

# ME2 Servo Console

## Operating Instructions

### July 25, 2005

#### Overview:

The servo console was originally designed as a diagnostic and testing interface for servo development. Subsequently it has become used to control the servo for other testing purposes not specifically related to servo, and evolved into the primary control interface for the Segway/ME2 research decks. Because of this “lab” orientation, the operator is assumed to be technically knowledgeable, and the console user-interface does not protect against some potentially destructive operations.

The console input and output comes entirely through an RS-232 port, in ASCII characters. The human interface comes via a simple terminal or terminal emulator such as Microsoft HyperTerminal. No intelligence, editing, or cursor addressing is required in the terminal, only simple ASCII text presentation. Menus and prompts are generated by firmware running in the servo controller, and user keystroke commands are also processed there. Many system setup parameters are also stored in flash EEPROM on the servo controller, to save the configuration for a particular deck.

This manual corresponds to version 4.12 of the servo firmware.

#### Setup:

The servo’s RS-232 port has a connector and pinout identical to the standard 9-pin serial port commonly found on personal computers. To connect the servo controller to a PC, use a standard 9-pin null-modem cable (sometimes also known as a serial LapLink cable).

Communication parameters for the serial port are as follows:

- 57600 bps
- 8 data bits
- No parity
- 1 stop bit
- Software (Xon/Xoff) flow control

#### Quick Start:

To start up and use the servo, follow the following procedure:

1. Plug the RS-232 cable into the 9-pin D connector at the back of the electronics enclosure on top of the deck, and the other end into the terminal or terminal emulator.
2. Power up the terminal, or start the terminal emulation program
3. Turn on the power supply to power up the servo system.

4. The *Main Menu* should now appear on the terminal screen.
5. Mount a tape reel on the spooler clutch and manually thread the tape from the spooler all the way through the tape path to the takeup reel. (It is acceptable to skip some of the air-bearings in the path.) Use a drop of alcohol to help the tape adhere to the takeup reel, and wind a few turns onto the takeup by hand.
6. Press 'control-D' on the terminal keyboard. The *Diagnostics/misc Menu* should appear.
7. Press '1' for "Spool to takeup". The servo will take up slack in the tape path and then start to move tape from the spooler to the takeup. The spooling operation will take several minutes. It should stop at about the end of the reel when the servo detects tape slipping on the spooler reel hub. Typically this will be just after the tape pulls free from the spooler, but sometimes you will have to manually spool the last few wraps of tape.
8. The servo console has measured an estimated reel radius as it finished spooling. It will prompt you to confirm whether you will use this radius estimate. Generally this will be accurate enough, so press 'y' on the console.
9. Manually rethread the tape back through the tape path to the supply motor (NOT the spooler motor). You must use all the air-bearings this time. As before, use a drop of alcohol to stick the tape to the reel and wind a few wraps manually.
10. Press backspace on the terminal keyboard to return to the main menu, then press '=' (equal-sign) on the terminal keyboard. This selects the Set Servo Parameters function from the menu. Verify that the displayed tape speed is as desired and press ENTER, or else type a new tape speed before pressing ENTER. Verify or correct the displayed tension in the same way.
11. Rethread the tape back from the takeup reel to the supply reel (NOT the spooler).
12. Press '.' (period) on the terminal keyboard. This selects the 'Initialize' function. The servo will take several seconds to initialize during which time it will move the tape slowly in order to measure tape parameters. When the menu prompt '>' returns, you should be ready to go! The tape is positioned at EOT (all the tape is on the takeup reel), so press 'r' to move the tape in reverse direction (towards BOT) at the selected speed and tension. Once tape is up to speed, the menu is "live" again and you can press 's' to stop tape motion or 'f' to change to forward direction. Tape will automatically stop before running off of EOT or BOT.
13. When you wish to unthread the tape from the tape path, use the 'f' command to run the tape all the way back to near EOT where it stops automatically. Then use the "wind tape" command in the diagnostics submenu to wind the remaining tape onto the takeup reel. When the tape comes off the takeup reel, press ESC to halt the spinning of the takeup reel.
14. Manually thread the tape from the takeup reel back to the reel on the spooler motor, then use the '2' command in the Diags/misc menu to despool from the takeup back to the spooler.

**Notes:**

- The '.' command can initialize the servo at any point in the tape, not just near BOT. There should be no problem with starting up with any amount of tape wound on the takeup reel. It is OK to leave tape in the tape path when powering down.
- If you do not explicitly initialize tension using the '.' command, the servo will attempt to do it

automatically before moving tape.

- To operate correctly, the servo needs to know how much tape is on the supply reel. If the “spool to takeup” function does not set the correct radius for any reason, the “reel full radius” parameter can be set from the *Set parameters in flash* function in the diagnostics sub-menu. This should be done before trying to initialize the radius and tension with the main-menu ‘.’ command.
- Parameters set with the ‘=’ command as described above will be valid only for the session, until the next reset. The defaults for tape speed and tension can be changed in flash EEPROM from the *Set parameters in flash* function in the diagnostics sub-menu.
- Press ESC at any time to abort servo operations. ESC causes all motion to stop, and the reel motors are powered down (so tape tension is lost). After pressing ESC, you may need to do the ‘.’ initialization again before moving tape.

## Detailed Description of the Menus:

The main servo menu appears as follows:

```

Main Menu
. - Initialize
t - Apply Tension
f - Move forward
r - Move reverse
s - Stop
S - Stop without stop handler
= - Set servo parameters
ctl-D - Diagnostics/misc submenu

<ESC> - shut down everything

? - Show servo status
q - Show analog inputs
v - Verbose mode OFF
V - Verbose mode ON
R - Reset motors
0 - Shut down motors
d - Freeze all traces
e - Unfreeze all traces
D - Dump trace data
# - Display Firmware Version
<SPACE> - redisplay menu
```

The commands on this menu perform the following functions:

### **. - Initialize**

This command initializes the motor controllers for all three motors, then applies tension to the tape, then moves tape slowly to measure the relative tape pack radii.

All of these things need to be done before moving tape. The ‘.’ command is therefore the usual thing you would use after any reset or dropped tension.

### **t - Apply Tension**

This function applies tension to the tape. This does not attempt to measure tape pack radii if the firmware believes it has valid radius numbers already. Therefore this can work quicker than the “Initialize” function above.

### **f - Move forward**

### **r - Move reverse**

These functions move tape at nominal speed and tension. “Forward” means toward EOT, “Reverse” means toward BOT. Tape motion continues until stopped from the console, or until the tape gets near BOT or EOT. If the servo does not know the reel radii when this command is given, it may move the tape slowly for a few seconds to make that measurement.

Once tape is moving at nominal speed, the menu prompt will be redisplayed. Further console commands can be accepted while tape is moving.

**s - Stop tape motion**

**S - Stop without stop handler**

These functions can be used to stop tape motion after an 'f' or 'r' function, or when tape is already stopped can switch stop-maintenance on and off. The lower-case 's' is the normal stop. Upper-case 'S' causes a stop without normal closed-loop stop handling. This means that the tape could drift into slow motion if there are imbalances in the motor or drive. The stop without stop maintenance can be useful if you wish to move the reels by hand without fighting the servo.

**= - Set servo parameters**

Displays prompts on the console asking for nominal tape speed and tension. Pressing ENTER at the prompt leaves the previous value intact; entering a number changes it. If tape is already under tension, the new tension value will not take effect until tension is dropped and re-applied.

Note that not all combinations of speed and tension are useable. Maximum speed is not reliable for either maximum or minimum tension. However the console will allow some of these unreliable combinations to be specified.

**? - Show servo status**

Displays debugging information about the current servo state. The most useful fields are the reel radius (in micrometers), rotational position (in 0.1 degree units), and rpm. All of these values are displayed for the supply and takeup motors, in that order. Other parameters are also displayed, these are usually only of use when debugging a malfunctioning servo.

**q - Show analog inputs**

Displays more debugging information, about the analog quantities that can be monitored by firmware. These include power-supply voltages and tension-sensor outputs. The Vmotor voltage should be approximately 15V. The tension-sensor values are in arbitrary units but are normally approximately 20 when there is no tension on the tape and 95 for 1N tension. If the two numbers do not agree roughly, there may be a problem with the tension sensors. Please note that it is common for there to be some discrepancy between the readings, due to various factors including friction in the tape path.

**v - Verbose mode OFF**

**V - Verbose mode ON**

These functions turn control "verbose" console mode for servo debugging. Turning on verbose mode will result in considerable more numeric output during most operations. This is of little usefulness under most circumstances, and also loads the servo processor considerably.

**R - Reset motors**

This function resets the motor-control and position-sensing firmware in all three motor-driver boards. It is useful if the firmware gets into an inconsistent state. This function should not normally be used when tension is applied to the tape or especially if tape is moving, because it will result in an uncontrolled shutdown of the motors. After this command, it is common to get a fault message on the servo console relating to the shutdown, this is not a cause for concern. Using this command stops the position-sensing in the motor-driver boards, and the accumulated position will be reset.

**0 - Shut down motors**

Turns off all current through the motors, including the low AC current used for position-sensing when the motors are unloaded. This will stop the “singing” sound caused by that AC current. This command should not be used when tension is applied to the tape or when tape is moving. Using this command stops the position-sensing in the motor-driver boards, and the accumulated position will be reset.

**d - Freeze all traces**

**e - Unfreeze all traces**

**D - Dump trace data**

These functions manage the servo analog-trace functions. Trace data is continuously sampled during operations. The ‘d’ command freezes the sampling, thus preserving the most recent information. This would be done at a time immediately after some interesting event. The ‘D’ function dumps the trace information (as ASCII text) out to the console; normally this is captured into a file by a terminal emulator program, for further analysis. The exact parameters being traced are dependent on what function is being executed, and interpretation may require detailed knowledge of the operation of the servo firmware. The ‘e’ command reverses the effects of the ‘d’ command, and allows more trace data to be collected. Traces are also unfrozen at the end of the ‘D’ dump.

**# - Display Firmware Version**

Dumps out a string describing the version and build-date of the servo firmware. This is the same string displayed at power-up.

**ctl-D - Diags and misc sub-menu**

Pressing control-D will bring up the diagnostics sub-menu, described below.

**<ESC> - shut down everything**

ESC can be pressed at any time to shut down the servo. Any tape motion in progress will be stopped as quickly as possible. The current through all motors will be shut down and tape tension is dropped. This is an emergency stop operation that should be used only when the normal stop function is not useable.

**<SPACE> - redisplay menu**

Pressing the spacebar always redisplay the current menu. Useful when the menu has scrolled off the top of the screen.

The diagnostics submenu appears as shown:

```

                                     Diag/misc Menu
w - Wind tape                        s - Stop tape motion
1 - Spool to takeup                  c - Send I2C Command
2 - Despool from takeup              i - Set motor current
3 - Spool from pancake               r - Set motor RPM
4 - Generalized spooling             p - Set motor position
5 - Precision spooling              l - Set rpm limits
! - Run tape wear-test              E - Talk to EPS console
e - Set wear-test BOT/EOT limits
f - Set parameters in flash
F - Set internal parameters in flash
= - Set internal parameters
X - Load servo firmware (XMODEM)
Y - Load EPS firmware (XMODEM)
m - Motor diag submenu
ctl-P - Pressure calibration sub-menu
<BACKSPACE> - Back to main menu
<ESC> - shut down everything         <SPACE> - redisplay menu
```

### **w - Wind tape**

This function prompts for supply or takeup reel, then winds tape slowly onto that reel, under no tension from the opposing reel. This is useful when winding tape out of the tape path, or when winding tape onto a reel from an external tape supply, or for recovery from some malfunctions. The RPM of the reel doing the winding is regulated and will continue until ESC is pressed at the console. Current in the winding reel is limited so that if the reel is stalled for any reason the motor will continue to pull but will not overheat or suffer any other problems.

### **1 - Spool to takeup**

This is the digit '1' not the letter L. It is used as described in the *Quick-Start* section earlier in this document, to spool tape from a cartridge reel on the spooler motor onto the takeup reel. At the end of the spooling operation, the servo will display a prompt:

```
Estimated tape pack radius = 46789 um.
Set radius in flash (Y/N) ?
```

This radius estimate is computed based on the relative motor RPM at the time the operation finishes. For most purposes, this estimate is usually accurate enough. Press 'Y' in the console to accept the radius estimate and write it into non-volatile storage on the servo controller. Press 'N' to ignore that estimate. You can manually input a tape-pack radius using the 'f' (Set parameters in flash) function.

### **2 - Despool from takeup**

This is used as described in the *Quick-Start* section earlier in this document to despool tape onto a cartridge reel on the spooler motor.

### **3 - Spool from pancake**

Similar to the “Spool to takeup” function above except that it displays two option prompts, and also does not calculate an estimated tape-pack radius..

The first prompt asks whether the spooler motor should rotate clockwise or counterclockwise. This is to accommodate pancakes wound with magnetic side in vs. magnetic side out.

The second prompt asks “Number of wraps to spool onto the takeup hub?” This allows the user to specify a limited amount of tape to be wound before the spooling stops. For reference, 700 wraps will spool about 100 meters of tape.

### **4 - Generalized spooling**

Similar to the “Spool to pancake” function above except that it displays more option prompts

The first prompt asks “From which motor”. You will tell it which reel the tape is coming from by pressing S for supply, T for takeup, or L for spooler motor.

The second prompt asks “To which motor”. You will tell it which reel the tape is going to by pressing S for supply, T for takeup, or L for spooler motor.

The third prompt is “Type 1 to make spooler unwind normally, 2 for reverse ?” Type 1 to make the “from” motor unwind in the normal sense, that is, the way it usually works in standard operation. This is to accommodate pancakes and cartridges wound with magnetic side in vs. magnetic side out.

The fourth prompt is “Type 1 to make takeup wind normally, 2 for reverse ?” Type 1 to make the “to” motor wind in the normal sense, that is, the way it usually works in standard operation.

The last prompt asks “Number of wraps to spool onto the takeup hub?” This allows the user to specify a limited amount of tape to be wound before the spooling stops. For reference, 700 wraps will spool about 100 meters of tape.



## 5 - Precision spooling

Provides spooling functions similar to the “spool to takeup” and “despool from takeup” functions, except that they operate at controlled tape speeds up to 6 m/s, and more precisely controlled tape tension. Before selecting this function, thread tape from the spooler motor to the takeup motor. Unlike the primitive spooling functions, tape *must* go across the tension sensors in the middle of the tape path, since these are used for closed-loop tension control.

The function will prompt “Press 1 to spool, 2 to despool”. Press 1 or 2, or ESC to back out of this operation.

Next, you will see the prompt “Spooling tape-speed (is 600 cm/s) ?” This sets the tape-speed during spooling. The legal range is 100 to 600 m/s.

If you selected “1 to spool” earlier, there are two more prompts. The first says “Full reel radius after spooling (is 47000 um) ?” For precision spooling to work the firmware must know the tape-pack radius (this differs from the standard “spool to takeup” function which spools slowly but is able to make an estimated radius measurement after spooling). This number is important: if it is too large, the servo will run off the end of tape unexpectedly both during spooling and later during normal operation. If the number is too small it will stop well short of end of tape, leaving extra tape on the reel. Inaccurate radius measurement will also cause the tape speed to be inaccurately controlled.

The final prompt is “Spooler hub radius (is 22000 um) ?”. This parameter is needed in case a non-standard reel is being used on the spooler motor. The default of 22 mm corresponds to a standard Ultrium cartridge reel. If you are using a pancake or some other kind of reel, you must enter the correct radius value.

The “precision spooling” function will initialize tape tension between the spooler and the takeup motor and then move tape in a controlled way. It will stop a short distance before the calculated end of tape, and then wind tape slowly until it slips free of the source reel.

## ! - Run tape wear-test

This actually comprises two different tests. The console will prompt for short or long-cycle wear test.

The **long-cycle wear test** goes from near BOT to near EOT, giving as long a period of continuous motion as possible. The console prompts for the number of cycles to be run. The operation continues until that cycle count is done, or the operation is interrupted from the console. The console is “live” during this operation so one way to terminate the operation would be to press BACKSPACE to return to the main menu, then ‘s’ to stop tape..

The **short-cycle wear test** performs a rapid shoe-shine operation where motion is reversed quickly. The console prompts for a cycle count as for the long-cycle test, it also prompts for position drift rate. This latter parameter controls how far the tape position advances for each cycle (in units of 1/10 degree revolution of the supply reel). A drift value of zero will cause the same section of tape to be continuously used; a value of 3600 will cause the tape to move about one extra revolutions each cycle. When the drift reaches EOT or BOT, the drift direction will be reversed so as to go back to the other end of tape.

**e - Set wear-test BOT/EOT limits**

This function sets the limits for the wear-test described above, describing supply-reel positions (in 1/10 degree revolution of the supply reel) for those limit positions.

**f - Set parameters in flash**

This function allows some servo parameters to be changed and stored in flash EEPROM on the servo controller. It prompts as follows:

```
Full reel radius (is 47000 um) ?
Takeup reel hub radius (is 22000 um) ?
Supply reel hub radius (is 22000 um) ?
Default tape speed (is 800 cm/sec) ?
Default tape tension (is 1000 mN) ?
Idle delay before motor shutdown (is 5 sec) ?
Takeup reel EOT stop radius (is 22500 um) ?
Supply reel EOT stop radius (is 22500 um) ?
```

The full reel radius describes the size of the tape pack on the full cartridge reel before tape is threaded and wound onto the takeup. The hub radius for each reel describes the size of the empty hub. Default tape speed and tension set the starting values for speed and tension, these can be modified temporarily by the '=' command on the main menu.

The "Idle delay" parameter allows the EPS motor drivers to be automatically shut down when the motors are inactive with no tension on the tape. When the motors are active but idle, the position-sensing currents cause a "singing" sound in the motors. After the "Idle delay" time has elapsed, the motors will be shut down and the "singing" will stop but rotational position sensing will also be disabled. If you wish the motor position sensing to stay active when tape tension is dropped, a value of greater than 32767 seconds will disable the idle-shutdown function.

The last two parameters are "Takeup reel EOT stop radius" and "Supply reel EOT stop radius". These control at what tape-radius the tape will stop to prevent running off the end of tape. These are normally around 22500 micrometers to allow a small safety margin above the 22000 micrometer hub. Reducing this value will allow you to use more tape at the risk of running off the end. Increasing the value will help if you have problems with running off the end of tape.

Once these parameters have all been specified (or confirmed by simply pressing ENTER), the following prompt is displayed:

```
Write to flash? (Y or N, default N) ?
```

Respond with 'Y' to write new values into flash and execute a soft reset to put them into effect. Any other response aborts the operation and leaves all parameters unchanged.

**F - Set internal parameters in flash**

**= - Set internal parameters**

These two functions are used at ME2 to configure servo firmware for specific applications. The parameters controlled here should not normally be changed in the field. Modifying these parameters could result in damage to tape or drive, and can easily make the servo inoperative.

**X - Load hex file (XMODEM)**

**Y - Load EPS firmware (XMODEM)**

These functions are used to load new firmware into the servo controller or into the motor controllers respectively. These functions require appropriate firmware update files and a terminal emulator program set up to transmit appropriately. Detailed instructions for loading firmware will be made available with the firmware updates.

**m - Motor calibration sub-menu**

This is used for testing of new motors and motor driver boards. The functions in this sub-menu will spin the motors rapidly and independently and can *NOT* be used when there is tape on the reels. These diagnostics are not normally usable in the field and are not documented here.

**ctl-P - Pressure calibration sub-menu**

This is used for initial calibration of new tension sensors. These diagnostics require special fixtures and are not normally usable in the field, so are not documented here.

**<BACKSPACE> - Back to main menu**

Use the BACKSPACE key to go back up to the main menu.

**s - Stop tape motion**

This duplicates the “stop” function on the main menu, for convenience. It is usually used to terminate wear-tests.

**c - Send I2C Command**

This diagnostic is used at ME2 for testing and characterization of the servo, and not normally useful in the field.

**i - Set motor current**

**r - Set motor RPM**

**p - Set motor position**

These functions are used when testing motors to send commands directly to the motor-driver board firmware, for diagnostic purposes or for very unusual circumstances. They bypass all normal checks and may damage any tape in the path, so should be used with caution. The servo will prompt for which motor to send the command to (S for Supply, T for takeup, or L for spooler) and then for the parameter value to be sent. Most users will never need these functions.

**l - Set rpm limits**

(This is the lower-case letter L, not the digit ‘1’.) Sends an RPM limit command to the motor-driver board firmware. This is useful only to bypass normal tape-integrity and safety checks, and will not normally be needed.

**E - Talk to EPS console**

This function is a gateway to allow direct manual communication with the motor-driver board firmware. It is used during manufacturing and trouble-shooting at ME2 and contains functions not normally useful to the end-user. After entering this function, you will see a new menu that looks similar to the servo console menus but actually comes from the EPS motor-driver firmware. If you should get into this function, press control-D to exit back to the servo console diags/misc menu. Playing with the EPS console functions could cause damage to any tape installed on the drive, or even to the motor and driver board.

## Servo Fault Messages:

The servo firmware contains a great deal of internal sanity checking. When problems are detected, the firmware usually can stop tape motion gracefully and perform an emergency shutdown to prevent further damage to the media or system.

When a fault is detected, a message will be displayed in the form:

```
*****Servo failure: Supply reel runaway (0xB)
```

After such a message, software shuts down the motors and then performs a soft reset to attempt to clear the fault. If this is successful, the main menu will be redisplayed. At this time the tape will be stopped and tension may be dropped. Depending on the nature of the fault, an initialization ('.') may need to be done to restore operation.

The fault handler also freezes the servo trace data, so that a trace can be dumped to show the time leading up to the fault.

These faults may indicate a mechanical or electronic hardware problem, but more commonly indicate a firmware bug or a problem with the tape media itself. ME2 can often analyze these faults remotely from the trace data to determine what is happening and how to work around or fix the problem.

If you are having problems involving servo failure or error messages, please capture or write down the exact text of the error message and email it to ME2. There are a large number of different checks of this kind and minor differences in the message text may be significant.