

Electronic Lead Screw Users Guide

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i) Revisions

Date	Author	Revision	Description
01NOV08	John Dammeyer	0.02	Changed text for button from 'ENTER' to 'OK' to match overlay
09NOV08	John Dammeyer	0.03	Added Revisions Table and RS232 reference section
24NOV08	John Dammeyer	0.04	Added Pin and Jumper Descriptions supplied by Richard Edwards.

ii) Acknowledgments

ii) Conventions

The ELS display is made up of two lines of 20 characters and three types of information are displayed: a Run Time display; Menu display or Parameter Entry display.

Run Time Display:

The run time display is shown whenever the the SCREW or TURN button is pressed.

0 SFM Z 0.100"=
T 0.005" X 0.000"

The Menu Displays always show the Menu Names on the top line in upper case characters and a set of up to four Menu Options on the second line. Underneath the Menu Options are are four function buttons that line up with the four Menu Options.

Each Function key tap brings up either a new Menu Option or Parameter Entry screen. For each Menu Option the first line displays in upper case characters an expanded description of the acronym displayed over the Function Key.

SETUP
SPDL FLGS CRSS LDSCR

Parameter Entry:

At the end of each sequence of Menu Options is a Parameter Entry. The text describing the parameter is in upper and lower case and the parameter is displayed on the second line with whatever units are relevant.

\

Turn Pitch
0.0050"

1. Introduction

2. User Interface

Manual Pulse Generator

The MPG Button on the top right hand side represents a 16 position quadrature encoder to allow movement of the carriage left or right by turning the dial. Pressing down on the dial actuates a button that allows a user to select between several preset distance per detent values and to choose which axis the dial moves.

Numeric Keypad

There's a numeric keypad for entering parameters, function keys for menu driven options and a predefined set of buttons to make the ELS more user friendly.

Movement Buttons

Tapping the single < or > jog buttons move the carriage a predetermined amount and if held down, move the carriage at the threading or turning rate. The << and >> buttons slew the carriage at full speed. With those 4 buttons it's pretty easy to maneuver the carriage and therefore the tool bit to an exact position. Similarly the ^,v buttons move the cross slide in and out if an X axis motor is connected and enabled. The LCD displays the motion in user units like inches or millimeters.

Setup Buttons

The **BEGIN/END** buttons set the beginning and ending points for the automatic operation. The system always moves the carriage in the direction from **BEGIN** to **END** so cutting left or right hand threads and turning to or from the headstock is really easy. Even if you jog past the **BEGIN** or **END** point the **START** Button takes you to the correct position in the **THREAD** or **TURN** cycle which is displayed on the LCD screen.

Function Buttons

Labels above each button on LCD display determine function when **ONLINE** LED is off.

When ELS is READY or RUNNING the **ONLINE** LED is **BLINKING** or **ON** respectively and then the function buttons serve as hot keys to access system information.

- **FN1** – Z axis start and end position
- **FN2** – X axis start and end position
- **FN3** – Threading control
- **FN4** – Taper Turning features

3. Configuring the Electronic Lead Screw

How to configure the ELS for your machine.

3.1 Getting Started:

Configuring the ELS for your machine. Refer to Appendix I for the electrical connections. Much of the setup can be done before anything is connected to the ELS. The only exception is the **ESTOP** input which is usually a Normally Closed (NC) switch that opens when activated. An NC switch is used for safety because an open circuit fault like a broken wire to the **ESTOP** switch will act the same as the switch activation.

Power it up –

E-LEADSCREW
Ver PIC18F4685 1.03m

If the ELS beeps and shows:

ESTOP INPUT
ACTIVE!!

then you will then have to solve a hardware problem before you can go ahead and set up the rest of the parameters. **ESTOP** is a serious situation and for safety reasons the ELS insists that the issue be solved before anything else can be done. That means it's not possible to temporarily override it while operating the lathe.

By default the **ESTOP** input is allowed to be left open circuit (not connected) and the parameter inversion flag is set ON. If you have the **ESTOP** switch connected and the button not asserted (closed switch to ground) the ELS thinks it's in **ESTOP**. To go further, assert the **ESTOP** by pressing and latching your **ESTOP** so the switch is open. Then tap the ESC key. The message should go away. Leave it for now with **ESTOP** on and we'll set it up later when we set up the system flags.

Press the **ESC** key to enter **IDLE** mode until you see this screen and begin entering parameters.

Choose Option
RUN SETUP

3.2 Setting Units

Before you set up the various machine parameters you want to choose the units compatible with the type of work you do. Tap RUN | UNITS | METRIC

SCREW OR TURN UNITS
Metric Mode is OFF

Tap the '.' key to toggle the OFF to ON and tap **OK** to save if you want all units in millimeters, leave it OFF to remain in imperial units. Then tap **ESC** twice to return to the 'Choose Option' menu and enter the SETUP menu by tapping the **FN4** key.

SETUP
SPDL FLGS CRSS LDSCR

Now choose 'LDSCR | PARAM' to set up lead screw (Z Axis) parameters.

MOTOR Z
RATE PARAM

3.3 Setting Z axis Leadscrew Parameters

MOTOR Z PARAMETERS
ACCL PTCH BKLSH STPS

We need to set up Acceleration, Pitch, Backlash and the number of motor steps per revolution. The default Acceleration value of 9000 is probably adequate to start but press the **FN1** key to verify the setting. If it's not 9000 tap the **DEL** key to erase it, enter the number 9000 and press **OK** to accept it. The ELS beeps twice every time a new value is saved to permanent EEROM memory. (More on acceleration later).

Motor Z Acceleration
9000_

Tap the **ESC** key to move up one menu and now select **PTCH** to set up the lead screw pitch.

LEADSCREW PITCH
TPI PITCH METRIC

If you know the lead screw pitch in Turns per Inch tap the **FN1** button under the **TPI** text. The other two options are pitch in inches or mm. Check your lathe operator's manual for this information. As in setting the acceleration, tap the **DEL** key to erase the current setting and enter the new value and tap **OK**. Then tap **ESC** to return to the previous memory.

Imperial Leadscrew 10.0 TPI

The ELS has only a single previous menu memory so tapping the **ESC** key again returns us to the Option Memory. Press **FN4** | **FN4** to get back into Lead Screw Setup and Motor Z parameters. Press **FN3** to select BKLSH and enter in the lead screw backlash or 0 if you don't know what it is.

Leadscrew Backlash Backlash 0.000"

Tap **ESC** to return up one menu to:

MOTOR Z PARAMETERS ACCL PTCH BKLSH STPS

Tap **FN4** (STPS) to select 'Motor Z Steps' per Lead Screw Revolution.

Motor Z Steps 01600_ Steps/Rev

The number entered for this parameter is pretty easy to determine. The stepper motor driver usually turns a stepper motor that has a base 200 steps per revolution. If it's a

micro-stepper driver this number is multiplied by a constant like 8 or 10. In the case of the on board micro-stepper driver the number is 8 so the motor has a minimum of 1600 steps per revolution. If the motor is directly coupled to the lead screw, key in this number and tap **OK**.

If you have pulleys between the motor and the lead screw then you need to multiply this number by the pulley ratio. Say for example, the Motor has a 16 tooth pulley and the lead screw has a 40 tooth pulley. That's a 2.5:1 ratio so the motor moves 2.5 x 1600 which equals 4000 steps per lead screw revolution.

Tap **ESC** twice to return to the 'Choose Option Menu' and then tap **FN4** (SETUP) again. Next set up the Lead Screw rate by tapping **FN1** (RATE).

<p>MOTOR Z MOVE RATE SLEW DELAY MOVE</p>

There are three available parameters. SLEW DELAY & MOVE

If the ELS has the on board micro-stepper driver installed then it can drop it to a lower power holding mode after a certain amount of time has passed. The following menu lets you set the number of seconds before power is reduced. External drivers may have their own parameter for this.

<p>Time Till Step Power Down 000 x 1.0S</p>

If you are using the on board micro-stepper drive you can leave it at 0 and the motor will always remain at full power even after it's stopped. Set it to a value between 1 and 255 and the ELS will wait that number of seconds before setting the motor to 50% power.

We'll leave the DELAY alone for now and set up the SLEW and MOVE values. Maximum possible step rates are 20000 steps per second.

<p>MOTOR Z MOVE RATE SLEW DELAY MOVE</p>

The **SLEW** rate is used for the high speed carriage movement buttons and during programmed operation to return the carriage back to the **BEGIN** position. Initially set this value to 10000 and tap **OK** to accept and then press **ESC** to return back to the previous menu.

Motor Z Slew Rate
10000

The **Move** rate is used to move the carriage when the spindle is stopped and the **>**, **<** buttons are pressed and held down. It needs to be a slow speed so you don't accidentally run the carriage into something. Set it to 3000 to start with and tap **OK** to accept and **ESC** to return to the 'Choose Option' menu.

Motor Z Move Rate
5000

3.4 Setting X axis Leadscrew Parameters

Tap **FN4** **SETUP** so we can now configure the cross slide parameters.

SETUP
SPDL FLGS CRSS LDSCR

Tap **FN3** (**CRSS**) and note that the menus are the same as for the carriage. Set up acceleration, pitch, backlash and the number of motor steps per revolution in the same way as you did for the carriage.

MOTOR X
RATE PARAM

As in the Carriage, the MOTOR X MOVE RATE has a SLEW and MOVE option.

The MOVE rate is used when the **^** and **v** keys are pressed and held. Don't set the MOVE rate too high or the tool will run into the work before you can release the button.

There is no direct way to test the SLEW rate which is used to insert and withdraw the tool from the work during programmed operation. Instead, determine a MOVE rate that will not skip steps or loose position and use that value for the SLEW rate.

The Setup Menu has a **FN1** (**SPDL**) entry to set up the number of encoder lines per revolution. Currently this entry can be set but is not used.

SETUP
SPDL FLGS CRSS LDSCR

3.5 Setting System Flags

Finally we have the **FN2** (FLGS) parameter flags section.

Use the number pad **^**, **v** and **'** Key to scroll through the menu entries. The **'** Button toggles the value and the **OK** key is used to accept the value and the **ESC** key restores the value to the original value.

SET PROGRAM FLAGS
SCRL ^,V TOGGLE '.'

Each menu entry has text describing the flag stating the setting is **ON** or **OFF**.

USE COMPOUND FOR
THREADING IS OFF

The ELS doesn't need a Compound Slide (or Top Slide as it's also called) since it moves the X and Z axis along the hypotenuse of the thread angle triangle. If the X axis isn't powered then this flag should be **ON** so that on each pass the carriage returns to exactly the same **BEGIN** position since the manually operated compound slide takes care of both Z and X motion.

*This Flag is also set to **ON** when using threading mode to do multiple pass turning and facing. More on that later under ELS operation.*

Tap the scroll down **v** key to bring up the next flag.

**BROACH MODE MOVEMENT
IS OFF**

The spindle must be turning in order to cut threads or turn the work so before and during automatic motion the ELS checks to make sure the spindle is turning. When using the lathe as a shaper to broach or cut splines the spindle is locked in position and should not turn. Setting 'Broach Mode Movement' disables the test for spindle turning. This option is also useful for testing ELS movement when it's not even connected to a lathe.

**AUTOMATIC X
MOVEMENT IS OFF**

If there is a stepper motor connected to the cross slide, set this flag **ON**, otherwise set it **OFF**. With it **OFF**, the ELS will prompt you to enter and remove the tool from the work between threading or turning passes. Remember, the '.' Key toggles the value, the **OK** key accepts and stores it and the **ESC** key discards it. We'll cover the manual non-automatic menus later.

The next flag is **TAPER TURNING** which is only useful if you have a powered cross slide. For now you should set off.

**TAPER TURNING
TAPERING IS OFF**

If you have wired up the Electronic Half Nut set this flag **ON**. Otherwise set it **OFF**. Initially while learning how to use the ELS it may be beneficial to leave it turned off so there is one less thing to think about.

ELECTRONIC
HALFNUT IS OFF

Tap on the scroll down **v** key to show the **ESTOP INVERSION** menu.

INVERT ESTOP LINE
INVERTED IS ON

Changing this flag will result in an immediate error message. At this point, to clear the error, the **ESTOP** input pin must be changed to the opposite of what it was. If the **ESTOP** flag was on it means the ELS can run without an **ESTOP** switch connected. If the **ESTOP** flag is OFF, then the **ESTOP** input pin must be connected to ground. This is the preferred method of using the **ESTOP**. A normally closed (NC) switch connects the **ESTOP** line to ground and pressing the **ESTOP** opens this contact. Then if there is an open circuit fault, like if a wire to the switch breaks, an **ESTOP** also occurs.

If you accidentally change the flag to OFF without an **ESTOP** button connected to ground the ELS will enter the **ERROR** state and it won't be possible to change the flag back to ON! There are two solutions:

Connect a wire to the DB-25 **ESTOP** pin and connect it to GND and then change the flag. That will cause the **ERROR** message. Disconnect the wire and continue setting up the ELS.

Turn off the ELS, hold down the **DEL** key and power up the ELS again.

WARNING! This will set all parameters back to factory settings. Use this as a last resort.

Now setup the Invert Limit Switch Flag.

INVERT LIMIT SWITCH INVERTED IS OFF

The limit switch is only tested during programmed movement. During Jogging the switch input is not tested. With the flag **ON** the switch needs to connect the input to ground to create a limit condition. With the **FLAG OFF**, the switch needs to be normally closed to ground and will open when a limit is encountered. Using the **MPG** knob results in a programmed distance movement and could also generate a **LIMIT Error**.

USE ONBOARD STEPPER STEP MOTOR IS OFF

Set the 'Use Onboard Stepper Motor' Flag on if you have and are using the on board micro-stepper.

The Z axis DIR and STEP pins on the DB-25 connector should not be connected to anything as they now have a totally different purpose and are used internally for the micro-stepper.

Z AXIS DIRECTION INVERTED IS OFF

The carriage must move in the correct direction in order for the automatic operations to work correctly. If the carriage moves to the right when the **<** button is pressed then the flag must be set to the opposite value.

The cross slide must move inwards toward the work when the **^** button is pressed. If it doesn't then set the flag to the opposite value.

**X AXIS DIRECTION
INVERTED IS OFF**

The STEP pin on the DB-25 connector goes high to approximately 5V for 5uS when a step is required. Some external drivers need the step line to go low for a step pulse. Consult your driver specifications to determine if this Flag needs to be set.

**Z AXIS STEP POL
INVERTED IS OFF**

As in the 'Z AXIS STEP' polarity, consult the driver specifications to determine what is needed.

**X AXIS STEP POL
INVERTED IS OFF**

The 'Serial Port' is currently used for diagnostics so this flag is used to enable an echo of what is typed. If controlled by a remote computer the echo is usually not wanted.

**SERIAL PORT
ECHO CHARS IS OFF**

Basic machine setup is now complete.

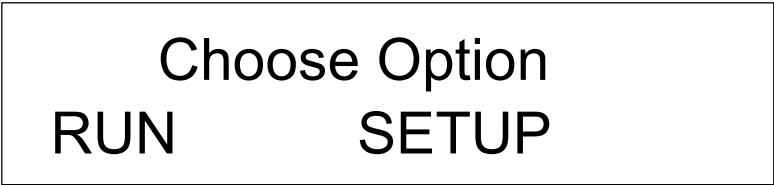
4. Running the ELS:

4.1 Configuring the Run Time Display.

Running the ELS isn't a lot different than working with a manual lathe. Whether turning down a shaft, turning a shoulder or screw cutting, the basic principles remain the same. The ELS does all cutting at an X axis position of 0.000" or 0.00mm; also called the X Axis HOME position. This is exactly the same as turning the cross slide handle for a 0.010" depth of cut and then setting the cross slide dial to zero just before the turning operation is started.

The ELS measures the cross slide motion as a change in radius. Movements are always considered to be a depth of cut or distance moved into or away from the work. There is no explicit assumption that the ELS knows where the tip of the tool is in relation to the lathe centre axis. That's because a manual lathe operator will often readjust the tool holder or tool bit angle to get an optimum cut. After each tool bit position change the lathe operator would have to recalibrate the absolute tool position. Necessary in a CNC system but awkward in a manual lathe.

There is a way to set the absolute X position of the tool bit relative to the lathe center line. This is needed if the spindle speed needs to be displayed in Surface speed per Minute (SFM or SMM) instead of RPM. Tap the **ESC** key to go into IDLE mode.



Choose Option
RUN SETUP

Then select RUN | UNITS | SFM



SPINDLE DISPLAY
SFM Mode is OFF

Tap the '.' key to change the FLAG from OFF to ON and tap **OK** to save. Tap the **ESC** key twice to return to the 'Choose Option' menu and select RUN | X | LOC to show the 'Tool Tip Position' menu.

With the tool tip touching the work and knowing the diameter of the work you can tap **DEL** and enter in a new diameter. The precise value to the nearest 0.001" isn't important. You are just telling the ELS approximately where the tool tip is so it can calculate surface speed.

Tap **OK** to save and then tap **SCREW** or **TURN** to show the Run Time Display .

<p>0 SFM Z 0.100"= T 0.005" X 0.000"</p>
--

4.2 Using the MPG control.

The Manual Pulse Generator (**MPG**) produces 16 pulses per revolution and can be electronically connected to either the Z or X axis and move the axis a predetermined amount. The active axis symbol [=,<,>] beside the Z or X Digital Read Out (DRO) indicates which axis the **MPG** controls. The **MPG** has detents which make it easy to generate single movements and also has a button that is activated when the button is pressed, resulting in the display of the MPG Menu and the next detent increment.

NEW JOG DSTZ 0.005"
CNCL SELX ACPT

Tap **FN1** (CNCL) to reject the new value or **FN4** (ACPT) to use the displayed value and return back to the 'RUN Time Display' .

For each click or detent the ELS moves the selected axis, Z in this example, one of four predefined distances. To select a new distance press the **MPG** downward again. The 'NEW JOG DISTZ' increments to the next predefined value:

[0.001", 0.005", 0.010", 0.020"]
or
[0.02mm, 0.02mm, 0.05mm, 0.10mm]

The **FN2** label displays which axis is not active. Tapping **FN2** (SELX) changes the **MPG** axis to the cross slide, changes the label to SELZ and the display text to 'NEW JOG DSTX'. The active axis indicator character is set beside the appropriate DRO.

Tap **ACPT**, **SCREW** or **TURN** to return to the 'Run Time Menu' .

4.2 Turning and reducing the diameter.

With the spindle turning you can use the cross slide jog buttons (**^**,**v**) to move the tool in and out and then use the carriage jog button (**<**, **>**) to move the carriage at the predefined turning rate. *Needs editing or embellishment.*

Choose Option
RUN SETUP

Let's set up a turning rate of 0.005" per revolution. Tap the **ESC** key and then the **FN1** (Z RUN Parameters). Next select **FN1** (TURN) to set the turning pitch.

Z RUN PARAMETERS
TURN THRD POS JOG

Tap the **DEL** key to clear the field and then enter in 0.005" and tap the **OK** key.

Turn Pitch
0.0050"

Tap the **TURN** key in the Setup Buttons group and the run time display menu shows up.

0 RPM Z 0.100"=
T 0.005" X 0.000"

Let's look at the information displayed. The '0' beside the text **RPM** tells us the spindle isn't turning. If the spindle is turning and the yellow light appears to be blinking but the value remains at zero it means that the ELS is having trouble with the spindle signal. There could be troubles with the sensor or some other hardware problem.

The letter 'T' at the left side of the screen tells us the number beside the 'T' represents pitch with the double quote representing inches. If the pitch were in mm then the number might be 0.12m where the 'm' represents millimeters. The 'T' for pitch means the lathe is will use the **TURN** parameters rather than the 'S' **SCREW THREADING** parameters.

On the right hand side of the display the ELS shows the position of the Z axis (carriage) and the X axis (cross slide). The '=' on the same line as the Z tells a user that the **MPG** knob will move the carriage. If the '=' is on the second line then the **MPG** will move the cross slide X axis.

Whenever the **RUN** time information is displayed the **GREEN** Status light blinks stating that the ELS is 'READY'. When the ELS is in 'READY' mode the 'Action' and 'Movement' buttons can cause the motors to turn and the lathe hardware to move.

Now that the basic lathe parameters have been set it's a good time to familiarize yourself with the operation of the Movement buttons.

Tap the left move button <. The carriage should move 0.001" (or 0.02mm) to the left and the display should show -0.001". It may be hard to see that short a movement so tap it 9 more times without holding it down and the 0.010" distance should be obvious.

Next tap the > button once. If you've got a fairly large backlash value set the lead screw motor will rapidly take up the backlash before moving the lead screw the single 0.001". Notice even with the backlash movement the Z axis display only changes 0.001".

Now try the slow move operation. Press and hold one of the two movement buttons < or >. The carriage will now move at the predefined move rate. If it's too fast, go back to 'SETUP | LDSCR | RATE | MOVE' and set the **MOVE** rate to a smaller number. Turn on the spindle and note that the **RPM** display stabilizes after 10 seconds showing an average speed. Press and hold one of the two *Movement* buttons again and note that now the carriage moves very slowly; in fact the carriage moves at the **TURN** rate of 0.005" per spindle revolution.

Before you try and cut metal, try the **SLEW** buttons: <<, >>. These move the carriage very quickly and are useful for getting the carriage close to where you want to start cutting. There is no delay like the **MOVE** buttons.

Finally if you've got a motor on the cross slide you can try the **^**, **v** *Movement* buttons to make the cross slide go in and out. If there isn't an X axis motor installed then operation of the cross slide and compound (top slide) are done manually.

So chuck up a piece of steel or aluminium extending out a few inches. Using the slew buttons bring the tool bit up until it's in line with the end of the bar. Tap the **Zero Z** button to set a new Z Home position and clear the Z Position display to 0.000".

Next move the tool towards the bar using the **^** button. When it's close, turn on the spindle and move the tool bit in until it just scratches the bar. Tap the **Zero X** button to establish the X Home position.

With the spindle turning, press and hold the **<** move button and watch as the carriage moves left at 0.005" per revolution. Continue holding the **<** button until the Z readout shows -0.500" .

Automatic Operations:

With the carriage at -0.500" tap the **END Setup** button. This menu shows up and you have the opportunity to edit it by tapping the **DEL** key and entering a new value (don't forget the '-' sign if the carriage is closer to the chuck and on the left side of 0.000").

Z End Position
-0.500"

Tap **OK** to save the value and tap the **TURN** button to go back to READY mode and withdraw the tool bit, using the **v** key, far enough so it clears the bar.

Now let's move the carriage back to where we started. We can use the **ALT-ZHOME** function for this. Press and hold down the **ALT** button and while holding it down tap the **Zero Z** button. The carriage moves automatically back to the 0.000" location.

Use the **>** button to move the carriage to the 0.100" location. This will be our **BEGIN** position for automatic turning. A **BEGIN** position in front of the work is needed to allow the stepper motor to accelerate up to turning or threading speed. Once at that location tap the **BEGIN Setup** button and just like the **END Setup** position a menu comes up to let you adjust, accept or reject (**ESC**) the value.

Z Start Position
0.100"

Tap **OK** and then tap **TURN** to return to the READYState.

Let's check and see what parameters are set. Whenever the run time display is active, the **FNx** buttons provide short cuts to other parameters and information.

FN1 shows the **BEGIN** and **END** positions for automatic carriage movement along with the current location of the carriage.

SETPOINTS Z 0.595"
B 0.100" E -0.500"

FN2 shows the **BEGIN** and **RETRACTED** positions of the cross slide. **BEGIN** should be 0.000" and **RETRACTED** will be positive for external turning and negative for boring. It needs to be set at a point so the tool bit *will always clear the work* between the carriage Z axis **BEGIN** and **END** positions.

SETPOINTS X 0.000"
B 0.000" R 0.100"

FN3 is a quick jump to a special threading menu. More on that later.

PASS COUNT = 0
CNCL RST SET CLR

FN4 is a quick jump to a special tapering menu and allows the **FN1**, **FN4** keys to enable and disable Tapering and **FN3** to set up the taper parameters. Tap the **TURN** button to get back to the **READY** state.

TAPER MODE OFF
ENABLE SET DISABLE

So you've verified that the parameters are all correct. You've done a pass with the **<** button to remove a little bit from the work. The **TURN** button was pressed to put the machine in the **READY** state with the **GREEN LED** blinking.

0 RPM Z 0.100"=
T 0.005" X 0.000"

Turn on the spindle and press the **START** button. The cross slide retracts, and if the carriage isn't at the **BEGIN** position the first thing the ELS does is send the carriage to the **BEGIN** position. It then moves the tool from the **X Retracted Position** and sends it back to the **HOME** or 0.000" position. Next the carriage moves towards the **END** position at the **TURN** pitch rate. When the carriage reaches the **END** position, it stops and the ELS retracts the cross slide back to the **RETRACTED** position and then sends the carriage back to the **BEGIN** position.

The last part of the sequence is the movement of the cross slide back to the ' **X Home Position**'. The ELS finishes there because if you want to do another pass, you use the jog inwards button **^** to move the tool in for the depth of cut desired, 0.010" in this example. Just look at the display and tap the button until the depth is reached. Then, *and this is very important*, tap the **Zero X** button. We have just re-zeroed the cross slide dial and the next turning pass will again cut at 0.000" but it's 0.010" deeper than the last time.

Tap **START** to do another pass! Remember, each time the ELS makes an automatic pass it cuts at the X equal to 0.000" or 0.00mm position and returns with the carriage at the ' **X Retracted Position**'.

4.3 Screw Threading.

Cutting Screw threads isn't a lot different from turning to a diameter except the tool bit has a special shape which matches the profile of the thread. Tools for standard threads are pointed while ACME or trapazoidal tool bits have flat ends. The pitch is coarser than what's used for turning and the operation is done with multiple passes with parameters similar to the G-Code G76 instruction.

The chart below shows the parameters needed for a screw thread cutting operation. The menu tree pictorial shows how to navigate through the menus to set up what's needed.

G76 Simulation has arguments:

Global Variable array indices

X -- X End position.
Z -- Z End position
Q -- Spring Pass Count
P -- Pitch
H -- First Pass cutting depth
I -- In feed thread angle.
R -- X Begin
K -- Z Begin position with room for synchronization
L -- Thread chamfer... not used in ELS.
C -- X retracted position
B -- Last Pass cutting depth
T -- Taper angle. Not used directly. ELS System uses " per foot.
J -- Cutting pass depth

Variables used for calculating new position of X,Z after each threading pass.

When the system is READY (Green LED Flashes) and the FNC3 key is pressed
the menu shows:
PASS COUNT = nn
FIRST RST SET CLR

After RST is pressed a recalculation is performed and Pass Count is updated.
This way an operator can start and stop the threading but has to explicitly
change to a new set of the threading operations.
When the SET softkey is pressed the display is changed to activate the
THREAD PARAMETERS Menu shown below.

```
THREAD PARAMETERS
TURN THRD POS JOG
|
PITCH ANGLE PASS SPRING
FLOAT FLOAT | Spring Pass Count
|          |
|          | uint8 n
|          |
|          | THREAD Pass Param
|          | DEPTH FRST EACH LAST
|          | | | |
|          | | | | Last Path Depth
|          | | | | FLOAT 0.ddd
|          | | | |
|          | | | | Each Pass Depth
|          | | | | FLOAT 0.ddd
|          | | | |
|          | | | | First Pass Depth
|          | | | | FLOAT 0.ddd
|          |
|          | DEPTH CALCULATION
|          | DEPTH MULT   CALC
|          | | |
|          | | | Calculated Depth
|          | | | FLOAT d.ddd
|          | |
|          | | Depth Pch Multiplier
|          | | FLOAT d.ddd
```

Depth of Thread
FLOAT d.dddd

Let's set up everything needed for threading.

Choose Option
RUN SETUP

Setting up to cut a thread begins with choosing the thread size in **TPI** or in an imperial or metric **PITCH** which is the distance between threads. Next the size of the lathe and diameter of the work piece will determine how deep to make the first pass and subsequent passes. There's also a last pass depth to clean up the thread and a number of spring passes that are made without changing the depth. And of course the depth of the thread is the most important parameter for an accurate screw thread.

Based on an assumption that the tool bit has the correct shape and tip radius, the thread depth parameter is from the surface of the material to the root of the thread. After all the parameters have been set the first task is to bring the cutting tool up to the work so that it just touches without cutting. Then **Zero** the **X** axis. The thread will be cut to a depth from this position.

Tap the **THREAD** key and then **FN3** to bring up the 'Thread Pass Count' screen. The four function keys are all shortcuts to other menus or are one touch commands.

Pass Count = 0
FIRST RST SET CLR

FN1 Key is a shortcut to setting the **FIRST** pass depth which is useful for tweaking a thread that needs to be deeper by only a tiny bit without running through the entire sequence again.

FN2 key **RST** calculates and resets the pass count back to the number required to cut a brand new thread.

FN3 key is a shortcut to the 'ESC | RUN | Z | THREAD' menu for setting up threading parameters. Once a parameter has changed a user can tap the **FN2** key to **RESET** the pass count based on the new values.

FN4 clears the pass count effectively stopping further threading passes until the pass count is reset.

Example Threading Operation:

The example assumes that you've just completed a turning sequence and that the last turning pass has left a smooth finish on the work and the X axis home position is at 0.00. The thread will be 20 TPI (0.050" pitch) and 1/2" long where the Z Axis Home position is the face of the work and the thread is RH towards the headstock.

Install the thread tool bit in the tool holder and insure that the tool bit is properly adjusted with a thread gauge. Now it's time to re-adjust the X axis so that the threading tool bit is just touching the surface. Turn on the spindle and using the jog buttons adjust the tool bit so it just starts to scratch the surface. Then tap the **ZERO X** Button so that the X BEGIN position is set at 0.00.

Next, stop the spindle, withdraw the tool bit with the 'v' jog button so it no longer touches the work and move the carriage until the tip of the tool is at the edge of the face or start of the thread. This is the Z axis Home position so tap the **ZERO Z** Button. The Z BEGIN position is still to the right of the face at 0.100". The ELS needs a short distance to bring the lead screw up to speed before the tool bit starts cutting. Otherwise the first part of the thread will be the wrong pitch.

The Z END position is still at 0.500" so we are set to cut a 1/2" long thread. You may want to turn a groove at 0.500" to the thread depth to serve as a runout area or just let the lead screw decelerate and consider the last half turn or so of the thread non-functional.

Now let's set up the rest of the thread parameters. Once done, most of the time you may never change many of these. Tap **FN3**, THREAD MODE to show the Pass Count Display and then **FN3** to short cut through to the THREAD Parameters menu.

<p style="text-align: center;">THREAD PARAMETERS PITCH DPTH ANGL PASS</p>

Tap **FN1** PITCH, then TPI and finally enter 20. Tap **OK** to accept and then **ESC** twice to reach the 'Choose Option' menu. Tap 'RUN | Z | THRD | DEPTH' to set up thread depth.

DEPTH MENU

DEPTH MULT CALC

There are two ways to set the thread depth. The first, and traditional method is to look up the depth for a given pitch and enter that depth, or calculate it using the information in Appendix 2 as derived from the Machinery Handbook.

Depth of Thread

Depth 0.027"

Just tap **FN1** DEPTH and **DEL** to clear out the old value and enter the new one.

There is an easier way. The ELS contains a thread depth calculator which uses the thread pitch and a **MULTIPLIER** constant to determine the final depth. If you use the same type of threading tool bit then once you adjust this multiplier for your lathe, cutting threads will be simple.

Depth Pth Multiplier

0.5413"

Tap **ESC** if you don't want to change the value or **DEL** to clear it and then use the number keys to tap in a new value and **OK** to accept. Tap **ESC**, then **FN4** CALC to have the ELS determine the thread depth based on the thread pitch which is 0.027" for our 20 TPI thread. Tap **OK** to accept the new value and **ESC** twice to return to the 'Choose Option' menu.

Now the thread angle. Tap 'RUN | Z | ANGL' . We're cutting a standard ANSI 60 degree thread so we enter in the ½ angle minus a little bit. A value of 29.5 is fine. **DEL** to clear the old value, the number keys to enter a new one and **OK** to accept; listen for the double beep and then **ESC** to go back up to the previous menu.

Tap **FN4** (PASS) to select the passes menu.

THREAD PASS PARAM
FRST EACH LAST SPRNG

Select **FN2** (FRST).

First Pass Depth
Depth 0.010"

Key in a value that you feel your lathe can comfortably cut without too much tearing or excessive load. A value between 0.005" (0.12mm) and 0.010" (0.25mm) is usually adequate. Leave enough depth so there is room to make at least one EACHpass and a LAST pass. Tap **OK** to accept and then **ESC** to go up one level and then tap **FN2** (EACH) to enter the EACHpass menu.

Each Pass Depth
Depth 0.003"

After the first pass the ELS continues with additional passes each time removing the amount specified in the 'Each Pass Depth' . Set this depth to an amount that suits the material and the ability of your lathe.

Finally you have the chance to add a last finishing pass that only skims the surface of your new thread.

Last Pass Depth
Depth 0.001"

Most lathes have some flex and even after that last pass it's possible that the thread is still not complete. Tap the **ESC** key after you've finished setting the 'Last Pass Depth' parameter and select **FN4 SPRNG**pass.

Spring Pass Count 03 Passes

The 'Spring Pass Count' parameter sets up the number of passes after the last pass where the depth is not changed. Once the ELS has finished cutting the thread it stops and you can try a nut on the thread. If it's tight, Tap the **START** button, and the ELS runs an additional spring pass. Take note if any more metal is removed from the thread groove. Run additional single cycle spring passes until no more metal is taken from the groove.

At this point, the nut may or may not fit. It depends on the radius of the tool bit and whether it properly reflects the depth chosen with the **MULT** parameter. If the nut is still tight the ELS has one other feature that lets you make an additional pass without redoing the entire sequence.

First Pass Depth Depth 0.029"

Change the 'First Pass Depth' to a value deeper than the original thread depth. The ELS determines that the first path is deeper than the total depth so runs a single cutting pass and then a the programmed set of spring passes. Test the nut. If it still doesn't fit, run a few more spring passes or set a new 'First Pass Depth' and do it all again.

4.4 Tapering

Tapering with the ELS can be difficult and very confusing unless you take an systematic approach to setting parameters. The fastest way to set up tapering is to tap the FN4 key during Ready Mode (when the Green Ready LED is flashing).

TAPER MODE OFF
ENABLE SET DISABLE

The display Shows the status of the Taper Mode as ON or OFF although the active axis symbol [=,<,>] beside the 'Run Time Menu' Z or X Digital Read Out (DRO) also lets you know at first glance that tapering is enabled.

- '=' Tapering OFF so the tool bit moves parallel to the spindle axis
- '<' Tapering ON and the tool bit moves inwards as the carriage moves towards the headstock
- '>' Tapering ON and the tool bit moves outwards as the carriage moves towards the headstock.

Tapering is enabled or disabled with the **FN1** (ENABLE) and **FN4** (DISABLE) buttons.

To set the taper angle, tap **FN2** (SET) to bring up the 'TAPER MENU CHOICE' menu.

TAPER MENU CHOICE
DIST ANGL DIR LIST

FN1 (DIST) lets you set the 'Tapering Ratio' in inches per foot.

Tapering Ratio
0.00000 " per Foot

FN2 (ANGL) lets you set the taper as an angle measured relative to the spindle axis. The maximum possible angle is 45 degrees. See Appendix 3 for details.

Taper movement to headstock is OUT >

To toggle between the two possible taper modes, tap the '.' key. The phrase 'OUT >' changes to 'IN <' and back each time the '.' key is tapped. Tap **OK** to accept and **ESC** to cancel.

Tapping **FN4** (LIST) brings up a convenience menu of 'PREDEFINED TAPERS' .

PREDEFINED TAPERS MRSE JACB ASRT CSTM

MRSE	MORSE TAPER LIST	#0 thru 7
JACB	JACOB TAPER LIST	#0, 1, 2, 2A, 3, 4, 5, 6, 33
ASRT	ASSORTED TAPER LIST	R8, ER, 5C, 3C, IT
CSTM	CUSTOMIZED TAPERS	User1 to User4

Tap **FN1** to **FN4** to select the category and then use the ^,v keys to scroll through the selections, Tap **OK** to select and save or **ESC** to return to previous menu. The numerical value of the taper is available for inspection or modification by choosing the Angle Selection described earlier.

Once you've chosen the taper you need to decide which direction the taper should go. Keep in mind that you want to keep the cross slide lead screw preloaded against the work so that as the ELS cuts the taper it doesn't have to remove the backlash after each movement of the Z axis.

An outside taper should be smaller further away from the spindle '>'. Cutting a taper in this manner means the X axis is always moving inwards as the carriage moves to the right.

An inside taper is exactly the opposite. As the carriage moves to the right, the cross slide lead screw needs to be constantly pulling into the work away from the lathe center line therefore the taper is larger further away from the spindle '<'.

Next think about retracting the cutting tool out of the work while returning to the BEGIN position. Outside tapers need an 'Cross Slide Retracted' that clears the work completely. The retracted value is relative to the cutting position 0.00 at the start of the cut, not the end.

Insert sketches here for showing tool path.

Appendix 1 -- Electrical Connections.

Appendix 2 -- Cutting threads with the ELS.

Cutting threads on a lathe like any potentially intimidating project can be broken down into a number of smaller steps. To illustrate the procedure let's assume we want to create a 1" long 5/16-18 TPI thread on the end of a 3/8" diameter shaft.

In our example the shaft is oversize so the first step is to reduce it to the major diameter of the thread. The machinery handbook states that the Major Diameter for a UNC 5/16" thread is 0.3125" and the Minor Diameter is 0.2452". We need to install a turning tool and set up to reduce the work to the Major Diameter.

If our tool bit was a perfectly sharp V then the depth of our thread would be $(\text{MajorD} - \text{MinorD})/2$ which is 0.0337".

The Height H of a sharp thread is listed as:

$$H = 0.86603 \times \text{Pitch of thread.} = 0.86603 \times 0.0556 = 0.0481"$$

This height extends above the Major Diameter by $0.125 \times H = 0.006"$ and provides an initial clue as to how far in we'll move the tool bit into the work; in this case a maximum of 0.0421". The root or bottom of the thread would also be a sharp V if we could grind a tool bit that way but in reality there will be a small flat or optional rounded tip with a width of

$$0.25 \times \text{Pitch} = 0.25 \times (1/18 \text{ TPI}) = 0.0139"$$

That also results in a thread depth reduction of

$$0.25 \times H = 0.25 \times 0.0481 = 0.0120$$

The total depth of tool travel is now $0.0421" - 0.012 = 0.0301$.

The short way to this value is

$$(\text{Thread Pitch} \times 0.86603) \times 0.625 = \text{Thread Pitch} \times 0.5413$$

$(1/18 \text{ TPI}) \times 0.5413 = 0.0301"$ which is our depth of cut for an 18 TPI thread.

This is a starting point and is totally dependant on the profile of your tool bit. If you use a carbide bit with predictable tips you might find you will need to adjust the constant slightly since the radius of the tip puts the point at a different location and a tip with no radius.

Enter 0.5413 into the 'Depth Pitch Multiplier' menu under 'RUN | Z | THRD | DPTH | MULT'

Appendix 3 – How Tapering works on the ELS.

The ELS carriage motion is dependant on the speed of the spindle and the cross slide is dependant on the position of the carriage. This is different from a CNC system that runs the tool bit along the hypotenuse of the triangle created together by the carriage and the cross slide as a co-ordinated movement.

On the ELS, the cross slide is slaved to the carriage which means the maximum distance the X axis (cross slide) can move is one motor step per Z axis (carriage) motor step. Regardless of the reduction ratios or lead screw pitch, the maximum 1:1 step remains constant.

If the pitch and ratio of the cross slide and carriage are identical then for each carriage and cross slide motor step the tool bit will follow a 45 degree angle. However, usually the cross slide screw is a finer pitch than the carriage so the potential angle is also less since the cross slide will move a shorter distance per step than the carriage.

This means the maximum taper angle is normally less than 45 degrees. Not really a problem since most mechanical taper attachments do far less than 45 degrees and the compound is used for acute angles greater than the taper capability. To turn these types of angle automatically use a CNC system.

As in a manual lathe, it's best to always turn a taper in a direction so the cross slide lead screw is loaded against the cut. Going in the other direction will result in an uneven taper determined by the cross slide backlash.

Ensure that the X retraction value is far enough away from the largest diameter of the work. It's easy to accidentally set the retraction value to a setting inside the cutting surface.

Appendix 4 – Menu Quick Reference Guide.

To be determined

Appendix 5 – Updating the Firmware

WinPIC settings.ini file:

```
[PicMain]
Left=212
Top=15
Width=500
Height=366
CodeMemBgColor=0
CodeMemFgColor=65280
DataMemBgColor=16777215
DataMemFgColor=0
SpeedButtonsVisible=1
ToolWinVisible=0
ToolWinLeft=30
ToolWinTop=30
Language=en
LanguageTestMode=0
[MostRecentFiles]
file0=C:\PROJECTS\ELeadscrew\PIC18Code\SRC\Output\ELS.hex
file1=C:\PROJECTS\ELeadscrew\PIC18Code\src\Output\ELS.hex
file2=
file3=
file4=
file5=
[INTERFACE]
InterfaceType=10
SupportFile=ELSPProgrammer.ini
ExtraRdDelay_us=10
ExtraClkDelay_us=5
SlowClockPulses=0
IdleSupplyVoltage=1
PortAccessDriver=0
[COM84_INTERFACE]
ComPortNumber=1
UnusualIoAddress=0
[LPT_INTERFACE]
LptPortNumber=1
UnusualIoAddress=0
[SESSION]
HexFileName=C:\PROJECTS\ELeadscrew\PIC18Code\src\Output\ELS.hex
[PROGRAMMER]
ProgramWhat=7
UseBulkErase=1
Disconnect=0
VerifyDifferentVoltages=0
DontCareForOsccl=0
DontCareForBGCalib=0
ClearBufferBeforeLoading=1
NeedVddBeforeRaisingMCLR=1
VerboseMessages=0
[PIC]
PathToDevFiles=C:\Program Files\Microchip\MPLAB IDE\Device
DeviceType=PIC18F4685
HasFlashMemory=0
UnknownCodeSize=4096
UnknownDataSize=256
```

WinPIC ELSProgrammer.ini file:

[Info]

Purpose=PIC programmer interface definition for WinPic and "ELS"

[ProgrammerControlLines]

VppOnOff=!D3

PullMclrDown=!D4

DataOut=D0

OutEnable=nc

DataIn=ack

ClockOut=D1

DataOutWhileReading=1

ClkEnable=nc

VddOnOff=nc

Connect=nc

RedLed=nc

GreenLed=nc

OkButton=nc

Insert PDF of Programmer adaptor and text on how to run WINPIC plus WPINPIC_ELS config file.

Appendix 6 – RS232/485 communications

Diagnostic information is available through the on board RS232 port configured for 115kbaud, 8 bits, no parity and one stop bit. Using a PC terminal emulator program like Hyperterm (for PC's running Windows before VISTA) the ELS has a series of commands that can be used to diagnose or display status information.

They are currently only useful for diagnostics when updating software. Eventually, the serial port will be used as a MODBUS port for external control of a VFD or MODIO. For commands that modify EEROM or ports, use at your own risk.

The commands are:

'E' – EEROM information

```
EMn,b -- Modify memory location.
EPn -- Put EEROM location to display
EFn -- Fill EEROM with n
EDx -- Dump EEROM page x to screen
ER -- Report EEROM in format of C nncfg.h file.
```

'F' – system Flags

```
ThreadFLAGS: RDY=xx, RUN=xx RUNFLAG=xx, STOPFlags=xx,
SystemCmd=xx
EEROM FLAGS: SYS=xx, MGMT=xx, ZMOTOR=xx, XMOTOR=xx, COMM=xx
Local Flags: Move: RUN=xx,
```

'In' – display I/O port values.

```
PORT n=xx
```

'M' – display Menus

Each Menu in the ELS is displayed with the MENU #, the type of variable it references and if it's dependant on any other menu values. The Min/Max values are currently not used.

```
LCD:07
-----
| Imperial Leadscrew |
| Pitch              |
|-----|
FLOAT:    0.250
Min=    0.001, Max= 200.000
Dependant on: 2E
```

'Oxx' – Output to port B.

```
PORT B =xx
```

‘t’ – spindle Tracking variable.

```
SpinRate nn
```

‘s’ – Status flags

```
CONTROLFlags=xx  
SYS: d, MV: d  
ZStepFlg: xx  
XStepFlg: xx  
ActiveFlg: xx
```

‘v’, ‘?’ – print Version

```
E-LEADSCREW    Ver PIC18F4685 1.10d
```

Here's the schematic of the ELS to DE-9S connector.

Appendix 7 – Schematics

Insert PDF copies of Schematics

Appendix 8 – Pin and Jumper descriptions.

LISTING OF ALL ELS JUMPERS AND CONNECTORS

JUMPERS

JP1 (NU indicates NOT USED)

1-2	Links ENC_PWR	to Pin 1 of DB25
3-4	Links ERR_LED	to Pin 14 of DB25
5-6	Links STEP_X	to Pin 2 of DB25
7-8	NU 8 connected	to Pin 15 of DB25
9-10	Links DIR_X	to Pin 3 of DB25
11-12	Links CHG_PMP	to Pin 16 of DB25
13-14	NU 14 connected	to Pin 4 of DB25
15-16	Links RUN_LED	to Pin 17 of DB25
17-18	NU 18 connected	to Pin 5 of DB25
19-20	Links STEP_Z	to Pin 6 of DB25
21-22	Links DIR_Z	to Pin 7 of DB25
23-24	NU 24 connected	to Pin 8 of DB25
25-26	NU 26 connected	to Pin 9 of DB25
27-28	Links ESTOP	to Pin 10 of DB25
29-30	Links LIMITS	to Pin 11 of DB25
31-32	Links -INDEX	to Pin 12 of DB25
33-34	Links +INDEX	to Pin 13 of DB25
35-36	NU	

J4 (Supply voltage for Index Sensor)

2-1	Links ENC_PWR to VCC (5v)
2-3	Links ENC_PWR to VRAW (Incoming supply voltage)

J9 (LCD Backlight supply (Use 2-3 for supplied LCD))

2-1	Connects to V_CC (5v)
2-3	Connects to V_RAW (12v or greater)

J11 (Allows power to Pic Programmer 12v Regulator)
This jumper MUST be fitted

CONNECTORS

J1 (Stepper supply. Max 55v)

1 DRV_PWR

2 GND

J2 (Possible Voltage source for a different LCD Display)

1 LCD_DRIVE

2 GND

J3 (Board Power AC or DC Nom 12v but 15 to 20v for PIC programming)

1 BRD_PWR_A

2 BRD_PWR_B

J5 (Onboard Stepper Drive connections)

1 PHASE_A2

2 PHASE_A1

3 PHASE_B2

4 PHASE_B1

J6 (DB25 connector)

1 ENC_PWR

2 STEP_X

3 DIR_X

4 NC

5 NC

6 STEP_Z

7 DIR_Z

8 NC

9 NC

10 ESTOP

11 LIMITS

12 -INDEX

13 +INDEX

14 ERR_LED

15 NC

16 CHG_PMP

17 RUN_LED

18 GND

19 GND

J6 (DB25 connector - continued)
 20 GND
 21 GND
 22 GND
 23 GND (Use for Estop circuit)
 24 GND (Use for Limits circuit)
 25 GND (Use for Encoder (Index) power)

J7 (PIC Programming Interface)
 DB25M pin on the Programming PC Parallel port

1	GND	Any one of 19-25
2	P_/RESET	6 (D4)
3	P_/VPP_ON	5 (D3)
4	P_ISPC	3 (D2)
5	P_ISPD_IN	2 (D1)
6	P_ISPD_OUT	10 (ack)

J8 (For Development use))

1	ISPC
2	ISPD
3	GND
4	VCC
5	Vpp

J10 (Allows the connection of an external Keypad)
 See circyuit diagram for connections

CONN1 RS232/485 Header

1	Gnd
2	RX232
3	TX232

CONN5 CAN Header

1	CAN_LO
2	CAN_HI
3	GND
4	TRM2
5	TRM1

VR4 (Half nut connection)

1 GND

2 HALF_NUT

3 VCC

TEST POINTS (Situated in the Stepper Drive area (not silk screened))

TP1

TP2 Test point for checking VR1 (setting of drive current)

TP3 Test point for checking VR2 (setting of drive current)

GND Ground connection for above test