ZABER

T-JOY Product
User's Manual
Firmware 5.00 and up

Last Update: December 10 2015
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Disclaimer

Zaber's devices are not intended for use in any critical medical, aviation, or military applications or situations where a product's use or failure could cause personal injury, death, or damage to property. Zaber disclaims any and all liability for injury or other damages resulting from the use of our products.

Specifications

The following specifications are specific to T-JOY devices

Current Draw:	50 mA
Joystick Controllable Axes:	3
User Configurable Buttons:	5
Visual Feedback:	Power LED (green) and Com LED (yellow)
Dimensions:	200 x 122 x 102 mm (L x W x H)
Weight:	350g

Compatibility

Device	Firmware version	Compatibility
T-CON	All	None
All T-Series except T-CON	1.00 to 4.99	None
All T-Series except T-CON	5.00 to 5.03	Partial*
All T-Series except T-CON	5.04 and up	Full

* T-Series devices with firmware version 5.00 to 5.03 may be used with the T-JOY, however their command set lacks two useful instructions that were added in version 5.04: Save Current Postion, and Go To Saved Position. These instructions are particularly useful in conjunction with the T-JOY since any button on the T-JOY may be programmed to issue these instructions to all connected units in order to store and recall a position in 3 dimensional space.

Firmware Version Information

This user's manual applies only to T-JOY devices with firmware version 5.04 and up. Due to the addition of new features, newer versions of firmware may not be 100% compatible with older versions. For more information on firmware versions, please check the support section of Zaber's website where user's manuals for all versions of firmware are posted for download. To determine which version of firmware your device is running issue command #51. A three-digit number will be returned. Assume 2 decimal places (ex a reply of 504 indicated a firmware version of 5.04).

Precautions

Zaber devices are precision instruments and must be handled with care. Avoid using excessive force or rapid motion when manipulating the joystick or buttons. Do not force the connectors; when properly aligned, only a gentle force should be needed to achieve connection.

Initial Setup and Testing

When you first receive your T-JOY, you may wish to perform a few simple steps to familiarize yourself with its operation. First you will need a power supply. If you did not order one with your device, you will require a power supply with output voltage between 10 and 16V DC. The power input accepts a standard 2.1mm center positive connector. Most unregulated 12V AC-to-DC adapters output around 16V under light current draw, dropping to 12V at their rated current. Some may output higher voltages and will not be suitable. The chosen power supply must also be rated to handle the maximum total current draw of the devices connected to it. For example, if you have one T-JOY joystick and 2 T-LA28A actuators daisy-chained together with a single power supply, you will need at least 690 mA (50mA for the joystick and 320 mA for each actuator). The current draw of each device is given in the specifications section of the user's manual for the device. When powering long chains of devices, we recommend connecting a power supply to every second or third device in the chain to reduce the current through the data cables.

Once you have a working power supply, you can test the operation of the T-JOY. Connect the power supply to the joystick and ensure that the green LED turns on indicating power. Move the joystick from left to right, forward and back, and rotate the handle counterclockwise and clockwise. Also try pressing the buttons. As you perform each of these actions you should notice the yellow LED blinking indicating communications are taking place. Each blink corresponds to a single instruction being sent by the joystick.

This is the extent of the testing you can perform without connecting other devices to interpret and execute the instructions being sent by the T-JOY, or connecting a computer to communicate with the T-JOY.

Installation

During normal operation, the T-JOY joystick does not need to be connected to a computer, however, it must be connected to a computer initially in order to change its settings (for example to change button functions from the defaults or to change what additional devices will be controlled by each axis of the joystick). Devices that will be used with the joystick must also be connected so that the computer may issue a renumber instruction which assigns all connected devices a unique device number. This is necessary so that the T-JOY can direct instructions to the appropriate device to control the correct axis of motion.

To connect the device properly please carefully follow the steps illustrated below:

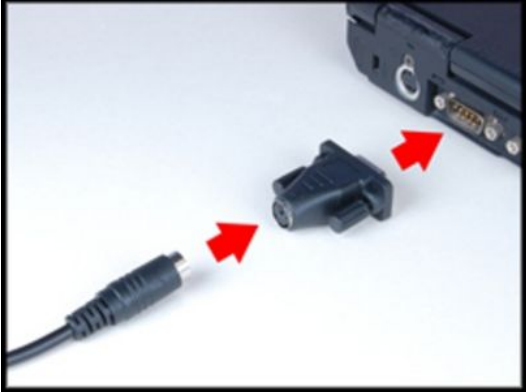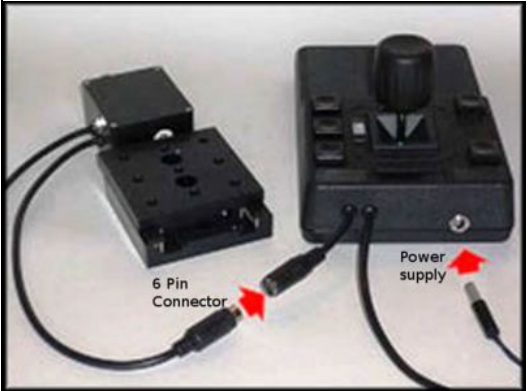|		
STEP 1		**1.** Either plug the Mini-DIN to D-Sub serial adaptor (T-DSUB9) into your computer's serial port, or the Mini-DIN to USB adapter (T-USBDC) into one of your computer's USB ports, then plug the device's data cable into the adaptor. For the USB adaptor, new computers will often be able to install the necessary drivers automatically when the cable is plugged in for the first time. If the computer reports that the driver installation was unsuccessful, you can download the drivers for Windows, Mac, or Linux here. Installation instructions and troubleshooting information are available for each operation system here. You may need to use a cable extension to reach your computer. There is no need to power-down or reboot the computer.
STEP 2&3		**2.** Connect the T-Series devices that you will be using with the joystick to the female end of the T-JOY data cable. **3.** Connect the power plug from your power supply (2.1mm center positive) to the T-JOY power connector. The green LED light should light on the T-JOY and any connected T-series devices. We recommend connecting additional power supplies to every second or third device to reduce the current draw through the data cables. Note: not all T-series devices have LEDs.
STEP 4		**4.** Download and install a desired software control program from the software section on our website. We recommend installing the Zaber Console. To begin controlling your device using the Zaber Console, select the correct COM port from the drop down menu (top left), and then press the open button next to the drop down tab. As a simple first test, try entering these
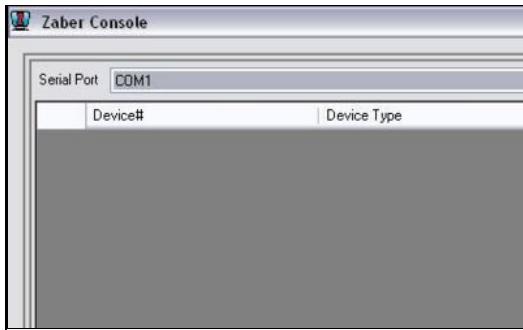
| | | instructions:

1. Renumber all devices - Device:0, Cmd:2, Data:0
2. Home device 1 - Device:1, Cmd:1, Data:0

Note: Zaber motion devices must be homed before entering any other commands. Homing a device gives it a starting referencing point. Your device will not move through its maximum range without issuing this command first.
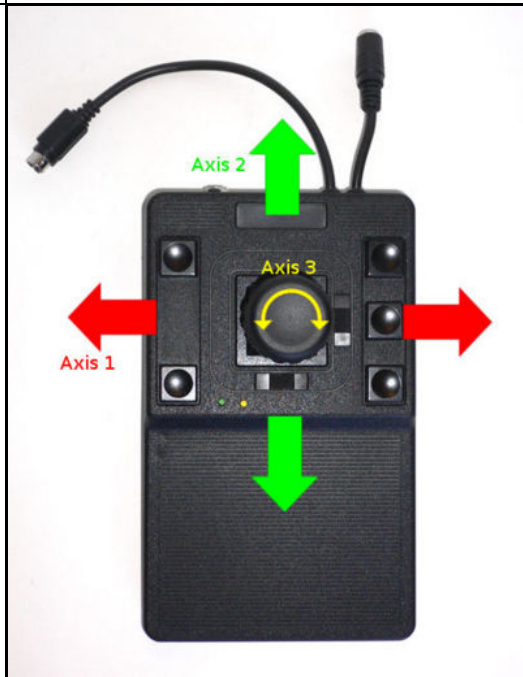
STEP 5		**5.** Once the renumbering command has been sent, the first three devices connected to the joystick will each be controlled by a joystick axis. The defaults are:

Axis #	Axis 1	Axis 2	Axis 3
Movement	left-right	up-down	twist joystick
Device #	2 (or first device # after joystick)	3 (or second device # after joystick)	4 (or third device # after joystick)

Note: If additional Zaber devices are connected before the T-JOY, the device numbers corresponding to the joystick axes will be the the first three devices connected after the joystick.

STEP 6		**6.** All buttons (keys) are programmable.

The default settings are shown here: |

Key	Press and Release Within 1 second	Press and Release After 1 second
1	Stop All Devices	Home All Devices
2	Echo "0" on press Echo "1" on release	Echo "0" on press Echo "2" after 1 second Echo "3" on release
3	Go to stored position 0 (all devices)	Store current position 0 (all devices)
4	Go to stored position 1	Store current position 1

	(all devices)	(all devices)	
5	Go to stored position 2 (all devices)	Store current position 2 (all devices)	

Note that by default, key #2 has no direct effect on connected devices but it can be used to trigger execution of a script on the computer.

Control Through The RS-232 Serial Port

All T-Series devices use the same RS232 communications protocol. Your communications settings must be: 9600 baud, no hand shaking, 8 data bits, no parity, one stop bit. The yellow LED will light when there is activity on the RS232 lines. You may use this feature to determine which COM port you are connected to. We recommend using the Zaber Console that you can download from our web site. The source code is also available for you to use as an example for writing your own custom code. See the troubleshooting section later in this manual if you have trouble communicating with the device.

Important: The first time you connect a device to your computer you must issue a renumber instruction to assign each device a unique identifier. This should be done after all the devices in the daisy-chain are powered up. In older firmware versions (prior to version 5xx) you must issue a renumber instruction after each powerup. In firmware 5xx and up, the device number is stored in non-volatile memory and will persist after powerdown, so you need only issue the renumber instruction when you add new devices to the chain, or rearrange the order of the devices, however it does no harm to issue the renumber instruction after every powerup. You must not transmit any instructions while the chain is renumbering or the renumbering routine may be corrupted. Renumbering takes less than a second, after which you may start issuing instructions over the RS232 connection.

All instructions consist of a group of 6 bytes. They must be transmitted with less than 10 ms between each byte. If the device has received less than 6 bytes and then a period longer than 10 ms passes, it ignores the bytes already received. We recommended that your software behave similarly when receiving data from the devices, especially in a noisy environment like a pulsed laser lab.

The following table shows the instruction format:

- Byte 1 - Device #
- Byte 2 - Command #
- Byte 3 - Data - Least Significant Byte (LSB)
- Byte 4 - Data
- Byte 5 - Data
- Byte 6 - Data - Most Significant Byte (MSB)

The first byte is the device number in the daisy-chain. Device number 1 is the closest device to the computer and device number 2 is next and so on. If the number 0 is used, all the devices in the chain will process the accompanying command simultaneously.

The second byte is the command number. Bytes 3, 4, 5, and 6 are data in long integer, 2's complement format with the least significant byte transmitted first. How the command data are interpreted depends on the command. Complete details are given in the command reference on the following page.

Examples:

- Renumber all devices: 0x00, 0x02, 0x00, 0x00, 0x00, 0x00
- Set Active Axis (command #25): 0x00, 0x1C, 0x01, 0x00, 0x00, 0x00
- Set Axis Velocity Profile (command #28): 0x00, 0x19, 0x02, 0x00, 0x00, 0x00

If you are using Zaber's demo software, you will only see 3 entry fields: Device#, Command#, and Data. The Device# and Command# fields accept integer values while the value you enter into the Data field can be

signed. The value in the data field is converted by the software to 4 separate bytes and then gets sent to the device.

Most instructions cause the device to reply with a return code. It is also a group of 6 bytes. The first byte is the device #. Byte #2 is the instruction just completed or 255 (0xFF) if an error occurs. Bytes 3, 4, 5 and 6 are data bytes in the same format as the instruction command data.

Examples:

Quick Command Reference

The following table offers a quick command reference for joystick products. For convenience, you may sort the table below by instruction name, command number, or reply number. Follow the links to view a detailed description of each instruction.

Instruction Name	Command#	Command Data	Command Type	Reply Data
Reset	0	Ignored	Command	None
Renumber*	2	New Number	Command	Device Id
Set Active Axis*	25	Axis	Setting	Axis
Set Axis Device Number*	26	Device Number	Setting	Device Number
Set Axis Inversion*	27	Invert Status	Setting	Invert Status
Set Axis Velocity Profile*	28	Velocity Profile	Setting	Velocity Profile
Set Axis Velocity Scale*	29	Maximum Velocity	Setting	Maximum Velocity
Load Event Instruction	30	Key Event	Command	Key Event
Return Event Instruction	31	Key Event	Command	Event Instruction
Set Calibration Mode*	33	Calibration Mode	Command	Calibration Mode
Restore Settings*	36	Peripheral Id	Command	Peripheral Id
Set Device Mode*	40	Mode	Setting	Mode
Set Alias Number*	48	Alias Number	Setting	Alias Number
Set Lock State*	49	Lock State	Command	Lock State
Return Device Id	50	Ignored	Read-Only Setting	Device Id
Return Firmware Version	51	Ignored	Read-Only Setting	Version
Return Power Supply Voltage	52	Ignored	Read-Only Setting	Voltage
Return Setting	53	Setting Command Number	Command	Setting Value
Echo Data	55	Setting Number	Command	Setting Value
Error	255	n/a	Reply	Error Code

* The settings for these commands are saved in non-volatile memory, i.e. the setting persists even if the device is powered down. To restore all settings to factory default, use command 36.

Detailed Command Reference

Reset - Cmd 0

Instruction Name	Reset
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	0
Command Type	Command
Command Data	Ignored
Reply Data	None
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Sets the device to its power-up condition.

This has the same effect as unplugging and restarting the device.

Special Note

All non-volatile settings (i.e. Device Number, Joystick Calibration, etc.) are saved and are not affected by reset or power-down.

Renumber - Cmd 2

Instruction Name	Renumber
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	2
Command Type	Command
Command Data	New Number
Reply Data	Device Id
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Assigns new numbers to all the devices in the order in which they are connected.

This command is usually sent to device number 0. When it is, the command data is ignored and all devices will renumber. The device closest to the computer becomes device number 1. The next device becomes number 2 and so on.

If sent to a device number other than 0, then that device will reassign itself the device number in the command data. Valid device numbers are 1-99 for version 6.05, and 1-254 otherwise.

Note: Renumbering takes about 1/2 a second during which time the computer must not send any further data. The device number is stored in non-volatile memory so you can renumber once and not worry about issuing the renumber instruction again after each power-up.

Set Active Axis - Cmd 25

Instruction Name	Set Active Axis
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	25
Command Type	Setting
Command Data	Axis
Reply Data	Axis
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Sets the active axis.

Only one axis can be active at a time, therefore each axis has to be set individually. The settings for each axis are stored in non-volatile memory, and will persist after powering down or resetting. To determine the joystick's current active axis issue the return settings command #53 with a command data value of 25.
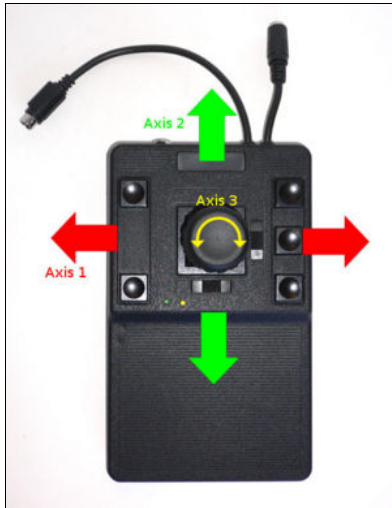
Valid Command Data values are:

- 1 (Axis 1)
- 2 (Axis 2)
- 3 (Axis 3)

Subsequent changes to any axis settings will apply only to the active axis.

Settings for the active axis can be changed using the commands shown here:

- Set Axis Device Number (Command #26)
- Set Axis Inversion (Command #27)
- Set Axis Velocity Profile (Command #28)
- Set Axis Velocity Scale (Command #29)

T-Joy Axes

The three axes on the joystick are defined as follows:

Axis #	Positive Direction	Negative Direction
Axis 1	right	left
Axis 2	up	down
Axis 3	clockwise	counter-clockwise

Example: To set the maximum velocity of axis number 2 follow the steps below:

- Issue the Set Active Axis command #25 with a command data value of 2 to make axis number 2 the active axis.
- Then issue the Set Axis Velocity Scale (Command #29) using the desired maximum velocity as the command data value. All subsequent "Set Axis..." commands will also apply to the axis number 2 until the user sets a different axis to be the active axis.

Set Axis Device Number - Cmd 26

Instruction Name	Set Axis Device Number
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	26
Command Type	Setting
Command Data	Device Number
Reply Data	Device Number
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile

Summary	Sets the device number to be controlled using the active axis.

Note: This setting affects only the active axis. See the Set Active Axis Command #25 for instruction on how to select an axis.

Valid command data values for setting an axis device number range between 0 and 254. Once a axis device number is set, the setting is stored in non-volatile memory and will persist after power-down or reset.

To restore the joystick to its factory default settings, issue a Restore Settings Command #36. The factory default settings for axis control are as follows:

- Axis #1 controls Device #2
- Axis #2 controls Device #3
- Axis #3 controls Device #4

Example: Suppose you would like to assemble a 3-axis system where:

- Joystick axis 1 (right / left) controls device #3.
- Joystick axis 2 (up / down) controls device #4, but with the motion inverted.
- Joystick axis 3 (clockwise / counterclockwise) controls device #2.

First, connect the joystick and the three additional T-Series devices. For installation instructions please view the T-JOY installation section of the manual. In the figure below we illustrate three T-LS devices connected in a daisy-chain to the T-JOY device:

-----Laptop-----------------------------T-Joy (Device #1) -----------------------Device #2, Device #3, and Device #4

Issue the Renumber Command #2 from the computer. After renumbering (less than 1 second) the joystick will become device #1, and the remaining devices will become devices #2, #3, and #4. Now commands may be issued to the joystick to set the desired behavior. Please note that the device # will need to change for each joystick axis in order to achieve the desired behavior. The command sequence is as follows:

- Device:1 Cmd:25 Data:1 - Set Axis # 1 to be the active axis.
- Device:1 Cmd:26 Data:3 - Set the active axis (#1) to control device #3.
- Device:1 Cmd:25 Data:2 - Set Axis # 2 to be the active axis. (Settings for each axis need to be set individually)

- Device:1 Cmd:26 Data:4 - Set active axis (#2) to control device #4.
- Device:1 Cmd:27 Data:-1 - Set active axis (#2) to be inverted (positive and negative directions switch).
- Device:1 Cmd:25 Data:3 - Set Axis # 3 to be the active axis.
- Device:1 Cmd:26 Data:2 - Set the active axis (#3) to control device #2.

Note: All commands are being sent to device #1 (joystick). This is because the 3 T-series devices will be controlled by the joystick. Setting axis number and directions must be done by changing the joystick settings, not the individual device settings.

Special Note: It is possible to have one axis control 2 or more devices. All of the devices on this axis will move together. Follow the steps below to set more than one device on a single axis:

- For each device you wish to control on one axis, set the device alias number with Command #48. Selecting an alias number much larger than the device numbers in use will help to differentiate between aliases and devices (Ex: 99). The alias number must be the same for each device you wish to control with a single axis.
- Issue the Set Active Axis Command #25 with command data equal to the axis number you wish to use.
- Issue the Set Axis Device Number Command #26 with command data equal to the alias number you selected.

Set Axis Inversion - Cmd 27

Instruction Name	Set Axis Inversion
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	27
Command Type	Setting
Command Data	Invert Status
Reply Data	Invert Status
Safe to retry?	No
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Inverts the active joystick axis.

Sometimes it is desirable to invert one or more axes to create a more intuitive user interface. The Set Axis Inversion (#27) command allows the user to set the invert status of the active axis. Use Invert Status = 1 to set the current axis to non-inverted, use Invert Status = -1 to set the current axis to inverted. Use Invert Status = 0 to toggle between invert and non-invert (the Invert Status of the reply will still be either 1 or -1).

See the Set Active Axis (#25) instruction for information on how to select an axis. Each axis can be inverted independently of the other two axis. See command #26 for an example of how to invert a particular axis.

Here are the default directions for each axis (not inverted):

- On axis 1, left is negative and right is positive.

- On axis 2, down is negative and up is positive.
- On axis 3, counter-clockwise is negative and clockwise is positive.

What constitutes positive or negative motion depends on the device; see the user's manual for the device in question. The default axis inversion setting for all joystick axes is non-inverted.

Set Axis Velocity Profile - Cmd 28

Instruction Name	Set Axis Velocity Profile
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	28
Command Type	Setting
Command Data	Profile Number
Reply Data	Profile Number
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Sets the relationship between the angle of the active joystick axis and the velocity of the device.

When the joystick is displaced from the neutral position, the T-JOY3 reads the angular position and calculates how fast and in which direction the corresponding devices should be instructed to move. There are three different velocity profile numbers that can be requested:

- 1 – Linear
- 2 – Squared (factory default)
- 3 – Cubed
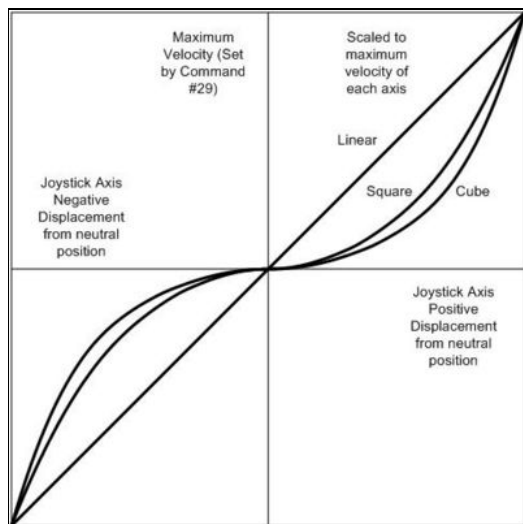
Velocity Profile

The maximum velocity is set by the Set Axis Velocity Scale (#29) command. Squared and cubed curves offer finer control at slow speeds, but still allow maximum velocity when the joystick is fully deflected.

Set Axis Velocity Scale - Cmd 29

Instruction Name	Set Axis Velocity Scale
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	29
Command Type	Setting
Command Data	Maximum Velocity
Reply Data	Maximum Velocity
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Sets the velocity scale of the active axis.

The data represents the desired maximum velocity corresponding to full displacement of the joystick. When the joystick is moved away from the neutral position, the displacement is translated into Move At Constant Velocity instruction which is sent to the device associated with the displaced axis. See the user's manual for the device in question for more information on the Move At Constant Velocity instruction.

The velocity scale setting works in conjunction with the velocity profile setting. See the Set Axis Velocity Profile (#28) command for more detail.

Setting the velocity scale to 0, will disable the active axis. This prevents the joystick from sending any instructions in response to displacement of that axis. This is useful when the user wants to execute a program from the computer, and does not want the joystick to be accidentally moved.

The default velocity scale for all three axes is 2922. Prior to Firmware 5.23, this command has an upper limit of 65535. This upper limit is removed in Firmware 5.23 and up to allow A-Series compatible speeds.

Load Event Instruction - Cmd 30

Instruction Name	Load Event Instruction
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	30
Command Type	Command
Command Data	Key Event
Reply Data	Key Event
Safe to retry?	No

Returns Current Position?	No
Persistence	Non-Volatile
Summary	Loads the next instruction as the event-triggered instruction specified in the Command Data.

When pressing and releasing a key (button on the T-JOY), there are a series of events that take place depending on how long the key is held. If the key is pressed and released before 1 second, the event sequence is 1-2. If the key is pressed, held for one second or more and then released, the event sequences is 1-3-4 (note that event 3 will be issued after the key is held for 1 second, and event 4 is issued upon release). This is illustrated in the figure below. The hold time of the key cannot be changed by the user.
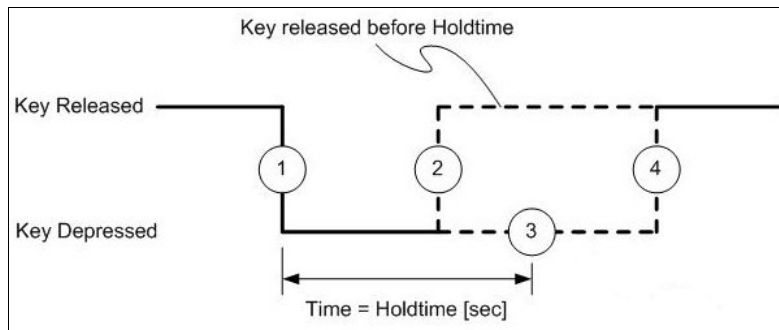
Diagram of the event path for each key. The events are numbered from 1-4. This diagram shows what events are issued depending on how long you hold the key.

Diagram showing the numbering configuration for each key.

Each key event can be programmed to issue only one instruction. The instruction written to an event can be different for each key. You can also set an event to do nothing by issuing a echo command for that event.

When programming a T-JOY key, we recommend disconnecting all of the devices connected to the joystick. When a command is loaded to the key it is also sent to the connected devices and may cause unexpected movement. On a side note, it is important to know that when a command is issued it is sent to all devices. Only the devices that the command is addressed to will actually perform that command, and all of the other devices will ignore it.

If you are using message ids we recommend that you disable them when programming the joystick. That way the programmed instructions will work whether the target device has message ids enabled or not.

To program an instruction to a key event please follow these steps:

1. Send a Load Event Instruction <u>Command #30</u> to the device # corresponding to the joystick, with a two digit command data value, where the first digit is the key number and the second digit is the event number. This command tells the device which key and event you would like to program an instruction for.
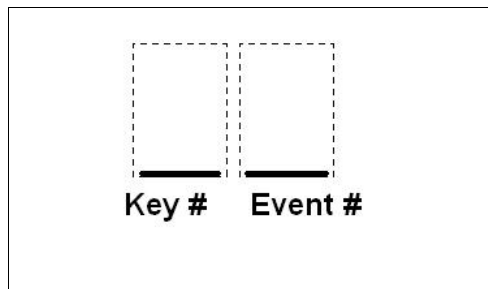

Diagram illustrating how to form the command data number for the load event instruction command

Example: If you want to program event #2 of Key #3 you would issue a Load Event Instructions command with a data value of 32.

2. Now that you have issued a Load Event Instruction command, The device is waiting for you to issue an instruction. At this point in time the Load Event Instruction command is volatile and will not persist after powering down (This means if you power down you will need to issue another Load Event Instruction command before sending the event instruction). The command that you issue now will be programmed to the key and event you specified in step 1. This command can be issued normally, and can be addressed to any device connected to and including the joystick.

Note: After issuing the command you wish to program, there will be no feedback (light, beep etc.) indicating you have correctly programmed the button. The response screen will only say that a command has been issued. If you see that your command has been issued immediately after the load instruction response then you have most likely correctly programmed the key. The best test is to manually test the key to see if it performs your command.

3. Now you have finished programming one event on a key. The instruction programmed to that key is now non-volatile and will persist after powering down. Repeat the steps above to continue programming events to keys. To set an event to do nothing, issue an Echo Data command to device number 255 for that event.

Important: Be sure to program all of the events each time you program a key. The key events may have instructions already programmed into them therefore you will have to program an event to either do nothing,

or perform the command you want it to do. If you do not do this pressing a key could cause a device or joystick to do something unexpected. A list of the default settings can be found on the <u>T-JOY installation page</u>.

Key Event Programming Examples

Example 1: Programming a key to stop and home a single device.

In this example we will use device #3 as the device we want address the instructions to. Device #1 is the Joystick. We will program these instructions to key #4. We want device #3 to home when the key is pushed and held for 1 second and we want it to stop when the key is pushed and released before 1 second. The home instruction will be programmed to event number 3 and the stop instruction will be programmed to event number 2.

To program the device, follow the instructions listed below:

Device#	Command	Cmd#	Cmd Data	Description
1	Load Event Instuction	30	42	This command prepares the joystick key for instruction, the command data number 42 means that you are directing this instruction towards key #4 and event #2.
3	Stop	23	0	Because this command is being issued immediately after the Load Event Instruction (#30) it will be programmed to event #2 at key #4.
1	Load Event Instruction	30	43	This command prepares the joystick key for instruction, the command data number 43 means that you are directing this instruction towards key#4 and event #3.
3	Home	1	0	Because this command is being issued immediately after the Load Event Instruction (#30) it will be programmed to event #3 at key#4.

Example 2: Disable/Enable an Axis

In this example we will be disabling Axis #1. This axis usually controls device #2. The way that we are going to disable the axis is by reassigning the axis device number. This way the instruction will be sent to a device that will ignore a move command (the Joystick). We will be programming key #5. The key will disable the axis when pressed and released before 1 second and enable the axis when pressed, held for one second or more and then released.

To program the device, follow the instructions below:

Device#	Command	Cmd#	Cmd Data	Description
1	Load Event Instruction	30	51	This command prepares the joystick so that key #5 at event #1 can be programmed.
1	Set Active Axis	25	1	

				This command makes the axis active so that its device number can be changed. It is loaded to event number 1 so that the axis will become active as soon as the key is pressed.
1	Load Event Instruction	30	52	This command prepares the joystick so that key #5 at event #2 can be programmed.
1	Set Axis Device Number	26	1	This causes the axis to control the joystick, however all of the move commands sent to the joystick will be ignored. Therefore moving this joystick axis will not cause motion.
1	Load Event Instruction	30	53	This command prepares the joystick so that key #5 at event #3 can be programmed.
1	Set Axis Device Number	26	2	This command causes the axis to now control device number 2. This will enable the axis again by setting it to control Device #2, as before.

Return Event Instruction - Cmd 31

Instruction Name	Return Event Instruction
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	31
Command Type	Command
Command Data	Key Event
Reply Data	n/a
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Returns the the event-triggered instruction associated with the key-event.

See the Load Event-Triggered Instruction (#30) for more information on definition of key events and event-triggered instructions.

To return the event-triggered instruction associated with a particular key event, issue the Return Event Instruction (#31) command to the joystick with data as follows:

Command Data = Key * 10 + Trigger

Where:

- Key is a number from 1 to 5 corresponding to the key location
- Event is a number from 1 to 4 corresponding to the key event

The reply will be comprised of the device, command and data of the event-triggered instruction associated with the specified key event. Note that as far as the computer is concerned, the reply will appear to come from whatever device the event-triggered instruction is addressed to, which may not be the joystick. We recommend that all additional devices be disconnected from the joystick before loading or returning event-triggered instructions to avoid confusion.

Set Calibration Mode - Cmd 33

Instruction Name	Set Calibration Mode
Applies to	**T-JOY**
Firmware Version	5.04 and up
Command Number	33
Command Type	Setting
Command Data	Calibration Mode
Reply Data	Calibration Mode
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Calibrates the joystick by adjusting the limits and the deadbands.

There are two sets of calibration variables: limits and deadbands. Limits define the maximum angular displacement of all axes of manipulation. Deadbands define the area around the neutral position of the joystick where no action should occur. Deadbands are useful to adjust the sensitivity of the joystick to vibration or accidental movement from the neutral position. Acceptable Calibration Mode values are: 0, 1, or 2. Mode 1 is for calibrating the maximum limits. Mode 2 is for calibrating the deadbands. Mode 0 exits the calibration routine.
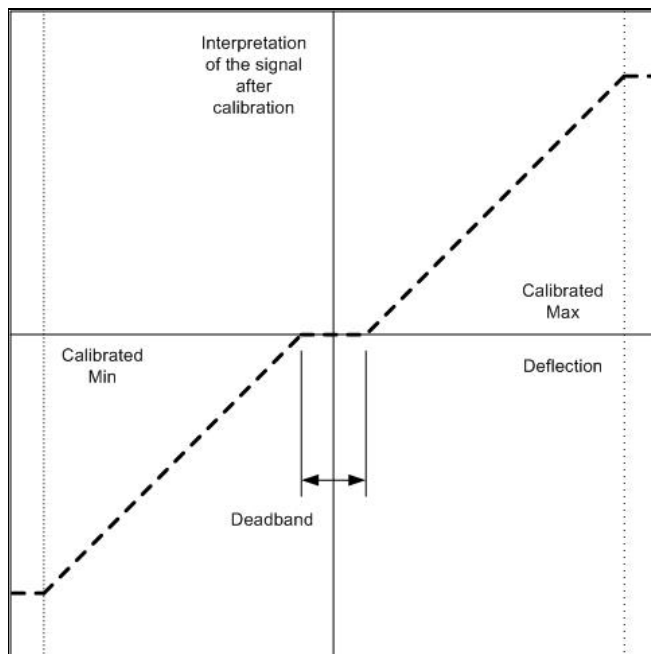
The T-JOY is pre-calibrated before shipping so that it should work well right out of the box. Note that restoring default settings using command #36 will have no affect on the joystick calibration. There is no default calibration since each joystick has slightly different properties that prevent a single set of settings from working well on all devices.

The joystick should work well as calibrated. We do not recommend re-calibrating it unless you encounter problems such as motion occurring while the joystick is in the neutral position, or an inability to reach maximum velocity even with the joystick fully displaced.

To calibrate the limits, follow these steps:

- Issue command 33, data 1 to put joystick in "calibrate limits" mode
- Move joystick all the way to the left and all the way to the right
- Move joystick all the way up and all the way down
- Turn joystick knob all the way counter-clockwise and all the way clockwise
- Issue command 33, data 0 to save the measured limit parameters

To calibrate the deadbands, follow these steps:

- Issue command 33, data 2 to put joystick in "calibrate deadbands" mode
- Wiggle joystick slightly to the left and right of the neutral position. Try to move only within the limits of the slack. Do not move past the point where resistance begins.
- Wiggle joystick slightly up and down from the neutral position
- Turn joystick knob slightly counter-clockwise and clockwise from the neutral position
- Issue command 33, data 0 to save the measured limit parameters

Restore Settings - Cmd 36

Instruction Name	Restore Settings
Applies to	**T-JOY**
Firmware Version	5.00 and up
Command Number	36
Command Type	Command
Command Data	Peripheral Id
Reply Data	Peripheral Id
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Restores the device settings to the factory defaults.

This command should be issued with Data 0 to return the device to factory default settings. This instruction is very useful for troubleshooting. If the device does not appear to function properly, it may be because some of the settings have been changed. This instruction will restore the settings to default values. For a table of default settings, see Appendix A. All settings affected by this instruction are stored in non-volatile memory and will persist after power-down or reset.

Set Device Mode - Cmd 40

Instruction Name	Set Device Mode
Applies to	**T-JOY**
Firmware Version	5.xx since 5.04
Command Number	40
Command Type	Setting
Command Data	Mode
Reply Data	Mode
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Sets the Mode for the given device.

This command allows setting several options. Each option is controlled by a single bit within the command data. Most software you will encounter, including most of our demo software, represents all 4 data bytes as a single decimal value rather than specifying each bit individually. To determine what decimal value to use requires a basic understanding of how the data is represented in binary. The command data may be considered as a single 32-bit binary value. The least significant bit is bit_0, the next is bit_1, the next is bit_2, and so on up to the most significant bit_31. Each bit may have a value of either 1 or 0.

The corresponding decimal representation of this 32-bit data is given by:

$$\text{Decimal value} = (bit\_0 * 1) + (bit\_1 * 2) + ... + (bit\_n * 2n) + ... + (bit\_31 * 2\char`^31)$$

Each bit controls a single mode option as described in the table below. To determine the data value to use with the Set Device Mode command, simply determine the desired value of each bit (1 or 0), and calculate the decimal value using the above formula. Note that not all 32 bits are currently used. Any unused or reserved bits should be left as 0.

For example, suppose you want all mode bits to be 0 except for bit_0 (disable autoreply), bit_14 (disable power LED), and bit_15 (disable serial LED). The Set Device Mode instruction should be sent with data calculated as follows:

Command Data

$$= 2\char`^20 + 2\char`^214 + 2\char`^215$$
$$= 1 + 16384 + 32768$$
$$= 49153$$

Note that each instance of the Set Device Mode command overwrites ALL previous mode bits. Repeated commands do not have a cumulative effect. For example, suppose you send a Set Device Mode command with data of 1 to disable auto-replies. If you then send another Set Device Mode command with data of 16384 to disable the power LED, you will re-enable auto-replies since bit_0 in the 2nd instruction is 0.

The T-JOY has a default mode setting of 0 (all bits are 0).

Bit_n	2^n	Description
bit_0	1	**Disable Auto-reply** A value of 1 disables ALL replies except those to "echo", "read", "renumber", and "return" commands. The default value is 0 on all devices.
bit_1	2	Reserved
bit_2	4	Reserved
bit_3	8	Reserved
bit_4	16	Reserved
bit_5	32	Reserved
bit_6	64	**Enable Message Ids** A value of 1 enables Message Ids. In this mode of communication, only bytes 3 through 5 are used for data. Byte 6 is used as an Id byte that the user can set to any value they wish. It will be returned unchanged in the reply. Message Ids allow the users application to monitor communication packets individually to implement error detection and recovery. The default value is 0 on all devices. Prior to firmware version 5.06, this feature was called "Virtual Channels Mode" and did not behave reliably. We do not recommend enabling this mode of communications unless you have firmware version 5.06 or later.
bit_7	128	Reserved
bit_8	256	Reserved
bit_9	512	Reserved
bit_10	1,024	Reserved
bit_11	2,048	Reserved
bit_12	4,096	Reserved
bit_13	8,192	Reserved
bit_14	16,384	**Disable Power LED** A value of 1 turns off the green power LED. It will still blink briefly, immediately after powerup.
bit_15	32,768	**Disable Serial LED** A value of 1 turns off the yellow serial LED.

Set Alias Number - Cmd 48

Instruction Name	Set Alias Number
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	48
Command Type	Setting
Command Data	Alias Number
Reply Data	Alias Number
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Sets an alternate device number for a device.

This setting specifies an alternate device number for a device (in addition to its actual device number). By setting several devices to the same alias number, you can control a group of devices with a single instruction. When you send an instruction to an alias number, all devices with that alias number will execute the instruction and reply using their actual device numbers. To remove an alias, simply set the device's alias number to zero. Valid alias numbers are 0 to 99 for version 6.05, and 0 to 254 otherwise. To avoid confusion, it is best to choose an alias greater than the number of devices connected.

This setting is stored in non-volatile memory and will persist after power-down or reset.

Set Lock State - Cmd 49

Instruction Name	Set Lock State
Applies to	T-Series devices
Firmware Version	5.xx since 5.07
Command Number	49
Command Type	Setting
Command Data	Lock State
Reply Data	Lock State
Safe to retry?	Yes
Returns Current Position?	No
Persistence	Non-Volatile
Summary	Locks or unlocks all non-volatile settings.

Sometimes it is desirable to lock all non-volatile settings to prevent them from being changed inadvertently. After changing all settings as desired, settings can be locked by setting the Lock State to 1. Subsequent attempts to change any non-volatile setting (e.g., Set Target Speed, command 42) will result in an error response with an error code of 3600 (settings locked). Note that the Set Lock State command does not apply to commands and settings that are specific to the **joystick**. Load Event Instruction and Set Axis Device Number for example, are unaffected by the Lock State.

How the Restore Settings instruction behaves when the settings are locked depends on the firmware version. In version 5.07 issuing a Restore Settings instruction while the settings are locked will result in an error response with an error code of 3600 (settings locked). This behavior was found to confuse many customers so in version 5.08 and up, the behavior was changed such that regardless of the current lock state, issuing a Restore Settings instruction will always return setting values to factory default values and leave settings in an unlocked state.

Settings can also be unlocked by setting the Lock State to 0.

Return Device Id - Cmd 50

Instruction Name	Return Device Id
Applies to	All Zaber devices
Firmware Version	5.00 and up

Command Number	50
Command Type	Read-Only Setting
Command Data	Ignored
Reply Data	Device Id
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Returns the id number for the type of device connected.

See the Zaber support web site for a table of device ids for all Zaber products.

Return Firmware Version - Cmd 51

Instruction Name	Return Firmware Version
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	51
Command Type	Read-Only Setting
Command Data	Ignored
Reply Data	Version
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Returns the firmware version installed on the device.

A decimal is assumed before the last two digits. For example, 502 indicates firmware version 5.02.

Return Power Supply Voltage - Cmd 52

Instruction Name	Return Power Supply Voltage
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	52
Command Type	Read-Only Setting
Command Data	Ignored
Reply Data	Voltage
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Returns the voltage level of the device's power supply.

A decimal is assumed before the last digit. For example, a value of 127 indicates 12.7 V. Note that the internal voltage measurement is not very accurate. Don't be alarmed if the indicated voltage is slightly different from your measurements.

Return Setting - Cmd 53

Instruction Name	Return Setting
Applies to	All Zaber devices
Firmware Version	5.00 and up
Command Number	53
Command Type	Command
Command Data	Setting Number
Reply Data	Setting Value
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Returns the current value of the setting specified in the Command Data.

Valid command data values are the command numbers of any "Set..." instruction. The device will reply using the command number of the specified setting (as if a command to change the setting had just been issued) but the setting will not be changed.

For example, command #48 is the "Set Alias" instruction. Therefore if you wish to return the current value of the alias number, simply send the Return Setting instruction with data of 48. The device will reply with command #48 and data equal to the setting value.

Since firmware version 5.21, this command also accepts the command numbers of any "Return..." instruction, such as command #50 "Return Device Id".

Echo Data - Cmd 55

Instruction Name	Echo Data
Applies to	All Zaber devices
Firmware Version	5.04 and up
Command Number	55
Command Type	Command
Command Data	Data
Reply Data	Data
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Echoes back the same Command Data that was sent.

This command is useful for testing communication, similar to a network "ping".

Special Note

This instruction is a useful one to use as an event-triggered instruction associated with a key event. It can be used to allow the computer (if one is connected) to detect a key press on the joystick. For more details see the Load Event-Triggered Instruction (#30) command.

Reply-only Reference

In general, a T-series device will reply to an instruction using the same command number as the instruction itself. However, there are occasions (such as when the user turns the potentiometer) when the device may transmit data without first receiving a request from the controlling computer. This type of reply may be considered to be a triggered reply as opposed to a requested reply. In this case the device uses a "reply-only" command number to distinguish the reply from those requested by the controlling computer. The meanings of these replies and their corresponding data are given below.

Error - Cmd 255

Instruction Name	Error
Applies to	**T-JOY**
Firmware Version	5.xx
Command Number	255
Command Type	Reply
Command Data	n/a
Reply Data	Error Code
Safe to retry?	Yes
Returns Current Position?	No
Persistence	n/a
Summary	Indicates to the user that an error has occurred.

This reply indicates that an error has occurred. The error code returned in the data indicates the type of error. The device may send an error code as a reply to an invalid instruction, or it may autonomously send an error code as a triggered reply (i.e. not in response to an instruction). The error code is typically the command number of the instruction that caused the error, but not always.

Error Codes

Code	Name	Description
2	Device Number Invalid	Renumbering data out of range.
14	Voltage Low	Power supply voltage too low.
15	Voltage High	Power supply voltage too high.
25	Axis Invalid	Set Active Axis - Data out of range. Must be 1, 2, or 3.
26	Axis Device Number Invalid	Set Axis Device Number - Data out of range. Must be between 0 and 254 inclusive.
27	Inversion Invalid	Set Axis Inversion - Data out of range. Must be 0, 1, or -1.
28	Velocity Profile Invalid	Set Axis Velocity Profile - Data out of range. Must be 0, 1, 2, or 3.
29	Velocity Scale Invalid	Set Axis Velocity Scale - Data out of range. Must be between 0 and 65535.
30	Load Event Invalid	Load Event-Triggered Instruction - Data out of range. See command #30 for valid range.

31	Return Event Invalid	Return Event-Triggered Instruction - Data out of range. See command #31 and #30 for valid range.
33	Calibration Mode Invalid	Must be 0, 1, or 2.
36	Peripheral Id Invalid	Restore Settings - peripheral id is invalid. Please use one of the peripheral ids listed in the user manual, or 0 for default.
40	Mode Invalid	Set Device Mode - one or more of the mode bits is invalid.
48	Alias Invalid	Alias out of range.
49	Lock State Invalid	Lock state must be 1 (locked) or 0 (unlocked).
53	Setting Invalid	Return Setting - data entered is not a valid setting command number. Valid setting command numbers are the command numbers of any "Set ..." instructions.
64	Command Invalid	Command number not valid in this firmware version.
3600	Settings Locked	Must clear Lock State (command 49) first. See the Set Lock State command for details.

Troubleshooting T-JOY Devices

Symptom	Check
Green LED does not come on	Check the A/C wall plug, the 12V adapter and its connection to the device. If the power is coming over the data cable, check the mini din connector for bent or broken pins.
Green LED flashes	The power supply voltage is outside the range of 10 to 16V. It may either be too low or too high. Some unregulated 12 V adapters may produce in excess of 16 V. If the number of devices connected on a single 12 V adapter exceeds its current capability, the voltage may drop below 10 V. You may experience this problem when many motors on a single supply move together. The load may exceed the maximum current available, causing the voltage to drop. If you experience this problem with a single device on a single unregulated 12V supply rated at over 300 mA, then the problem is probably that the supply voltage is too high.
Communications do not seem to work, the amber light does not come on or flash	Make sure that you are on the correct com port. Check the baud rate, hand shaking, parity, stop bit, etc. Check the cable and adapter for bent or broken pins. Make sure you do not have a null modem adapter or cable in the line. The serial to mini-din adapter comes in many varieties and many have different pin connections. Check the adapter for continuity on the proper pins by consulting the adapter pin-out diagram below. If you encounter the problem when trying to control the device with your own software, try using one of the demo programs from our website to verify that the hardware is functioning properly.
The amber light comes on briefly when sending a command, but the device does not reply.	Check baud rate, hand shaking, parity, stop bit, etc. Make sure that your software does not transmit any control characters like line feed, spaces or something else. The device numbers may not be what you think they are. Issue a renumber command, make sure that the computer does not transmit anything else while the devices renumber. Check that you transmit 6 bytes and that the device number and command are valid. If you encounter the problem when trying to control the device with your own software, try using one of the demo programs from our website to verify that the hardware
The device does not send replies but otherwise works.	If you encounter the problem when trying to control the device with your own software, try using a demo program from our website to verify that the hardware is functioning properly. Make sure that the receiving part of your code or commercial package is correct. Check baud rate, etc. Check connectors for bent or broken pins.
The device sometimes returns fewer than 6 bytes.	This problem usually indicates a problem with the settings for your serial port. Some serial ports are set to automatically recognize and remove specific control characters such as carriage returns when they appear in the RS232 receive buffer. When this happens, it appears as though the device has not sent enough bytes, but really the controlling computer has just removed some before you could read them. You will need to change the serial port settings to fix the problem.
Moving the joystick causes no motion. The green LED is on, and the yellow LED blinks when I move the joystick.	The joystick may not be configured correctly to control the devices daisy-chained to it. i.e. the joystick may be trying to communicate to a device number that is different than the device numbers of the devices connected. Try the following steps:

	- Verify that each device in the daisy chain works individually. - Plug all the devices in a daisy-chain with the joystick being the first device next to the computer, and issue a renumber instruction. - Verify again that the computer can communicate with each device independently. - Check the device numbers associated with each axis of the joystick to see that they address the correct device in the daisy-chain. - Try moving the joystick again.
Moving the joystick causes no motion. The green LED is on, but the yellow LED stays off.	One of the following conditions could cause this symptom: -The joystick axis could have been disabled, by setting the velocity scale to 0. Solution: re-enable the joystick axis by setting the velocity scale to a non-zero value. -You may be in calibration mode. When the T-JOY is in calibration mode it does not send instructions to other devices. Solution: turn off calibration, recalibrate, or power off/on. -Calibration may be wrong. If the dead-bands and limits were reversed, it could make the joystick unresponsive. Solution: recalibrate.

Warranty and Repair

For Zaber's policies on warranty and repair, please refer to the <u>Ordering Policies</u>

Standard products

Standard products are any part numbers that do not contain the suffix ENG followed by a 4 digit number. Most, but not all, standard products are listed for sale on our website. All standard Zaber products are backed by a one-month satisfaction guarantee. If you are not satisfied with your purchase, we will refund your payment minus any shipping charges. Goods must be in brand new saleable condition with no marks. Zaber products are guaranteed for one year. During this period Zaber will repair any products with faults due to manufacturing defects, free of charge.

Custom products

Custom products are any part numbers containing the suffix ENG followed by a 4 digit number. Each of these products has been designed for a custom application for a particular customer. Custom products are guaranteed for one year, unless explicitly stated otherwise. During this period Zaber will repair any products with faults due to manufacturing defects, free of charge.

How to return products

Customers with devices in need of return or repair should contact Zaber to obtain an RMA form which must be filled out and sent back to us to receive an RMA number. The RMA form contains instructions for packing and returning the device. The specified RMA number must be included on the shipment to ensure timely processing.

Email Updates

If you would like to receive our periodic email newsletter including product updates and promotions, please sign up online at www.zaber.com (news section). Newsletters typically include a promotional offer worth at least $100.

Contact Information

Contact Zaber Technologies Inc by any of the following methods:

Phone	1-604-569-3780 (direct) 1-888-276-8033 (toll free in North America)
Fax	1-604-648-8033
Mail	#2 - 605 West Kent Ave. N., Vancouver, British Columbia, Canada, V6P 6T7
Web	www.zaber.com
Email	Please visit our website for up to date email contact information.

The original instructions for this product are available at http://www.zaber.com/wiki/Manuals/T-JOY.

Appendix A: Default Settings

Please see the Zaber Support Page for default settings for this device.

Appendix B: Device Specifications

For complete device specifications for T-JOY actuators please see <u>our website</u>.

Specification	Value	Alternate Unit
Communication Interface	RS-232	
Communication Protocol	Zaber Binary	
Maximum Current Draw	50 mA	
Power Supply	12-16 VDC	
Power Plug	2.1mm center postive	
Data Cable Connection	Minidin 6 M/F	
Buttons	5	
Axes of Motion	3	
LED Indicators	Yes	
RoHS Compliant	Yes	
CE Compliant	Yes	

Comparison - T-JOY Series

Part Number	Weight
T-JOY3	0.35 kg