

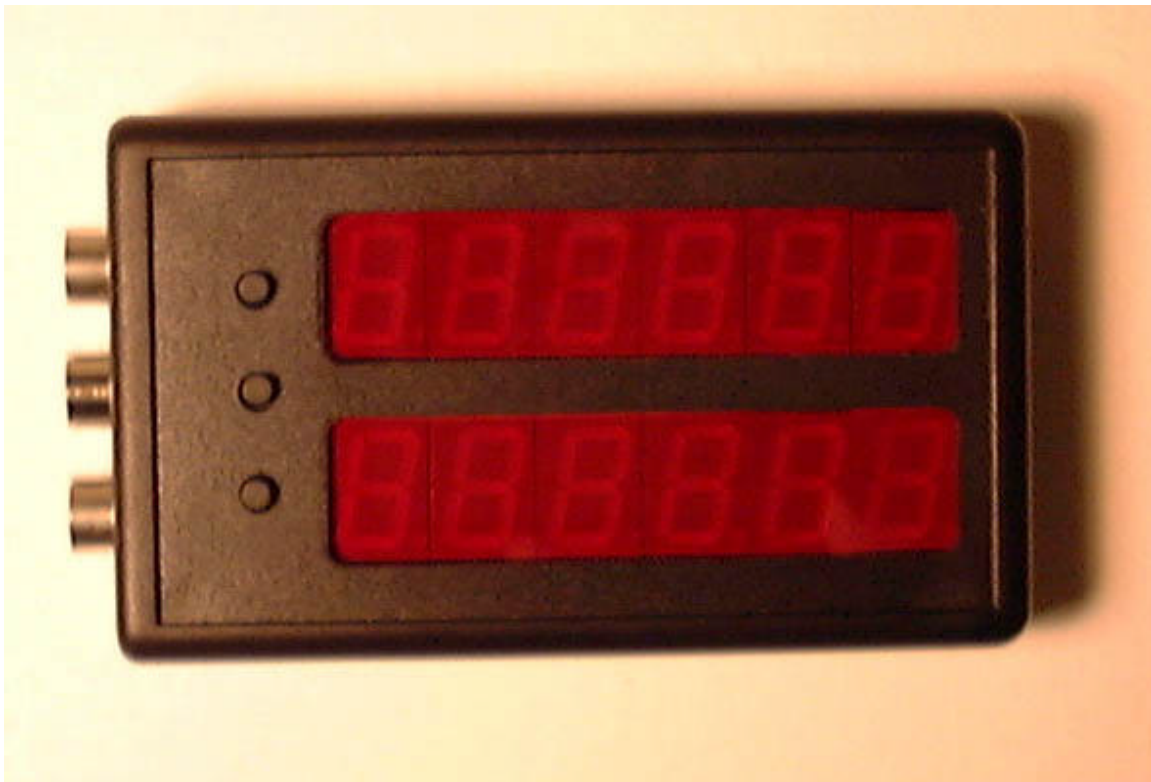


DRO-2

2-axis digital readout box

User Manual

Feb-14-2003



Product Description

Overview

The DRO-2 is a multi-function remote digital readout box displaying both two linear axes and spindle RPM. It also displays cutting speeds on a lathe and electronically signals limit positions to a power feed. DRO-2 is meant to be used in conjunction with digital scales, that feature a 4-pin data port connection. These are usually no-name units imported from China by various vendors and can easily be found on ebay using search words DRO, quill kit or scale. They are available as horizontal or vertical units and DRO-2 works with both kinds. In our experience these units are remarkably accurate for their price and make a great basis for axis readouts on machine tools.



horizontal type scale



vertical type scale

DRO-2 interfaces to two scales and has five digit plus sign 7-segment LED displays that offer vastly superior readability over the scale's built-in LCDs or external LCD based boxes.

It is available with either high intensity red or green LEDs in a housing made of either black or light gray ABS.

Features

DRO-2 is packed with features that no competing product has to offer.

- Fast Readout -

In standard mode the scales output about 3 readings per second, which is appropriate for calipers and well matched to the low refresh rate of LCDs. The scales also have a fast readout mode of about 40 to 50 readings per second.

Unfortunately this mode is practically useless because the readings are too noisy and blur the last digit on LCDs. Not so on DRO-2. We implemented a smart digital signal processing filter that eliminates the readout noise to give a stable display when the scale sits still while retaining fast display updates when the scale is moving.

- Dual Display Functions -

DRO-2 has two separate display settings. The user toggles between the two by pressing the center (mode) button. The two settings are freely programmable, to display any of the different modes.

- Zero Buttons -

Of course, each scale has its own zero button located to the left of each display. Pressing the button will zero the display. It should be noted, that since the scales' own LCDs cannot be zeroed in high speed mode their reading will not change. Not a problem, because you will never have to look at them again...

- Inch / MM modes -

The displays can be programmed to convert the scale readings to either inch (imperial) or mm (metric). The range in mm mode is -999.99 to +999.99 with a resolution of 0.01 mm. In inch mode the range is -99.9995 to +99.9995 inches with a resolution of 0.0005 inches. The half mil is displayed by the decimal point to the right of the least significant digit.

- Sign Selection -

The direction of the scale readout can be programmed. This allows the scale to be mounted in a way that is easiest from a mechanical viewpoint without having to worry about the direction of the readout. This is programmed once during setup and retained in non-volatile memory.

- Diameter Mode -

Each display can be programmed to read either 1x (radius) or 2x (diameter). 1x is the normal mode as it should be used on a milling machine for example. The 2x mode is useful for lathe cross slides when the user is more likely to be interested in the diameter of a part being turned. Just make sure to turn it back to 1x when using a milling attachment on your lathe.

- RPM Mode -

DRO-2 has an input for an optional photo-interrupter sensor on the upper scale connector to detect the rotation of a spindle and display its RPM. The range is 30 to just under 100,000 RPM.

When the range is exceeded either -SLO- or -HI- will be displayed. The RPM number is updated once per spindle rotation, but no more than 4 times a second to facilitate easy readout.

- SFM Mode -

DRO-2, when equipped with an RPM sensor, also calculates cutting speeds in surface feet per minute for lathes. This works by taking the reading from the upper scale, which on a lathe should be connected to the cross slide, and calculating the cutting speed using the following formula:

$$\text{SFM} = \text{RPM} * 2 * \text{Pi} * \text{cross slide reading in inches} / 12$$

The cross slide has to be set to zero when the cutting edge of the lathe tool bit is at the center for SFM mode to work correctly. The SFM reading will be calculated properly regardless of the readout mode of the cross slide scale (1x or 2x) The display range is 0 to 100,000. Just as in RPM mode when the range is exceeded either –SLO- or –HI- will be displayed. Just don't try cutting anything at 100,000 SFM...

- Limit Stops -

When pressing the zero button while holding down the center button the current position is stored as an electronic limit. Whenever the scale is moved across this position a pin on the lower scale connector changes logic states. This can be used by some external circuit to stop a power feed and thereby limiting a cut to not go beyond the set position. The two scales have separate limit memories, but act on the same pin. This shouldn't be a limitation even if a lathe or mill has two power feeds as they wouldn't be used at the same time. Just make sure to set the limit of the unused axis at a position outside the work envelope of the part you are machining so you don't accidentally trigger the limit bit. If there is enough interest, we will design a control box to hook up to this. If you are interested in building your own circuit please contact us, so we can help you get started.

- Display Off -

Removing power from the DRO-2 box will erase position information and the scales will be reset to zero on power-up. When you want to turn off the display without losing position, just press the center button for 3 seconds. The scales are still being read, so it will keep track of position. Pressing any button will turn the display back on. This is a handy feature to have if your machine shop also happens to be your bedroom (!?!) and you can't sleep under the bright light of our high efficiency LEDs...

- Data Output -

For use with future products all readings are also sent out over a serial data link on two unused pins of the power connector. We currently have no concrete plans for this, but thought it would be nice to have...

Installation

General

To connect the scales to the DRO-2 remove the small plastic slider that covers the data port of your scale or caliper. Insert the supplied data cable. Make sure it is seated firmly and straight. Be careful to avoid jamming and bending the contact pins. These connectors are rather poorly designed and don't hold too well by themselves, especially on the horizontal scale units. For permanent installations it is therefore highly recommended that you provide strain relief to assure a reliable connection. The scales are sensitive to cutting fluid and chips and we suggest you to protect them as much as possible. Mounting them in a U-channel as shown in this picture would be a good idea.



horizontal scale mounted in U-channel (hardwired cabling)

It is important to mount the scales in a way that the head can move freely along the entire length. This is not all that easy to achieve, since binding in a completed assembly is difficult to detect when the table is driven by a lead screw. The best way is usually to mount the scale first and measure the position of the sliding head relative to its desired mounting point at both extremes of the motion. Then adjust one or both mounting points of the scale and repeat the process until the head's position perpendicular to the motion remains the same at both ends. Now you can attach the mounting bracket for the head. A good bracket design will allow some adjustment for alignment. The bracket in the picture was mounted by sliding it up on the 45deg slope until it sat flush with the back plate mounted to the scale's head. The mounting screws to the base were then tightened followed by the screws into the back plate. Some slop or oval holes are needed to give room for this adjustment.

Some thought should be given to the cable routing. A strain relief at the mounting bracket of the head is mandatory and the cable should be routed to a place where any loop formed by the movement of the table or carriage will not interfere with the cutting action or the removal of chips.

The DRO-2 box itself should also be mounted away from any cutting fluid and chips.

Setup

The DRO-2 display modes are easily programmed using this simple procedure. To enter program mode press all three buttons at the same time until P0 is displayed. When you then release the buttons the current readout modes for the first setting (P0) will be displayed.

You can select the desired mode for each display by repeatedly pressing the button next to each of the displays. This will cycle through the available modes shown in the table below.

1.000	Inch mode
2.000	Inch mode diameter
-1.000	Inch mode reverse direction
-2.000	Inch mode diameter reverse
1.00	mm mode
2.00	mm mode diameter
-1.00	mm mode reverse direction
-2.00	mm mode diameter revers
0	RPM mode
F	SFM mode

When you have selected the desired modes for each display press the center button and the display will show P1 followed by the current modes for the second setting (P1) when you release the button. Now select the modes just like before and press the center button again when done. This will store the mode information in non-volatile memory and reset the DRO-2.

Cross Slide Zeroing

Here is the easiest way to zero a cross slide on a lathe:

Take a scrap piece of round stock and turn it down just enough to get a smooth surface all around. Zero the cross slide reading and take out the piece. Measure the diameter of the section you just turned with some calipers. Move the cross slide in until the display reads minus the diameter you measured (or half that if you like to run your lathe in radius mode). Hit zero again and you're done until you change tools or move your compound.



DRO-2 power supply



DRO-2 scale interface cable

Troubleshooting

Display only reads –OFF-:

Make sure the connectors are plugged into the scales properly. On rare occasions, a scale can lock up and can only be revived by removing its battery. A more intricate reason for a scale misbehaving can be a ground loop. The scale's body is electrically connected to the positive supply of the battery. This puts it at about 1.5V relative to the ground reference of the DRO-2. If you are using your own 5 Volt power source make sure that is floating relative to earth ground, else you would be shorting the scale's power supply if the machine that the scale is attached to is grounded as it should be. The power supplies we supply have no connection between ground and earth ground. Be aware that you can also create an unintended ground connection via the RPM sensor or limit output. Make sure that the RPM sensor's ground is not connected to earth ground and use an opto-isolator to avoid grounding issues on the limit output.

Display shows –LO-:

This can happen on startup when the reading is out of range with a large negative number. The condition can be cleared by pressing the zero button. If this happens during normal operation it indicates that you might have a problem with your cable connection or grounding issues.

Display shows –HI-:

This code is shown under two conditions. The first is when similar to when the display shows –LO- except that the reading is out of range on the positive side. The second scenario occurs in RPM or SFM mode when the readout would exceed 100,000.

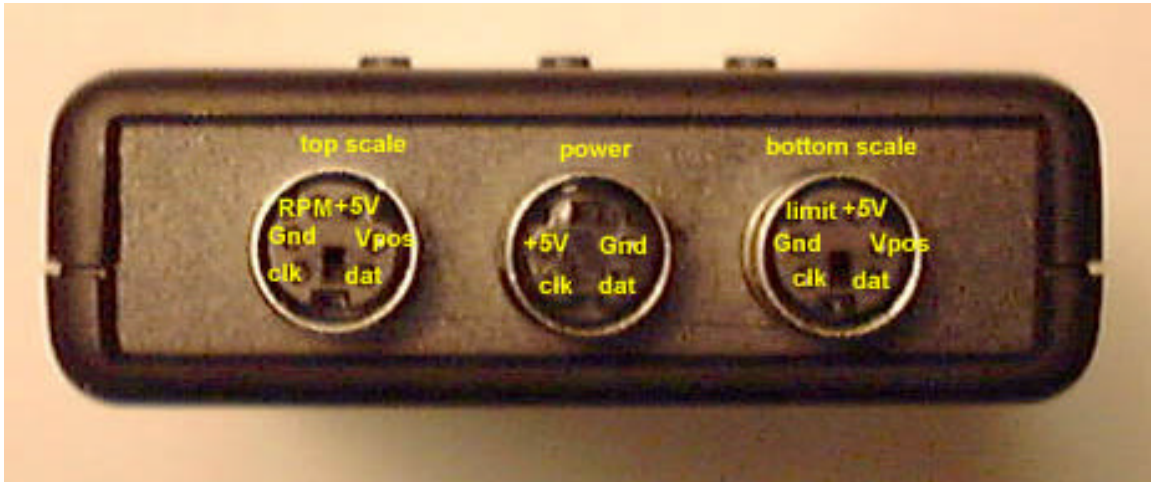
Display shows –SLO-:

This happens in RPM or SFM mode when the spindle speed drops below 30 RPM. This can also indicate a problem with the spindle sensor, if –SLO- is displayed at faster spindle speeds.

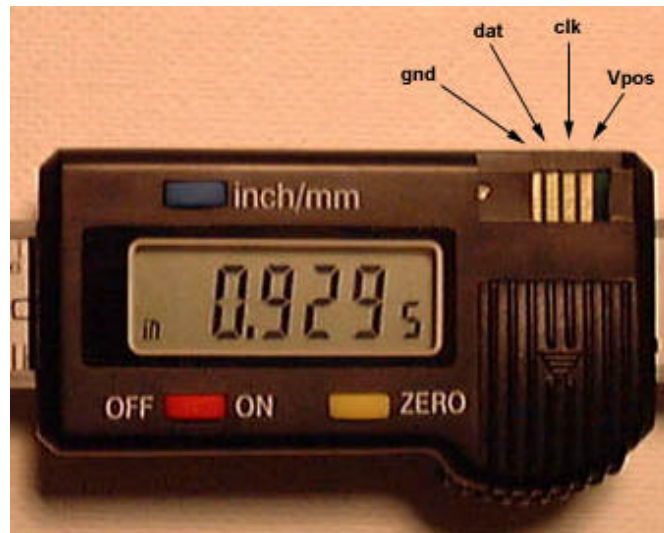
Technical specification

Power consumption: 5V, 400mA max

DRO-2 provides power to the scales. However for reliable operation in noisy environments it is still recommended to leave batteries in the scales.



pinout of connectors



scale connector pinout

Ordering information

DRO-2 is available in two different box colors and two different display colors.

DRO-2BG	black box, green display
DRO-2BR	black box, red display
DRO-2WG	light gray box, green display
DRO-2WR	light gray box, red display

Please check our web site for availability.

Contact

If you have further questions regarding this product or suggestions on how we can improve it or this manual, please feel free to contact us by sending email to info@zietlowdesign.com

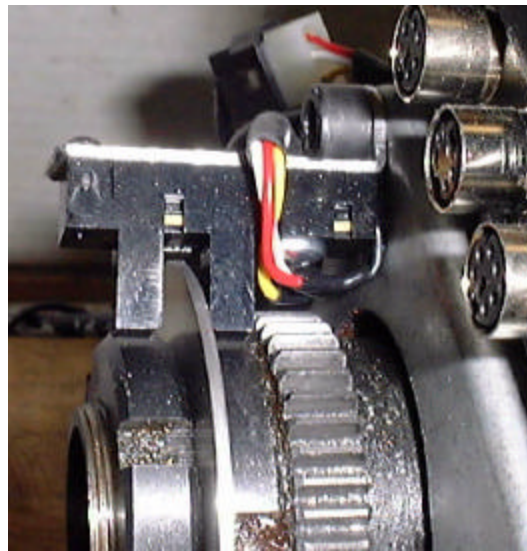
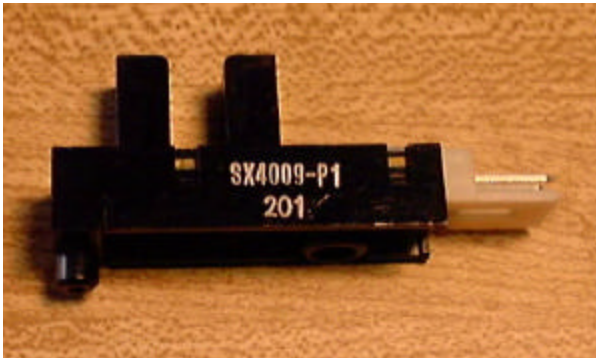
Please visit us on the web at
<http://www.zietlowdesign.com/products/products.htm>

Mini-Lathe Installation

The DRO-2 is a particularly good match for Mini-Lathes. Here is how we fitted a Grizzly 7*12 with DRO and RPM readout.

RPM sensor

The RPM sensor is a photo interrupter module that senses the passing of a slot in a disc mounted to the spindle of the lathe. The sensor is mounted on a right angle sheet metal strip and is attached to the back gear carrier plate with the existing M6 screw in the top left corner.



corner. The cable is routed to exit through the back cover opening for the forward-reverse lever. It is held in place by a cable tie. The mounting hole for the cable tie needed to be drilled and tapped. To do this remove the cover plate which is only held in place by two M6 screws. Any drilling should be done on a drill press whenever possible. The sensor could also be mounted in the area where our cable tie sits, as long as it doesn't interfere with the lever mechanism. The disc was also made



out of sheet aluminum. We cut a 2.4" square piece and centered it in the 4-jaw and then bored out a 1.060" hole. Then changed to the 3-jaw chuck and held it from the inside to turn the outside to 2.300". We then cut out a notch with a nibbler to complete the disc, which was then mounted between the two retaining nuts for the spindle.



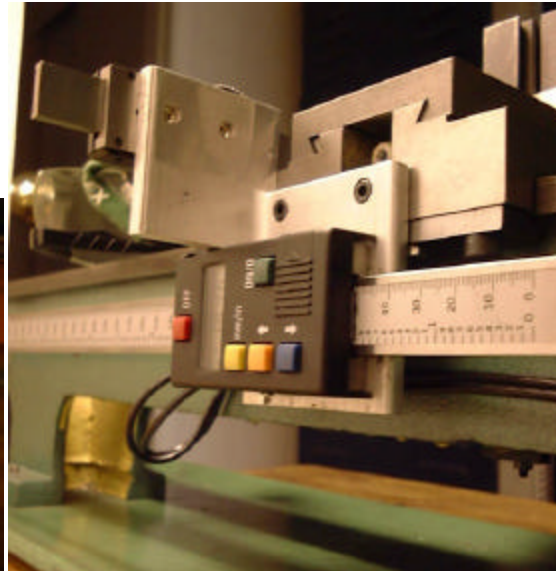
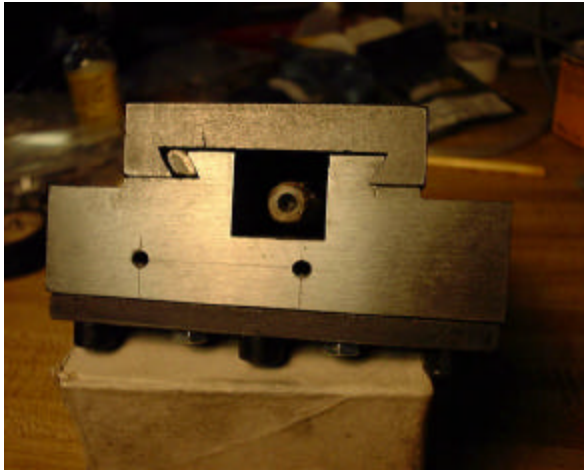
Scale Mounting

We used a 6" horizontal scale for the cross slide and a 12" vertical model for the carriage (A 4" scale should be sufficient for the cross slide). The modifications to the lathe itself were kept to a minimum. The center piece of the mounts is an aluminum L-bracket

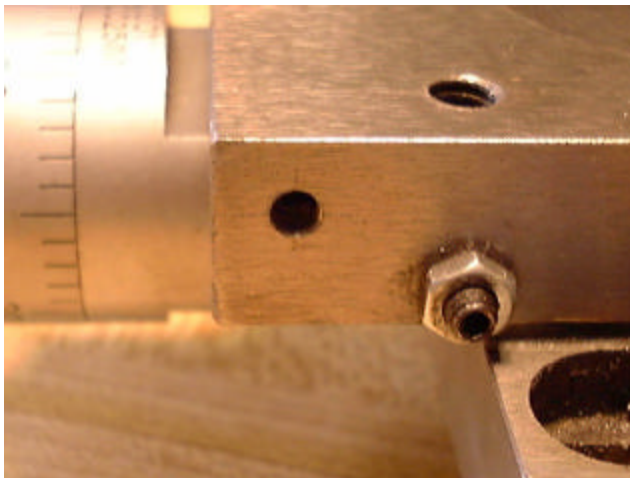


that attaches to the rear of the carriage. The bodies of both scales are mounted to this bracket. It is attached to the carriage by two M4 screws. The mounting height was determined by the required clearance of the cross slide scale. The

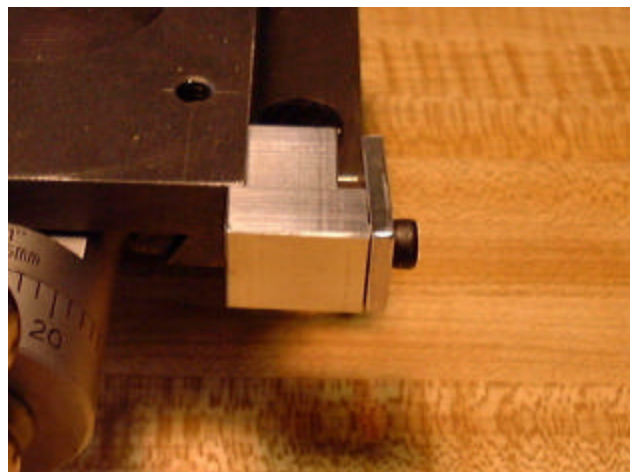
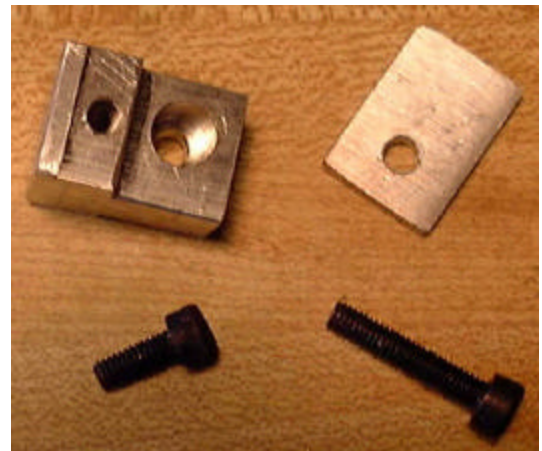
carriage was disassembled (remove the two M8 screws attaching it to the apron in the front and slide it off) and then scribed on a surface plate, drilled on the drill press and finally tapped (M4). While



the carriage is off, we also added a hole toward the front of the cross



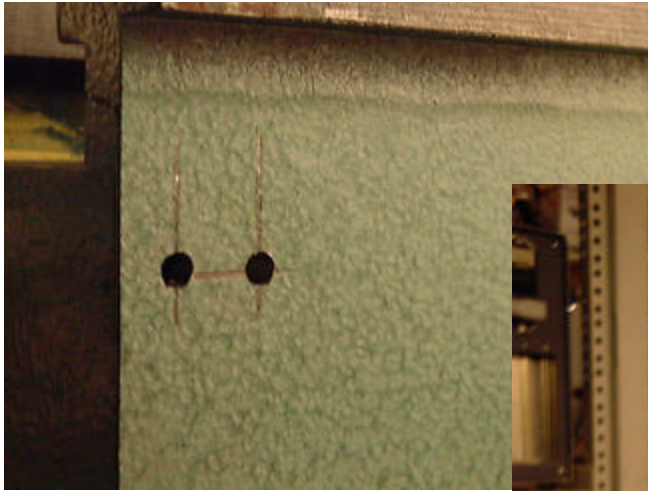
slide to attach the cross slide mounting bracket. Again, don't try drilling by hand, but use a scribe, center punch and drill press. We then mounted the cross slide scale's mounting block. The block



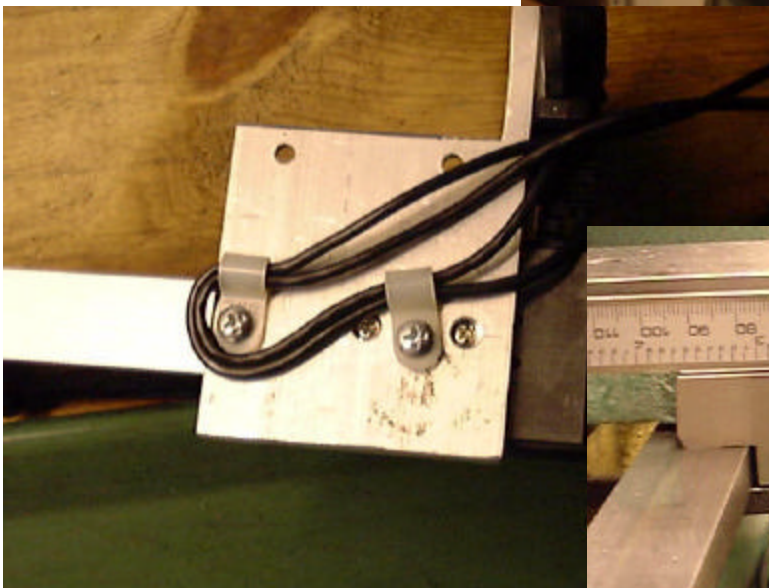
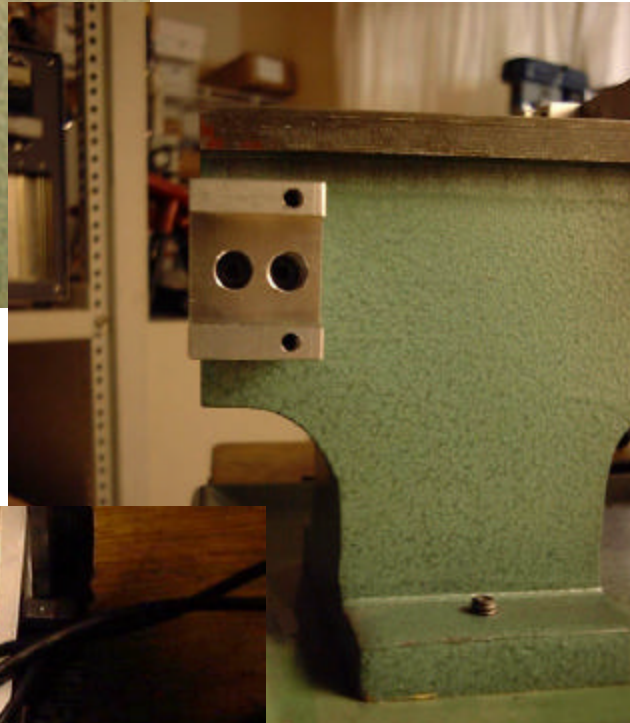
is designed with a lip to catch the edge of the cross slide. This way one screw is enough to securely fasten it. The geometry of the top of the block has a wedge that allows the cover plate to grab the slide with a line of contact rather than flat, giving a better grip.

The next step is adding two tapped holes to the tail stock end of the lathe bed casting. These holes are needed for the carriage slide end support. Both slides

are only supported on one side, making them easier to align. The picture shows why we recommend doing all the drilling in the drill press. Hand drilling will invariably result in offset holes like these making alignment more difficult. The



block again is designed with a lip to catch the edge of the casting, so one screw would probably be sufficient. Next we mounted the scales to the L-bracket and fixed



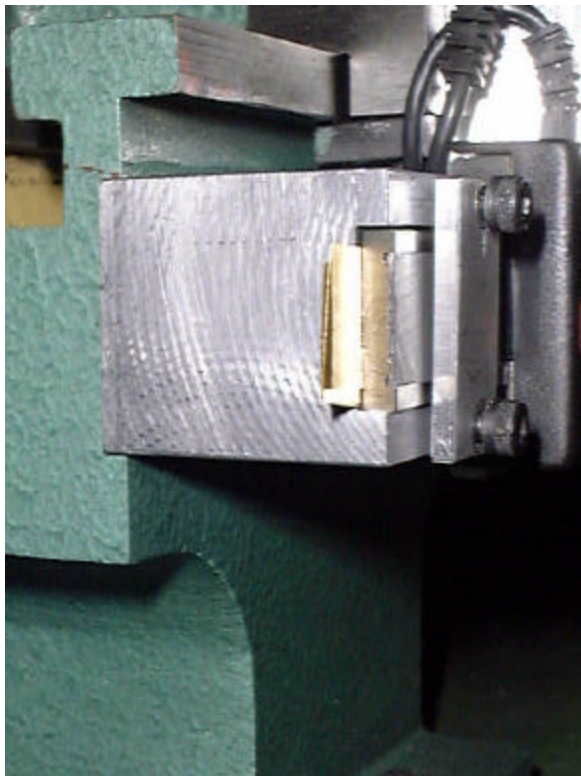
the cables with two strain relief cable ties. The cables exit near the front of the bracket, but facing back. This is the optimal position for using the existing mounting holes (for the splash guard) on the lathe's bed casting for cable guides. Now we were ready to fix the carriage scale. When attaching the carriage scale to the L-bracket, make sure that it remains parallel to the



edges. Only minor angular error should be taken up by the L-bracket to carriage mount, since this will introduce a twist in the cross slide scale. To test level on the carriage scale we used 1-2-3 blocks as seen in this picture. The upper edge of the scale was just a little more than 1" below the lathe bed surface. When it was level we tightened the two M4 screws attaching the L-bracket to the carriage. Next the carriage slide is fixed to the support block at the tail stock end. Some shims might be needed to



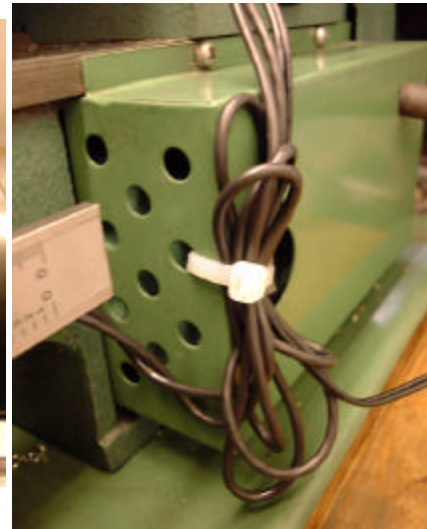
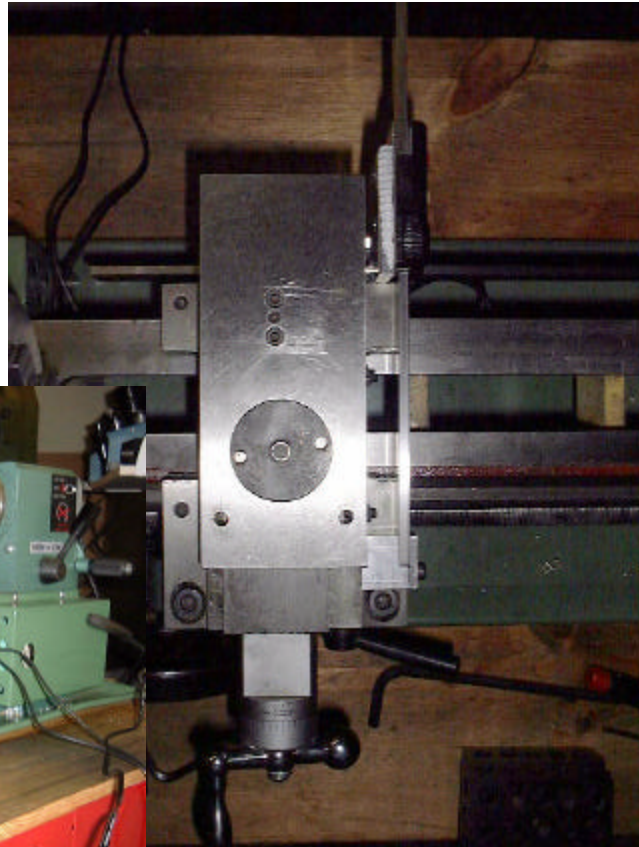
avoid flexing the scale near the end of travel. After the carriage slide is attached, we did the same with the cross slide scale. This one is easier because the scale's body never comes very close to the mounting end (we used a 6" scale for 2.9" of travel). Also angular adjustments are easier since the mounting screws are reachable without removing the L-bracket. We had to file down one of the set screws for the cross slide gib adjustments, as it was sticking out too



far and would have interfered with the L-bracket. We took it out and filed its tip down about 0.1" and reshaping the tip to its original form. When put back in place it ended up being flush with the retaining nut. The only things remaining were attaching the DRO-2 to the top of the headstock using double sided foam tape and tidying up the extra cable with tie wraps to the motor housing. The cross slide cable goes into the upper display



connector and the carriage into the lower. The upper display was programmed to -2.000 (inch diameter reading increasing toward the user), the lower to 1.000 (inch mode, increasing toward tail stock). The alternate modes were F and O, displaying SFM in the top display and RPM in the bottom.



Drawings for the mounting brackets we used can be found at

<http://www.zietlowdesign.com/products/dro2/bracket/acwebpublish.htm>

By no means can we guarantee that these will work for you. They are only meant to give an idea of how it can be done. So please measure twice, so you only have to cut once...