (sub-message ID = 0B)

This message can be used to adjust or read the front panel LED display brightness and the display units.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
70	08	08	00	d|	s	SubMsgID		DispIntensity		Unused		Unused	

Data Structure:

field	description	format
MsgID	The message ID (i.e. 0B00) of the message containing the parameters	word
DispIntensity	The intensity is set as a value from 0 (Off) to 255 (brightest).	word
Reserved	N/A	word
Reserved	N/A	word

Example: Set the display to max brightness:

TX 70, 08, 08, 00, D0, 01, 0B, 00, FF, 00, 00, 00, 00, 00

Header: 70, 08, 08, 00, D0, 01: Quad_SetParams, 08 byte data packet, Generic USB Device.
SubMsgID: 0B, 00: Set Display Settings
DispIntensity: FF, 00: Sets the display brightness to 255 (100%)

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	0B	00	d	s

Example: TX 71, 08, 0B, 00, 50, 01

GET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
72	08	08	00	d|	s	SubMsgID		DispIntensity		Unused		Unused	

See SET for data structure.

Set/Request/Get Quad_PositionOutputs (sub-message ID = 0D)

This sub message can be used to set and get the position demand signals (on the XDIFF, YDIFF connectors).

When the quad detector unit is used with a beam steering device (e.g. a piezo mirror via piezo drivers), this message allows the beam to be positioned by entering a value (-10 V to +10V) in the XPos and YPos parameters.

SET:

Status update messages are received with the following format:-

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
70	08	06	00	d|	s	SubMsgID		XPos		YPos	

Data Structure:

field	description	format
MsgID	The message ID (i.e. 0D00) of the message containing the parameters	word
XPos	The X axis position output value -10 V to 10 V (i.e. -32768 to 32767)	short
YPos	The Y axis position output value -10 V to 10 V (i.e. -32768 to 32767)	short

Example Set the XPos and YPos signals to be -10 V and 10V respectively.

TX 70, 08, 06, 00, D0, 01, 0D, 00, 01, 80, FF, 7F

Header: 70, 08, 06, 00, D0, 01: Quad_Get_Params, 06 byte data packet, Generic USB Device.
MsgID: 0D, 00: Get Quad_PositionOutputs
XPos:. 01, 80: 0x8001 (-32767 decimal), i.e. -10 V.
YPos: FF, 7F: 0x7FFF (32767 decimal), i.e. 10 V.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	0D	00	d	s

TX 71, 08, 0D, 00, 50, 01,

GET:

Status update messages are received with the following format:-

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
72	08	06	00	d|	s	SubMsgID		XPos		YPos	

Set/Request/Get Quad_LoopParams2 (sub-message ID = 0E)

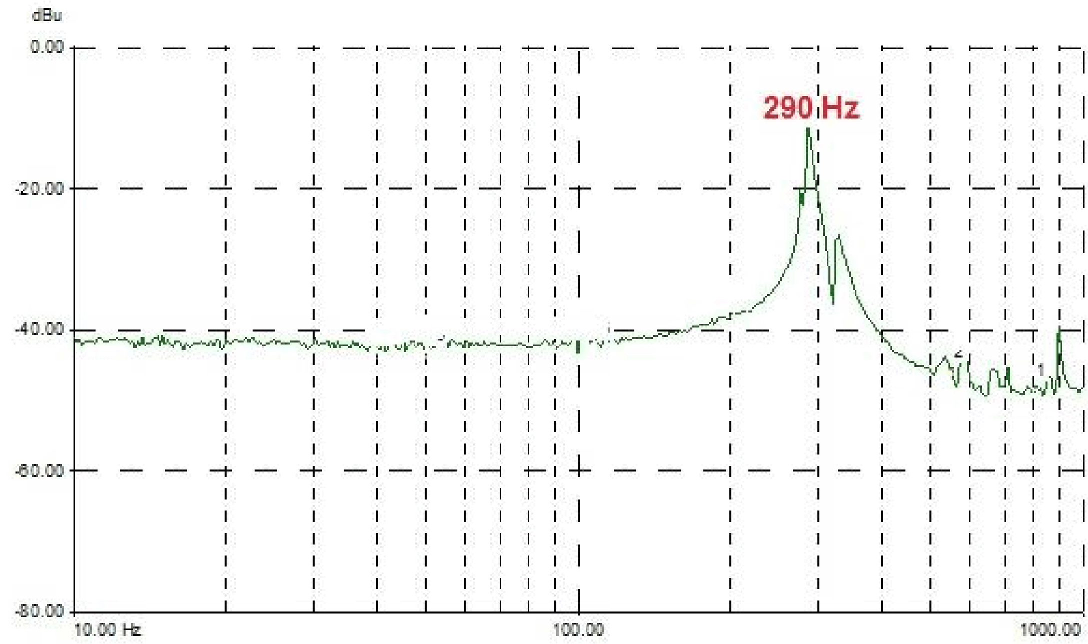
This sub-message is applicable only to the TPA101 unit.

Used to set the proportional, integration and differential feedback loop constants and also to set the derivative cut off frequency and the notch filter center frequency.

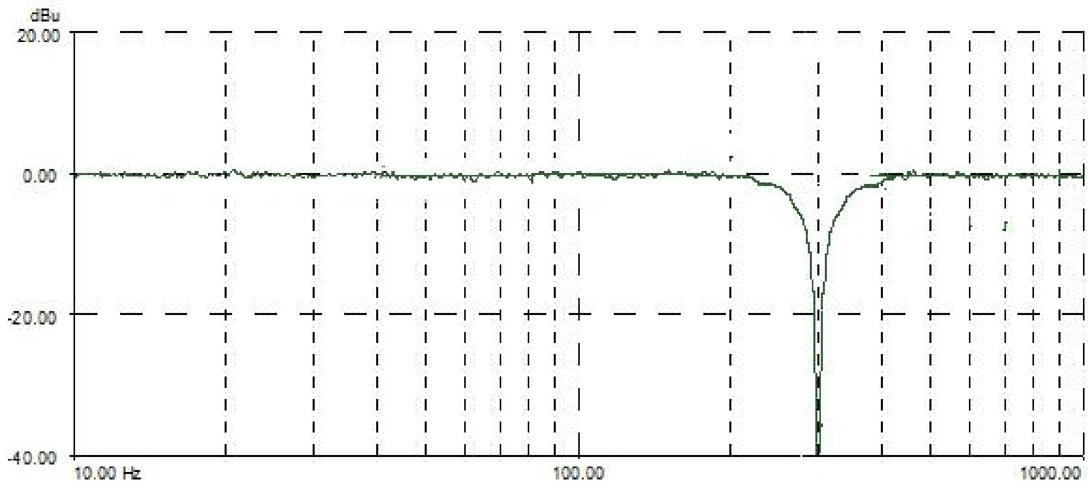
PID Constants: The PID constants apply when the unit is operated in closed loop mode, and position demand signals are generated at the rear panel SMA connectors by the feedback loops. These position demand voltages act to move the beam steering elements (e.g. a piezo driven mirror) in order to centralize a beam at the centre of the PSD head.
When operating in closed loop mode, the proportional, integral and differential (PID) constants can be used to fine tune the behaviour of the dual feedback loops to adjust the response of the position demand output voltages. The feedback loop parameters need to be adjusted to suit the different types of sensor that can be connected to the system. The default values have been optimized for the PDQ80A sensor.

*Derivative Filte*r: The output of the derivative (differential) part of the PID controller can be passed through a tuneable low pass filter. Whilst the derivative component of the PID loop often improves stability (as it acts as a retaining force against abrupt changes in the system), it is prone to amplifying noise present in the system, as the derivative component is sensitive to changes between adjacent samples. To reduce this effect, a low pass filter can be applied to the samples. As noise often tends to contain predominantly high frequency components, the low pass filter can significantly decrease their contribution, often without diminishing the beneficial, stabilizing effect of the derivative action. In some applications enabling this filter can improve the overall closed loop performance.

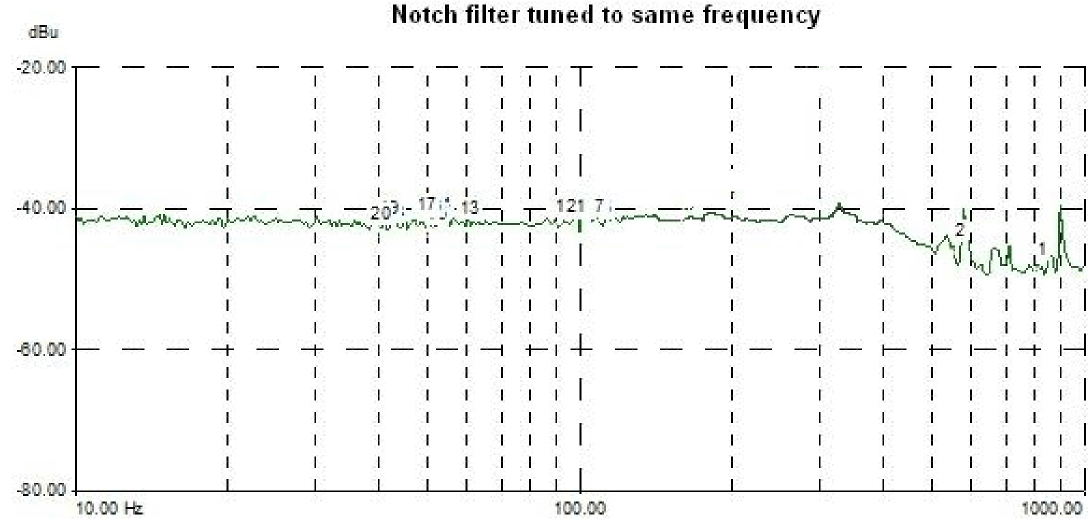
Notch Filter: Due to their construction, most actuators are prone to mechanical resonance at well-defined frequencies. The underlying reason is that all spring-mass systems are natural harmonic oscillators. This proneness to resonance can be a problem in closed loop systems because, coupled with the effect of the feedback, it can result in oscillations. With some actuators (for example the ASM003), the resonance peak is either weak enough or at a high enough frequency for the resonance not to be troublesome. With other actuators (for example the PGM100) the resonance peak is very significant and needs to be eliminated for operation in a stable closed loop system. The notch filter is an adjustable electronic anti-resonance that can be used to counteract the natural resonance of the mechanical system. As the resonance frequency of actuators varies with load in addition to the minor variations from product to product, the notch filter is tuneable so that its characteristics can be adjusted to match those of the actuator. In addition to its centre frequency, the bandwidth of the notch (or the equivalent quality factor, often referred to as the Q-factor) can also be adjusted. In simple terms, the Q factor is the centre frequency/bandwidth, and defines how wide the notch is, a higher Q factor defining a narrower ("higher quality") notch. Optimizing the Q factor requires some experimentation but in general a value of 5 to 10 is in most cases a good starting point.



Frequency response of actuator showing resonance at 290 Hz



Notch filter tuned to same frequency



The resonance is largely eliminated

SET:

Command structure (36 bytes)

6 byte header followed by 30 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
70	08	1E	00	d|	s	SubMsgID		PIDConstsP				PIDConstsI	

14	15	16	17	18	19	20	21	22	23	24	25	26	27
Data													
PIDConstsI		PIDConstsD				PIDConstsDFc				FilterFc			

28	29	30	31	32	33	34	34
Data							
FilterQ				NotchFilterOn		PIDDerivFilterOn	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0E,00) of the message containing the parameters	word
PIDConstsP	The proportional gain. This term provides the force used to drive the piezo to the demand position, reducing the positional error. Together with the Integral and Differential, these terms determine the system response characteristics and accept values in the range 0 to 10000.	float
PIDConstsI	The integral gain. This term provides the 'restoring' force that grows with time, ensuring that the positional error is eventually reduced to zero. Together with the Proportional and Differential, these terms determine the system response characteristics and accept values in the range 0 to 10000.	float
PIDConstsD	The differential gain. This term provides the 'damping' force proportional to the rate of change of the position. Together with the Proportional and Integral, these terms determine the system response characteristics and accept values in the range 0 to 10000.	float
PIDConstsDFc	The cut off frequency of the Derivative Low Pass Filter, in the range 0 to 10,000	float
FilterFc	The Notch Filter center frequency, in the range 0 to 10,000	float
FilterQ	The Notch Filter Q factor, in the range 0.1 to 100	float
NotchFilterOn	Turns the notch filter on (set to 1) and off (set to 2)	word
PIDDerivFilterOn	Turns the derivative filter on (set to 1) and off (set to 2)	word

Example: Set the PID parameters for TPA101 as follows:
Proportional: 65.7
Integral: 80.3
Differential: 60.9
Derivative LP Cutoff: 500 Hz
Notch Filter Center Freq: 500Hz
Q Factor: 5.0
Notch Filter ON
Derivative Filter ON

TX 70, 08, 1E, 00, D0, 01, 0E, 00, 66, 66, 83, 42, 9A, 99, A0, 42, 9A, 99, 73, 42, 00, 00, FA, 43, 00, 00, FA, 43, 00, 00, A0, 40, 01, 00, 01, 00

Header: 70, 08, 1E, 00, D0, 01: Quad_SetParams, 30 byte data packet, Generic USB Device.
SubMsgID: 0E, 00 SetQuadControlLoopParams2)
Prop: *66, 66, 83, 42:* Set the proportional term to 65.7
Int: *9A, 99, A0, 42*: Set the integral term to 80.3
Deriv: 9A, 99, 73, 42: Set the differential term to 60.9
Derivative LP Cut Off: 00, 00, FA, 43: Set the low pass cut off frequency to 500 Hz
Notch Filter Center: 00, 00, FA, 43: Set the notch filter center frequency to 500 Hz
Q Factor: 00, 00, A0, 40: Set the Q factor to 5.0
Notch Filter ON: 01, 00: Set the notch filter ON
Derivative Filter ON: 01, 00: Set the low pas filter ON.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
71	08	01	00	d	s

GET:
6 byte header followed by 30 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
72	08	1E	00	d|	s	SubMsgID		PIDConstsP				PIDConstsI	

14	15	16	17	18	19	20	21	22	23	24	25	26	27
Data													
PIDConstsI		PIDConstsD				PIDConstsDFc				FilterFc			

28	29	30	31	32	33	34	35
Data							
FilterQ				NotchFilterOn		PIDDerivFilterOn	

For structure see Set message above.

MGMSG_QUAD_REQ_STATUSUPDATE 0x0880
MGMSG_ QUAD_GET_STATUSUPDATE 0x0881

Function: This function is used in applications where spontaneous status messages (i.e. messages sent using the START_STATUSUPDATES command) must be avoided.
Status update messages contain information about the position and status of the controller (for example position and O/P voltage). The response will be sent by the controller each time the function is requested.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
80	08	00	00	d	s

GET:

Status update messages are received with the following format:-

Response structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
81	08	0E	00	d|	s	XDiff		YDiff		Sum		XPos	

14	15	16	17	18	19
header only					
YPos		Status Bits			

Data Structure:

field	description	format
XDiff	The present X axis difference (XDIFF) signal from the detector head. (-10V to 10V in the range -32768 to 32767)	short
YDiff	The present Y axis difference (XDIFF) signal from the detector head. (-10V to 10V in the range -32768 to 32767)	short
Sum	The present Sum signal value from the detector head (0V to 10V in the range 0 to 65535)	word
XPos	The X axis position output value -10 V to 10 V (i.e. -32768 to 32767)	short
YPos	The Y axis position output value -10 V to 10 V (i.e. -32768 to 32767)	short
StatusBits	The individual bits (flags) of the 32 bit integer value are described in the following table	dword

TQD001 or TPA101 controller Status Bits

Hex Value	Bit Number	Description
0x00000001	1	Position Monitoring Mode (1 - enabled, 0 - disabled).
0x00000002	2	Open Loop Operating Mode (1 - enabled, 0 – disabled)
0x00000004	3	Closed Loop Operating Mode (1 - enabled, 0 – disabled)
0x00000008	4 to 32	For Future Use

Example

RX 81, 08, 0E, 00, 81, 50, FF, 3F, FF, 3F, FF, 7F, 00, 00, 00, 00

Header: 81, 08, 0E, 00, 81, 50: QUAD_Get_StatusUpdate, 14 byte data packet, Generic USB Device.
XDiff:.FF, 3F: 0x3FFF (16383 decimal), i.e. 5 V.
YDiff:. FF, 3F: 0x3FFF (16383 decimal), i.e. 5 V.
Sum: FF, FF: (65535 decimal), i.e. 10 V.
XPos: 00, 00 i.e. Zero
YPos: 00, 00 i.e. Zero
StatusBits: 04,00,00,00, i.e. 100 Closed Loop operating mode is enabled.

MGMSG_QUAD_ACK_STATUSUPDATE 0x0882

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called “server alive” must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5
header only					
82	08	00	00	d	s

TX 82, 08, 00, 00, 21, 01

MGMSG_QUAD_SET_EEPROMPARAMS 0x0875

Function: Used to save the parameter settings for the TQD001 or TPA101 unit. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:

Command structure (8 bytes)

6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
75	08	02	00	d|	s	SubMsgID	

Data Structure:

field	description	format
SubMsgID	For future use	word

Example:

TX 75, 08, 02, 00, D0, 01, 00, 00,

Header: E7, 07, 04, 00, D0, 01: Set_EEPROMPARAMS, 02 byte data packet, Generic USB Device.

TEC Control Messages

Introduction

The ActiveX functionality for the TEC Controller is accessed via the APTTEC Control Object, and provides the functionality required for a client application to control a number of T-Cube TEC Controller units.

Every hardware unit is factory programmed with a unique 8-digit serial number. This serial number is key to operation of the APT Server software and is used by the Server to enumerate and communicate independently with multiple hardware units connected on the same USB bus.

The serial number must be allocated using the HWSerialNum property, before an ActiveX control can communicate with the hardware unit. This can be done at design time or at run time.

The methods of the T-Cube TEC Controller can then be used to perform activities such as switching between display modes, reading the present TEC element temperature, and setting the LED display intensity.

For details on the use of the TEC T-Cube Controller, refer to the handbook supplied for the unit.

MGMSG_TEC_SET_PARAMS 0x0840
MGMSG_TEC_REQ_PARAMS 0x0841
MGMSG_TEC_GET_PARAMS 0x0842

Function: This generic parameter set/request message is used to control the functionality of the TEC001. The specific parameters to control are identified by the use of sub-messages. These sub messages comply with the general format of the APT message protocol but rather than having a unique first and second byte in the header carrying the "message identifier" information, the first and second byte remain the same.
Instead, for the SET and GET messages, the message identifier is carried in the first two bytes in the data packet part of the message, whilst for the REQ message it is encoded as the third byte of the header.
Likewise, when the TEC001 responds, the first two bytes of the response remain the same and the first two bytes of the data packet identify the sub-message to which the information returned in the remaining part of the data packet relates.

The following sub messages are applicable to the TEC001:

Set/Request/Get TEC_TempSetPoint (sub-message ID = 01)
Request/Get_TEC_Readings (sub-message ID = 03)
Set/Request/Get_IOSettings (sub-message ID = 05)
Request/Get_TEC_StatusBits (sub-message ID = 07)
Set/Request/Get_TEC_LoopParams (sub-message ID = 09)
Set/Request/Get TEC_Disp_Settings (sub-message ID = 0B)

To explain the principle, the following examples describe these messages in more detail.

Set/Request/Get TEC_TempSetPoint (sub-message ID = 01)
Used to set the target temperature of the TEC element associated with the ActiveX control instance.

SET:
Command structure (10 bytes)
6 byte header followed by 4 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
40	08	04	00	d|	s	SubMsgID		TSet	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0100) of the message containing the parameters	word
TSet	Used to set the target temperature of the TEC element associated with the ActiveX control instance. Note. The units in which the temperature is returned are	word

	dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ). For a 200 kΩ. sensor the range is 0 to20000 (0 to 200 kΩ.).	

Example: Set the Temperature Setpoint for TEC001 as follows:
TSet: 65 °C

TX 40, 08, 04, 00, D0, 01, 01, 00, 64, 19

Header: 70, 08, 08, 00, D0, 01: TEC_SetTempSetPoint, 4 byte data packet, Generic USB Device.
SubMsgID: 01, 00 SetTempSetPoint
TSet: *64, 19 ,(6500):* Set the set point to 65 °C

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	01	00	d	s

GET:
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
42	08	04	00	d|	s	SubMsgID		TSet	

For structure see Set message above.

Request/Get TEC_Readings (sub-message ID = 3)
This message returns the present readings of the TEC unit as follows:
ITec The TEC output current in mA. (0 to 2000mA in the range -0 to 2000)
TAct The actual temperature of the TEC element associated with the ActiveX control instance.
Note. The units in which the temperature is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ For a 200 kΩ sensor the range is 0 to20000 (0 to 200 kΩ).
TSet The temperature setpoint of the TEC element associated with the ActiveX control instance.
Note. The units in which the setpoint is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ For a 200 kΩ sensor the range is 0 to20000 (0 to 200 kΩ).

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	03	00	d	s

TX 41, 08, 03, 00, 50, 01,

GET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
42	08	08	00	d|	s	SubMsgID		ITec		TAct		TSet	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0300) of the message containing the parameters	word
ITec	Returns the TEC output current in mA. (0 to 2000mA in the range -0 to 2000)	short
TAct	Returns the present temperature of the TEC element associated with the ActiveX control instance. Note. The units in which the temperature is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ). For a 200 kΩ. sensor the range is 0 to20000 (0 to 200 kΩ.).	short

TSet	Returns the target temperature of the TEC element associated with the ActiveX control instance. Note. The units in which the temperature is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ). For a 200 kΩ. sensor the range is 0 to20000 (0 to 200 kΩ.).	word

Example: Get the Quad Detector T-Cube readings (T-Cube in open loop mode)

RX 42, 08, 08, 00, D0, 01, 03, 00, E8, 03, DC, 05, 40, 1F,

Header: 42, 08, 08, 00, D0, 01: TEC_GetPARAMS, 8 byte data packet, Generic USB Device.
MsgID: 03, 00: Get Quad Readings
ITec:.E8, 03: 0x03E8 (1000 decimal), i.e. 1 V.
TAct:. DC, 05: 0x05DC (1500 decimal), i.e. 1.5 V.
TSet: 40, 1F: 0x1F40 (8000 decimal), i.e. 80 °C.

Set/Request/Get IOSettings (sub-message ID = 5)

This message sets the type of TEC element associated with the ActiveX control instance.
If an AD59x transducer is selected, the temperature is set and displayed in °C.
If a 20kOhm or 200kOhm thermistor is selected, the temperature is set and displayed in kOhms.

SET:

Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
40	08	06	00	d|	s	SubMsgID		wSensor		sILim	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0500) of the message containing the parameters	word
wSensor	This parameter contains constants that specify the type of TEC element controlled by the unit. 0 SENSOR_IC_AD59X TEC element is a AD59x IC type transducer. 1 SENSOR_THERM20KOHM TEC element is a 20kOhm thermistor. 2 SENSOR_THERM200KOHM TEC element is a 200kOhm thermistor.	word
sILim	This parameter returns the maximum current that the TEC controller associated with the ActiveX control instance can source into the TEC element. Values are set in the range 0 to 2000 (0 to 2000 mA).	short

Example: Set the TEC IO Settings as follows

RX 40, 08, 0C, 00, D0, 01, 05, 00, 01, 00, 01, 80

Header: 42, 08, 0C, 00, D0, 01: TEC_SetPARAMS, 6 byte data packet, Generic USB Device.
SubMsgID: 05, 00: Set TEC_IOSettings
wSensor:.01, 00: 0x0001 i.e. AD59x IC type transducer.
sILim:. E8, 03: 0x03E8 (10000 decimal), i.e. 1A.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	05	00	d	s

TX 41, 08, 05, 00, 50, 01,

GET:
Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
42	08	06	00	d|	s	SubMsgID		wSensor		sILim	

See Set message for structure

Request/Get TEC_Status Bits (sub-message ID = 7)

This sub command can be used to request the TEC001 status bits. The message only has a request/ get part.

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	07	00	d	s

TX 41, 08, 07, 00, 50, 01,

GET:

Status update messages are received with the following format:-

Response structure (12 bytes)

6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
42	08	06	00	d|	s	SubMsgID		StatusBits			

Data Structure:

field	description	format
MsgID	The message ID (0700) of the message containing the parameters	word
StatusBits	The individual bits (flags) of the 32 bit integer value are described in the following table.	dword

TEC controller Status Bits

Hex Value	Bit Number	Description
0x00000001	1	TEC output enabled state (1 - enabled, 0 - disabled).
	2 to 4	For Future Use
0x00000010	5	Display mode (1 – TAct, 0 - else).
0x00000020	6	Display mode (1 – TSet, 0 - else).
0x00000040	7	Display mode (1 – TDelta, 0 - else).
0x00000080	8	Display mode (1 – ITec, 0 - else).
	9 to 30	For Future Use
0x40000000	31	Error
0x80000000	32	For Future Use

Example

RX 42, 08, 06, 00, 81, 50, E8, 03, DC, 05, 40, 1F, 11, 00, 00, 00

Header: 42, 08, 06, 00, 81, 50: TEC_SetParams, 6 byte data packet, Generic USB Device.
SubMsgID: 07, 00: Set TEC_StatusBits

StatusBits: 11,00,00,00, 0X00000011 (17 decimal) i.e. TEC is enabled with Tact display mode selected. No errors.

Set/Request/Get TEC_LoopParams (sub-message ID = 9)

Used to set the proportional, integration and differential feedback loop constants to the value specified in the PGain, IGain and DGain parameters respectively. They apply when the TEC unit is operated in closed loop mode, and demand signals are generated at the rear panel connectors by the feedback loops. These demand signals act to drive the heating element to the temperature required.

When operating in closed loop mode, the proportional, integral and differential (PID) constants can be used to fine tune the behaviour of the dual feedback loops to adjust the response of the temperature demand output current. The feedback loop parameters need to be adjusted to suit the different types of sensor that can be connected to the system.

SET:

Command structure (14 bytes)

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
70	08	08	00	d|	s	SubMsgID		PGain		IGain		DGain	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 09,00) of the message containing the parameters	word
PGain	The proportional gain. This term provides the force used to drive the output to the demand set point, reducing the positional error. Together with the Integral and Differential, these terms determine the system response characteristics and accept values in the range 1 to 32767 (i.e. 1 to 100 in APT User GUI).	word
IGain	The integral gain. This term provides the ‘restoring’ force that grows with time, ensuring that the set point error is eventually reduced to zero. Together with the Proportional and Differential, these terms determine the system response characteristics and accept values in the range 0 to 32767 (i.e. 0 to 100 in APT User GUI).	word
DGain	The differential gain. This term provides the ‘damping’ force proportional to the rate of change of the temperature. Together with the Proportional and Integral, these terms determine the system response characteristics and accept values in the range 0 to 32767 (i.e. 0 to 100 in APT User GUI).	word

Example: Set the PID parameters for TEC001 as follows:
Proportional: 65
Integral: 80
Differential: 60

TX 40, 08, 08, 00, D0, 01, 09, 00, 41, 00, 50, 00, 3C, 00,

Header: 40, 08, 08, 00, D0, 01: TEC_SetParams, 8 byte data packet, Generic USB Device.

SubMsgID: 09, 00 Set_TECLoopParams)
PGain: *32, 53,(32767x65/100):* Set the proportional term to 65
IGain: *65, 66, (32767x80/100)*: Set the integral term to 80
DGain: CC, 4C, *(32767x60/100)*: Set the differential term to 60

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	09	00	d	s

GET:
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
72	08	08	00	d|	s	SubMsgID		PGain		IGain		DGain	

For structure see Set message above.

Set/Request/Get TEC Display Settings (sub-message ID = 0B)

This message can be used to adjust or read the front panel LED display brightness and the display units.

SET:
Command structure (14 bytes)
6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
40	08	08	00	d|	s	SubMsgID		DispIntensity		DispMode		Unused	

Data Structure:

field	description	format
MsgID	The message ID (i.e. 0B00) of the message containing the parameters	word
DispIntensity	The intensity is set as a value from 0 (Off) to 255 (brightest).	word
DispMode	The LED display window on the front of the unit can be set to display four different values; the actual temperature of the TEC element (TAct), the difference between the actual temperature and the set point (TDelta), the applied current (ITec), or the demanded set point value (TSet). 0 DISPMODE_TACT the display shows the actual temperature of the TEC element 1 DISPMODE_TSET the display shows the demanded set point value. 2 DISPMODE_DELTA the display shows the difference between the actual temperature (TAct) and the set point temperature (TSet).. 3 DISPMODE_ITEC the display shows the current (in Amps) sourced into the TEC element by the controller.	word
Reserved	N/A	word

Example: Set the display to max brightness and the display mode to TAct

TX 40, 08, 08, 00, D0, 01, 0B, 00, FF, 00, 01, 00, 00, 00

Header: 40, 08, 08, 00, D0, 01: TEC_SetParams, 08 byte data packet, Generic USB Device.
SubMsgID: *0B, 00: Set Display Settings*
DispIntensity: *FF, 00*: Sets the display brightness to 255 (100%)
DispMode: 01, 00 Sets the display to show the actual temperature of the TEC element.

REQ:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
41	08	0B	00	d	s

Example: TX 41, 08, 0B, 00, 50, 01

GET:

Command structure (14 bytes)

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
42	08	08	00	d|	s	SubMsgID		DispIntensity		DispMode		Unused	

See SET for data structure.

MGMSG_TEC_SET_EEPROMPARAMS 0x0850

Function: Used to save the parameter settings for the TEC001 unit. These settings may have been altered either through the various method calls or through user interaction with the GUI (specifically, by clicking on the 'Settings' button found in the lower right hand corner of the user interface).

SET:
Command structure (8 bytes)
6 byte header followed by 2 byte data packet as follows:

0	1	2	3	4	5	6	7
header						*Data*	
50	08	02	00	d|	s	SubMsgID	

Data Structure:

field	description	format
SubMsgID	For future use	word

Example:

TX 75, 08, 02, 00, D0, 01, 00, 00,

Header: E7, 07, 04, 00, D0, 01: Set_EEPROMPARAMS, 02 byte data packet, Generic USB Device.

MGMSG_TEC_REQ_STATUSUPDATE 0x0860
MGMSG_ TEC_GET_STATUSUPDATE 0x0861

Function: This function is used in applications where spontaneous status messages (i.e. messages sent using the START_STATUSUPDATES command) must be avoided.
Status update messages contain information about the output current and actual temperature of the transducer. The response will be sent by the controller each time the function is requested.

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
60	08	00	00	d	s

GET:
Status update messages are received with the following format:-

Response structure (16 bytes)
6 byte header followed by 10 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
61	08	0E	00	d|	s	ITec		TAct		TSet	

12	13	14	15
header only			
Status Bits			

Data Structure:

field	description	format
ITec	The TEC output current in mA. (0 to 2000mA in the range -0 to 2000)	short
TAct	The actual temperature of the TEC element associated with the ActiveX control instance. Note. The units in which the temperature is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°). For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ). For a 200 kΩ. sensor the range is 0 to20000 (0 to 200 k Ω.).	short
TSet	The temperature setpoint of the TEC element associated with the ActiveX control instance. Note. The units in which the setpoint is returned are dependent upon the 'Sensor Type' selected (via the Settings panel or by calling the SetTempSetPoint submessage). If an IC type sensor is selected, the set point temperature is displayed in °C in the range -4500 to 14500 (45.0° to 145.0°).	word

	For a 20 kΩ.thermistor sensor, the set point is displayed in kΩ in the range 0 to 2000 (0 to 20 kΩ). For a 200 kΩ. sensor the range is 0 to20000 (0 to 200 k Ω.).	
StatusBits	The individual bits (flags) of the 32 bit integer value are described in the following table	dword

TEC controller Status Bits

Hex Value	**Bit Number**	**Description**
0x00000001	1	TEC output enabled state (1 - enabled, 0 - disabled).
	2 to 4	For Future Use
0x00000010	5	Display mode (1 – TAct, 0 - else).
0x00000020	6	Display mode (1 – TSet, 0 - else).
0x00000040	7	Display mode (1 – TDelta, 0 - else).
0x00000080	8	Display mode (1 – ITec, 0 - else).
	9 to 30	For Future Use
0x40000000	31	Error
0x80000000	32	For Future Use

Example

RX 61, 08, 0A, 00, 81, 50, E8, 03, DC, 05, 40, 1F, 11, 00, 00, 00

Header: 61, 08, 0A, 00, 81, 50: TEC_Get_StatusUpdate, 10 byte data packet, Generic USB Device.
ITec:.E8, 03: 0x03E8 (1000 decimal), i.e. 1 V.
TAct:. DC, 05: 0x05DC (1500 decimal), i.e. 1.5 V.
TSet: 40, 1F: 0x1F40 (8000 decimal), i.e. 80 °C.
StatusBits: 11,00,00,00, 0X00000011 (17 decimal) i.e. TEC is enabled with Tact display mode selected. No errors.

MGMSG_TEC_ACK_STATUSUPDATE 0x0862

Only Applicable If Using USB COMMS. Does not apply to RS-232 COMMS

Function: If using the USB port, this message called “server alive” must be sent by the server to the controller at least once a second or the controller will stop responding after ~50 commands.
The controller keeps track of the number of "status update" type of messages (e.g.move complete message) and it if has sent 50 of these without the server sending a "server alive" message, it will stop sending any more "status update" messages.
This function is used by the controller to check that the PC/Server has not crashed or switched off. There is no response.

Structure (6 bytes):

0	1	2	3	4	5

header only					
82	08	00	00	d	s

TX 62, 08, 00, 00, 21, 01

TIM Control Messages

Introduction

The ActiveX functionality for the TIM101 Piezo Motor Controller is accessed via the APTPZMOT Control Object, and provides the functionality required for a client application to control a number of T-Cube Controller units.
Every hardware unit is factory programmed with a unique 8-digit serial number. This serial number is key to operation of the APT Server software and is used by the Server to enumerate and communicate independently with multiple hardware units connected on the same USB bus.
The serial number must be allocated using the HWSerialNum property, before an ActiveX control can communicate with the hardware unit. This can be done at design time or at run time.
The methods of the T-Cube TIM Controller can then be used to perform activities such as setting the drive voltage, setting the jog step size and setting top panel button parameters.

Note. The channel being addressed must be enabled by calling the SetChanEnableState method, before the following methods can be used.

For details on the use of the TIM101 T-Cube Controller, refer to the handbook supplied for the unit.

MGMSG_PZMOT_SET_PARAMS 0x08C0
MGMSG_ PZMOT_REQ_PARAMS 0x08C1
MGMSG_ PZMOT_GET_PARAMS 0x08C2

Function: This generic parameter set/request message is used to control the functionality of the TIM101. The specific parameters to control are identified by the use of sub-messages. These sub messages comply with the general format of the APT message protocol but rather than having a unique first and second byte in the header carrying the "message identifier" information, the first and second byte remain the same.
Instead, for the SET, REQ and GET messages, the message identifier is carried in the first two bytes in the data packet (7 and 8) part of the message,
Likewise, when the TIM101 responds, the first two bytes of the response remain the same and the first two bytes of the data packet identify the sub-message to which the information returned in the remaining part of the data packet relates.

The following sub messages are applicable to the TIM101:

Set/Request/Get_TIM_PositonConters (sub-message ID = 05)
Set/Request/Get_TIM_DriveParameters (sub-message ID = 07)
Set/Request/Get_TIM_JogParameters (sub-message ID = 09)
Set/Request/Get TIM_PotParameters (sub-message ID = 11)
Set/Request/Get TIM_ButtonParameters (sub-message ID = 13)

To explain the principle, the following examples describe these messages in more detail.

Set/Request/Get_TIM_PositionCounters (sub-message ID = 05)
This sub-message sets the position counter value, and is usually used to set the counter to zero when the motor is at the required zero position. All absolute moves are then measured from this zeroed position.

SET:
Command structure (18 bytes)
6 byte header followed by 12 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
C0	08	0E	00	d|	s	SubMsgID		ChanIdent	

10	11	12	13	14	15	16	17
Data							
Position				EncCount			

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0500) of the message containing the parameters	word
ChanIdent	The channel to be addressed. Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
Position	The position counter value, specified in number of steps.	long
EncCount	Not Used	long

Example: Set the TIM Position Counter

TX C0, 08, 0C, 00, D0, 01, 05, 00, 01, 00, 00, 00, 00, 00, 00, 00, 00, 00

Header: C0, 08, OC, 00, D0, 01: PZMOT_SET_PARAMS, 12 byte data packet, USB Device.
SubMsgID: 05, 00 *Set_TIM_PositionCounters*
ChanIdent: 01, 00 Channel 1
Position: 00, 00, 00, 00 Zero
EncCount: 00, 00, 00, 00 Not Used

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	08	05	01	d	s

TX C1, 08, 05, 01, D0, 01,

GET:
Command structure (20 bytes)
6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9
header						*Data*			
C0	08	0E	00	d|	s	SubMsgID		ChanIdent	

10	11	12	13	14	15	16	17
Data							
Position				EncCount			

See Set message for structure

Set/Request/Get_TIM_DriveOPParameters (sub-message ID = 07)

This sub-message sets various drive parameters which define the speed and acceleration of moves initiated in the following ways:

- by clicking in the position display
- via the panel buttons when 'Go To Position' mode is selected (in the Set_TIM_JogParameters sub-message).
- via software using the MoveVelocity, MoveAbsoluteStepsEx or MoveRelativeStepsEx methods.

Note. Drive parameters for Jog moves are specified in the Set_TIM_JogParameters sub-message.

SET:

Command structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C0	08	0E	00	d|	s	SubMsgID		ChanIdent		MaxVoltage	

12	13	14	15	16	17	18	19
Data							
StepRate				StepAccn			

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0700) of the message containing the parameters	word
ChanIdent	The channel to be addressed. Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
MaxVoltage	The maximum piezo drive voltage, in the range 85V to 125V.	word
StepRate	The piezo motor moves by ramping up the drive voltage to the value set in the MaxVoltage parameter and then dropping quickly to zero, then repeating. One cycle is termed a step. This parameter specifies the velocity to move when a command is initiated. The step rate is specified in steps/sec, in the range 1 to 2,000.	long
StepAccn	This parameter specifies the acceleration up to the step rate, in the range 1 to 100,000 cycles/sec/sec.	long

Example: Set the TIM Drive Params

TX C0,08,0E,00,81,50,07,00,01,00,6E,00,F4,01,00,00,A0,86,01,00

Header: C0, 08, OE, 00, 81, 50: PZMOT_SET_PARAMS, 18 byte data packet, USB Device.

SubMsgID: 07, 00	*Set_TIM_DriveParameters*	
ChanIdent: 01, 00	Channel 1	
MaxVoltage: 6E, 00	100V	(6E)
StepRate: F4, 01, 00, 00	500 Steps/Sec	(01F4)

StepAccn: A0, 86, 01, 00 10,000 Steps/Sec/Sec (0186A0

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	08	07	01	d	s

TX C1, 08, 07, 01, 50, 01,

GET:

Command structure (20 bytes)

6 byte header followed by 14 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C2	08	0E	00	d|	s	SubMsgID		ChanIdent		MaxVoltage	

12	13	14	15	16	17	18	19
Data							
StepRate				StepAccn			

See Set message for structure

Set/Request/Get_TIM_JogParameters (sub-message ID = 09)

This sub-message sets various jog parameters which define the speed and acceleration of moves initiated in the following ways:

by clicking the jog buttons on the GUI panel
by pressing the buttons on the unit when 'Single Step' mode is selected.
via software using the MoveJog method.

Note. Drive parameters for motor moves are specified in the Set_TIM_DriveParameters sub-message.

SET:

Command structure (24 bytes)

6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C0	08	12	00	d|	s	SubMsgID		ChanIdent		JogMode	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
JogStepSize				JogStepRate				JogStepAccn			

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 0900) of the message containing the parameters	word
ChanIdent	The channel to be addressed. Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
JogMode	Jog commands can be issued by calling the MoveJog method, via the Motor Control GUI panel or by pressing the buttons on the hardware unit. When a jog command is received, if the jog mode is set to 1 (i.e. 'Continuous') the motor continues to move until the jog signal is removed (i.e. the jog button is released) when the motor will stop immediately. If the mode is set to '2' (i.e. Single Step) the motor moves by the step size specified in the JogStepSize parameter.	word
JogStepSize	A jog step consists of a number of drive pulses. This parameter specifies the number of pulses which make up a jog step, in the range 1 to 2,000.	long
JogStepRate	The piezo motor moves by ramping up the drive voltage to the value set in the Set_TIM_DriveParameters sub-message and then dropping quickly to zero, then repeating. One cycle is termed a step. This parameter specifies the velocity to move when a command is initiated. The step rate is specified in steps/sec, in the range 1 to 2,000	long
JogStepAccn	This parameter specifies the acceleration up to the step rate, in the range 1 to 100,000 cycles/sec/sec.	long

Example: Set the TIM Jog Parameters

TX C0,08,12,00,81,50,09,00,01,00,02,00,FA,00,00,00,F4,01,00,00,A0,86,01,00

Header: C0, 08, 12, 00, 81, 50: PZMOT_SET_PARAMS, 18 byte data packet, Generic USB Device.

SubMsgID: 09, 00	*Set_TIM_JogParameters*	
ChanIdent: 01, 00	Channel 1	
JogMode: 02, 00	Single Step Jog Mode	
JogStepSize: FA. 00, 00, 00	250 steps (FA)	
JogStepRate: F4, 01, 00, 00	500 Steps/Sec	(01F4)
JogStepAccn: A0, 86, 01, 00	10,000 Steps/Sec/Sec	(0186A0

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	08	09	01	d	s

TX C1, 08, 09, 01, 50, 01,

GET:
Command structure (24 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C2	08	12	00	d|	s	SubMsgID		ChanIdent		JogMode	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
JogStepSize				JogStepRate				JogStepAccn			

See Set message for structure

Set/Request/Get_TIM_PotParameters (sub-message ID = 11)

This sub-message defines the speed of a move initiated by the potentiometer on the top panel of the hardware unit.

The potentiometer slider is sprung such that when released it returns to its central position. In this central position the piezo motor is stationary. As the slider is moved away from the centre, the motor begins to move. Bidirectional control of the motor is possible by moving the slider in both directions. The speed of the motor increases as a function of slider deflection.

SET:

Command structure (14 bytes)

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
C0	08	08	00	d|	s	SubMsgID		ChanIdent		MaxStepRate			

Data Structure:

field	description	format
MsgID	The message ID (i.e. 11,00) of the message containing the parameters	word
ChanIdent	The channel to be addressed. Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
MaxStepRate	The speed (in drive pulses per second) of a move initiated by the top panel potentiometer, in the range 1 to 2,000.	long

Example: Set the TIM Pot Parameters

TX C0,08,08,00,81,50,11,00,01,00,E8,03,00,00

Header: C0, 08, 08, 00, 81, 50: TIM_SetParams, 08 byte data packet, Generic USB Device.
SubMsgID:11, 00: *Set_TIM_PotParams*
ChanIdent: 01, 00 Channel 1
MaxStepRate: E8, 03, 00, 00 1000 (03E8) pulses per second

REQUEST:

Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	08	09	01	d	s

TX C1, 08, 11, 01, 50, 01,

GET:

Command structure (14 bytes)

6 byte header followed by 8 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11	12	13
header						*Data*							
C2	08	08	00	d|	s	SubMsgID		ChanIdent		MaxStepRate			

See SET for data structure.

Set/Request/Get_TIM_ButtonParameters (sub-message ID = 13)

The buttons on the top of the unit can be used either to jog the motor, or to perform moves to absolute positions. This sub-message sets the operation mode of the buttons.

SET:

Command structure (24 bytes)

6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C0	08	12	00	d|	s	SubMsgID		ChanIdent		JogMode	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Position1				Position2				TimeOut1		TimeOut2	

Data Structure:

field	description	format
SubMsgID	The message ID (i.e. 1300) of the message containing the parameters	word
ChanIdent	The channel to be addressed. Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
Mode	This parameter specifies the mode of operation of the buttons. If set to '1' (Jog Mode), the front panel buttons are used to jog the motor. Once set to this mode, the move parameters for the buttons are taken from the 'Jog' parameters set via the 'Set_TIM_JogParameters sub-message. If set to '2' (Position Mode) each button can be programmed with a different position value (as set in the Position1 and position2 parameters below), such that the controller will move the motor to that position when the specific button is pressed.	word
Position1	This parameter is applicable only if Position mode is selected above, and is the position to which the motor will move when the top button is pressed. The position is set in number of steps, measured from the zero position.	long
Position2	This parameter is applicable only if Position mode is selected above, and is the position to which the motor will move when the bottom button is pressed. The position is set in number of steps, measured from the zero position.	long
TimeOut1	For Future Use	word
TimeOut2	For Future Use	word

Example: Set the TIM Button Parameters

TX C0,08,12,00,81,50,13,00,01,00,01,00,C8,00,00,00,F4,01,00,00,FA,00,FA,00

Header: C0, 08, 12, 00, 81, 50: PZMOT_SET_PARAMS, 18 byte data packet, Generic USB Device.

SubMsgID: 13, 00	*Set_TIM_ButtonParameters*
ChanIdent: 01, 00	Channel 1
Mode: 01, 00	Jog Mode
Position1: C8. 00, 00, 00	200 steps from the zero position
Position2: F4, 01, 00, 00	500 steps from the zero position
TimeOut1: FA, 00,	Not Used
TimeOut2: FA, 00,	Not Used

REQUEST:
Command structure (6 bytes):

0	1	2	3	4	5
header only					
C1	08	13	01	d	s

TX C1, 08, 13, 01, 50, 01,

GET:
Command structure (24 bytes)
6 byte header followed by 18 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
C2	08	12	00	d|	s	SubMsgID		ChanIdent		JogMode	

12	13	14	15	16	17	18	19	20	21	22	23
Data											
Position1				Position2				TimeOut1		TimeOut2	

See Set message for structure

MGMSG_PZMOT_MOVE_ABSOLUTE 0x04D8

Function: Used to start a move to a position specified as the number of steps away from the zero position. The move will be executed using the parameters set in the TIM_Set_DriveOPParams sub-message.

Command structure (12 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D8	04	06	00	d|	s	Chan Ident		AbsPosition			

Data Structure:

field	description	format
Chan Ident	The channel being addressed Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
AbsPosition	The distance to move, relative to the zero position, specified in number of steps.	long

Example: Set an absolute move to 100 steps

Tx D8,04,06,00,D0,01,01,00,64,00,00,00

Header: D8,04,06,00,D0,01: PZMOT_MOVE_ABSOLUTE, 6 byte data packet, Generic USB Device.
ChanIdent: 01, 00 Channel 1
AbsPosition: 64. 00, 00, 00 100 steps (H64) from the zero position

On completion of the move, a Move_Completed message will be sent.

MGMSG_PZMOT_MOVE_COMPLETED 0x08D6

Function: No response on initial message, but upon completion of the absolute move sequence, the controller sends a "move completed" message:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
D6	08	0E	00	d|	s	Chan Ident		AbsPosition			

12	13	14	15	16	17	18	19
Data							
EncCount				Status Bits			

Data Structure:

field	description	format
Chan Ident	The channel being addressed Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
AbsPosition	The distance moved, relative to the zero position, specified in number of steps.	long

Example: Send message that move to 100 steps is complete

RX D6,08,0E,00,81,50,01,00,64,00,00,00,00,00,00,00,00,00,00,00

Header: D6,08,0E,00,81,50: PZMOT_MOVE_COMPLETE, 14 byte data packet, Generic USB Device.
ChanIdent: 01, 00 Channel 1
AbsPosition: 64. 00, 00, 00 100 steps (H64) from the zero position
EncCount: Not Used
StatusBits: Not Used

MGMSG_PZMOT_MOVE_JOG 0x08D9

Function: Used to start a jog move. The move will be executed using the parameters set in the TIM_Set_JogParameters sub-message.

Command structure (6 bytes)
6 byte header followed by 6 byte data packet as follows:

0	1	2	3	4	5
header					
D9	08	ChanIdent	JogDir	d	s

Channel Idents
0x01 channel 1
0x02 channel 2
0x03 channel 3
0x04 channel 4

JogDir
0x01 Forward
0x02 Reverse

Example
TX D9,08,01,01,50,01

On completion of the move, a Move_Completed message will be sent.

MGMSG_PZMOT_GET_STATUSUPDATE 0x08E1

Function: This message is returned 10 times a second, when status update messages have been requested using the MGMSG_HW_START_UPDATEMSGS function.

GET:

Status update messages are received with the following format:-

Response structure (62 bytes)

6 byte header followed by 56 byte data packet as follows:

0	1	2	3	4	5	6	7	8	9	10	11
header						*Data*					
E1	08	38	00	d|	s	Chan Ident		Position1			

12	13	14	15	16	17	18	19
Data							
EncCount1				Status Bits1			

Data Structure:

field	description	format
Chan Ident	The channel being addressed Chan 1 = 1, Chan 2 = 2, Chan 3 = 4, Chan 4 = 8	word
Position1	The position count for channel 1.	long
EncCount1	Not Used.	long
StatusBits1	Not Used	dword

The remaining 42 bytes for channel 2 to channel 4 are the same as for channel 1

Message Cross Reference by Unit Part Number

This section lists the messages applicable to each controller part number

Messages Applicable to BPC20x Series

Messages Applicable to BPC30x Series

Messages Applicable to TPZ001

Messages Applicable to TSG001

Messages Applicable to MPZ601

Messages Applicable to TDC001

Messages Applicable to TSC001

Messages Applicable to TST001 and TST101

Messages Applicable to TST101

Messages Applicable to BSC10x and BSC20x

Messages Applicable to LTS150 and LTS300

Messages Applicable to MLJ050

Messages Applicable to MFF101 and MFF102

Messages Applicable to BBD10x, BBD20x and TBD001

Messages Applicable to BNT001, MNA601 and TNA001

Messages Applicable to TLS001

Messages Applicable to TQD001 and TPA101

QUAD_PARAM Sub-Messages

Messages Applicable to TPA101 Only

QUAD_PARAM Sub-Messages

Messages Applicable to TTC001

TEC_PARAM Sub-Messages

Messages Applicable to TIM101

PZMOT_PARAM Sub-Messages