

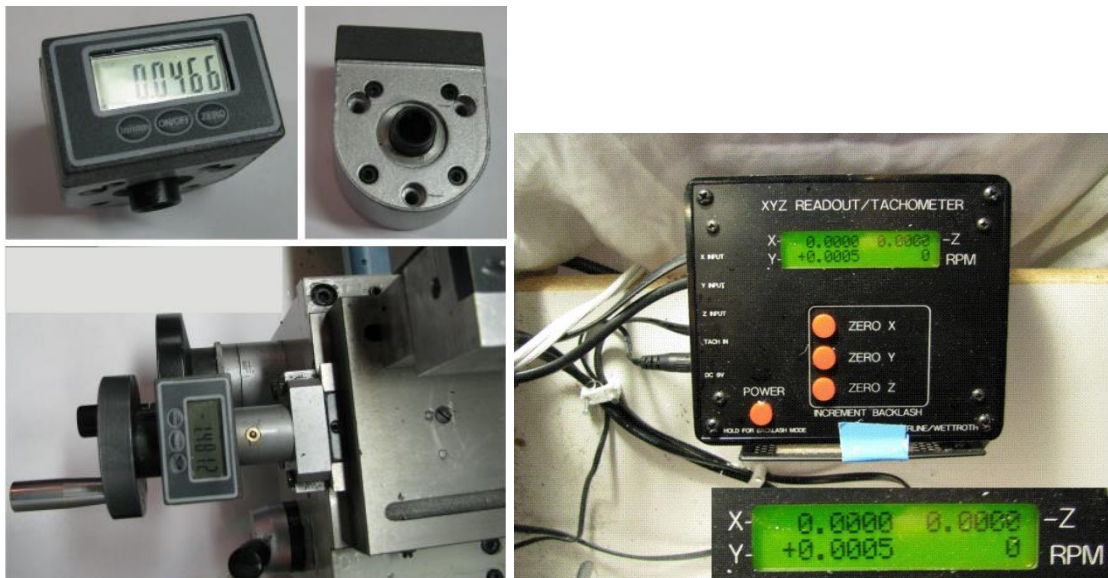
## Digital read out (DRO)

Briefly discussed is the following.

- How do they work?
- Lathe vs. mill
- How to mount DROs?
- Trouble with these systems
- Expensive vs. cheaper systems
- Where to get DROs?

### DRO – Digital read out for a lathe

I got the DRO separately from my China lathe. Not a good idea. That tool came with a one page exploded view drawing labeled in Chinese. In addition, that drawing did not match entirely the parts I obtained. Thus, it took me too long mounting this. Just a sloppy shop (purchased from “Little Machine Shop” in 2012) or are they doing this on purpose, forcing you to purchase complete systems in the first place? Whatever it is, getting the lathe together with a DRO will save you some time and stress. As always, that’s just my opinion other customers may have a different one.



**Left)** Rotary encoder often used as a DRO on a small China import lathe. That one here is from “Little Machine Shop”, Grizzly offer the same system.

**Right)** Sherline's digital read-out system used for their lathes and milling machines. The inset shows the coordinates and the motor revolutions. This setup is quite similar to professional full size systems.

Most common for small lathes are **rotary encoders** which are just mounted on the lead screws and cross slide feed screw. The set I had did require to remove gears from the cross-slide, drill a hole through the spindle and whatnot. In principle, the setup is simple once you have mounted one of these. However, getting it to run the first time is a hazel. A rotary encoder basically just counts the number of rotations of the hand wheel. If the pitch (or threads per

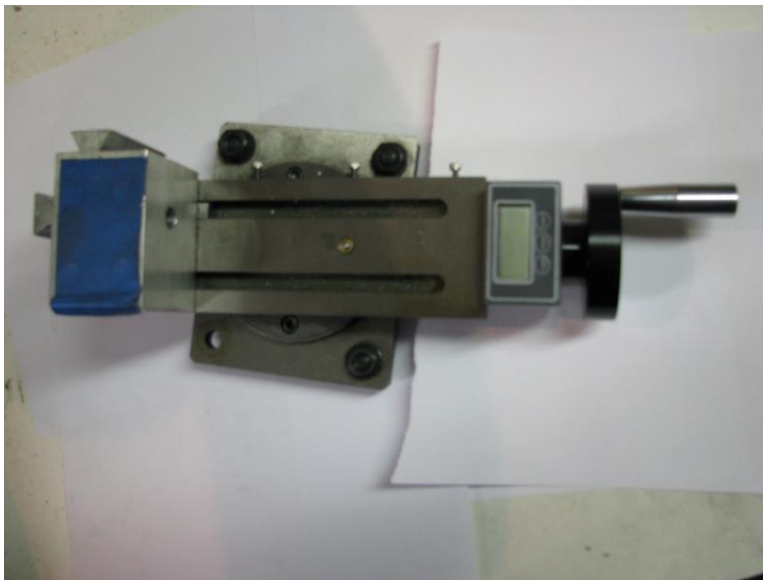
inch) of the feed screw is known, this translates into a forward feed. Inch to metric conversion and resetting the readout to zero is standard for these systems. Typically the scale is directly on the hand wheel which is not really great. These also use little batteries which can become expensive. Sherline has a similar system which comes, however, with a separate display box which is directly connected to a power supply.

I used a set for a M8-1.25 lead screw, important is the pitch 1.25 mm. Unfortunately, I have not seen one which would allow for selecting different pitches. Thus, you are stuck with the e.g. 1.25 mm. I did use these DROs also for self-made accessories since these units are rather cheap (\$40/piece or so). Sherline's encoder fits to a ¼-20 (1 mm pitch for metric version) and it is, however, not cheap. One can probably find other versions.

On larger lathes or larger mills **linear scales** are used. Old style glass scales or magnetic scales are available. I have a magnetic scale on my mill. An example about how to mount these is given next.

#### Different technologies

Basically two concepts are used: linear encoders or rotary encoders. The latter counts rotations or degrees of a rotating spindle. The former works like a ruler. Now different sensors can be used to read "the ruler" (e.g. optical or magnetic).



Compound-slide with rotary DRO from "little machine shop". The fast tool change system is self-made.

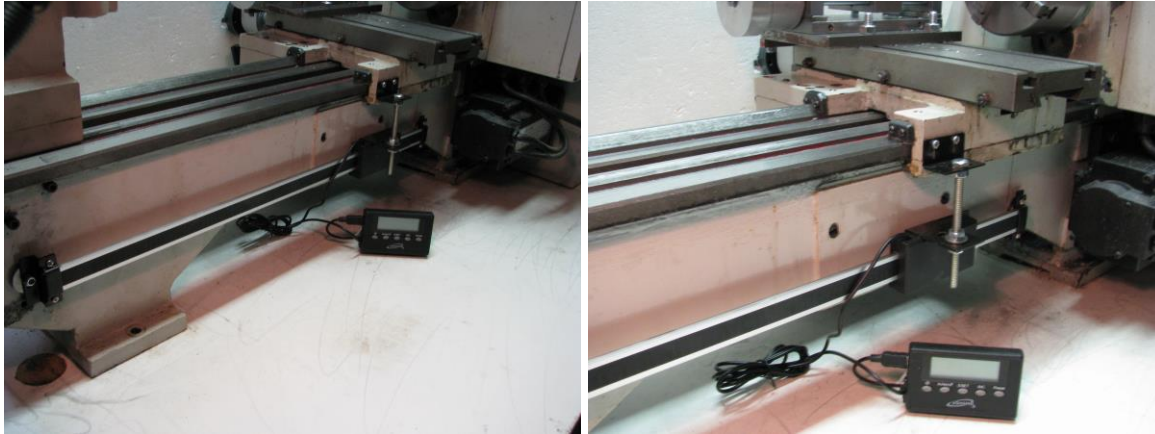
**Suggestion for your lathe.** If you have a typical China import lathe, I would suggest

- get a professional X-/Y-DRO e.g. from DROpros (\$400 for glass scales, \$800 magnetic system & metal scales).
- For your compound-slide, add a single rotary encoder to that (\$50). Exchanging the feed screw by your-self is not a big deal.

**A cheaper option:** use a less expensive linear DRO (\$50 at e.g. eBay) along the lathe bed and two rotary encoders for cross-slide and compound slide. Disadvantage: typically 3 digit systems, rather small display, no scale covers included, probably not that sturdy, battery systems.

- For a really complete DRO system, add a small linear encoder to the tailstock spindle. Also here, I would not get a set, but rather a single system for \$50 or less. (Tailstock DRO sets are available from Grizzly, but expensive.)

You will need to machine some fixtures and the project will keep you busying for a weekend or two, but it's not a big deal.



*Less expensive DRO (purchased via eBay) mounted on a typical China import lathe. Here the mounting brackets were actually useful.*



*Custom made ([www.LatheCity.com](http://www.LatheCity.com)) compound-slide with rotary DRO. That one has no gibs to adjust and is therefore absolutely sturdy. No swinging or wobbling as with a cheap dovetail design. That version here is set to cut machine taper.*

### Mounting a DRO on a mill - example / case study

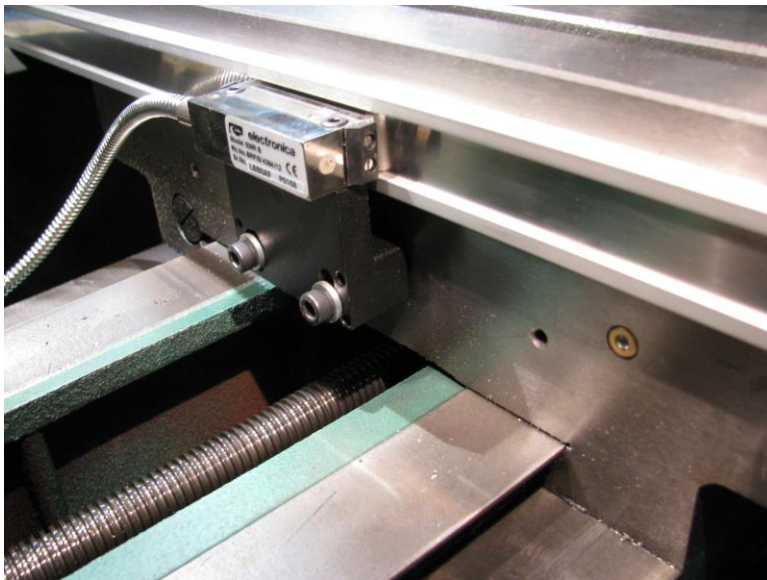
For giving you an idea about the process and how a mill DRO really looks like, I added this “case study”.

I used one with a magnetic scale, purchased from DROpros in Dec 2013 for about \$800; apparently made in India. Watch their on-line videos. The on the website promised free DVD was not included in my kit. Similarly, the manual is a thin black-&-white print and not, as promised, a full color version. That manual is not very helpful anyway (– watch the videos). The information you will find in the following is probably more detailed than the black-&-white manual I got.

#### **Advantage of magnetic scales**

- can be cut to any length
- contamination resistant
- thin scales (and rather bulky reader heads)

The **X-axis** scale of the DRO is mounted along the longer side of the mill table; typically on its backside. In doing so, at least two holes need to be drilled in the mill table and taped for mounting the scale. That's not really fun since mill tables are usually made from rather cheap cast iron which is difficult to machine. Therefore, get a couple of HSS drill bits or a carbide drill. Using a diameter a little larger than recommended for a given tap size will save you some sweat and pain since the taping will be much easier. All the hardware I got was metric (M4 & M6). One can find recommendations to level that scale by a few thousands of an inch over its entire length, using a dial indicator. To my experience that extra work is not required. (When milling, one moves a small mill table, typically at center position, by at most perhaps 2". Assume you are off by even one full degree over these 2". That would generate an offset for the sensor of  $0.03" = \tan(1^\circ) \times 2"$ . Thus, the sensor moves up/down by 0.03" when you move it by 2". I actually don't think that this would affect at all the sensor reading since this is a linear sensor that reads the position perpendicular to these 0.03". Thus, one has again a projection of these 0.03". On a 5 ft. mill table, use a dial indicator ... I used a water balance. Don't go too close with magnets to these magnetic scales.) Don't drill into the dovetails or oil reservoirs of your mill.

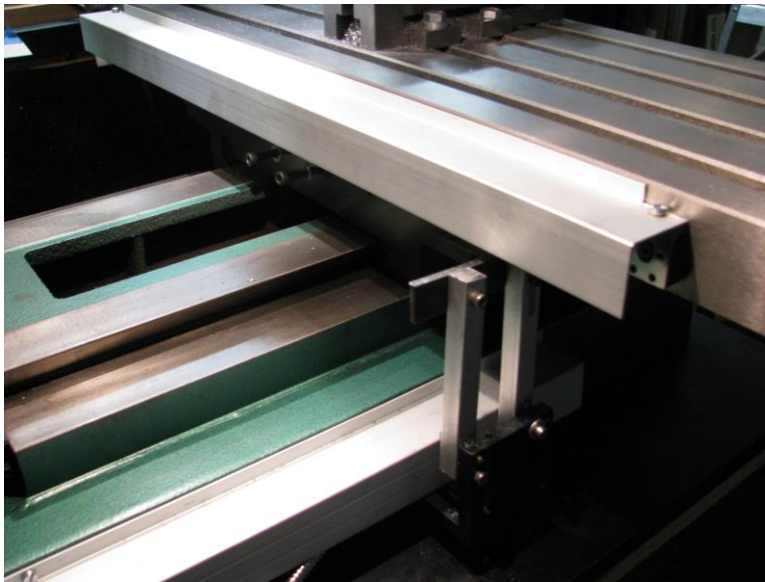


*X-scale mounted on the mill. Lathe and mill systems look basically the same.*

Next, the **X-sensor** is mounted on the backside of the table. (Thus, the X scale moves with the table, the X-sensor is stationary.) Drilling and taping cast iron again. Now, fancy

procedures are suggested to set the distance of the sensor to the scale. In my experience, the sensors are quite robust and this is not required either. In my tests, it was more important having the sensor leveled and having an even sensor – scale distance over the entire length of the sensor, otherwise the display flickers. Drilling the holes on the backside of the mill/satle can be tricky on a smaller mill since a hand-drill barely fits behind the mill table. In the worst case, well, glue the scale and sensor fixture. The scale is not that heavy. The DRO will take about one inch off your maximum Y-travel.

Finally, a scale cover needs to be mounted. Think about how to mount the scale cover early on (☺), since it requires space to do so. Perhaps use double sided tape to test mount everything before starting to dill any holes – a good idea I found when watching the on-line DVDs. These are indeed good.



*The scale covers are now mounted. X and Y axis are shown. These scales are magnetic and attract all chips you may generate, i.e., you will need to mount the scale covers. (In my case they also cover up the ball oiler ...) Finally, I used one of the provided fixtures for the Y-scale which results in a very bulky setup. I will redo this when I find some time. You will also need to modify the way covers of your mill.*

#### **5 micron vs. 1 micron scales**

- Standard: 5 micron (that's how the display may look like 0.0007" but the resolution is  $\pm 0.005$  mm or  $\pm 0.0002$ ")
- 1 micron (that's how the display looks like 0.00005" and the resolution is  $\pm 0.00005$ ")



*That's the display of a professional DRO. The X-channel was set to 2 micron resolution; the Y-channel to 5 micron. The system came with an extra handout for that procedure – that one was indeed in color print. Not clear to me why, however, since a 2 micron scale is not available for a mill. I purchased a mill kit. Good news, no tiny batteries to change; that system is connected to 110 V.*

Step 3 or so, mounting the scale for the **Y-direction** (that's the shorter side of the mill table). Here, the Y-scale is stationary mounted on the bottom stand of the mill. The Y-sensor is fixed (somehow) on the saddle and moves. I could use the provided fixture for the X-scale. However, the "universal" mounting fixture for the Y-scale was useless to mount the Y-sensor (step 4) on my mill. I did improvise a fixture within an hour or so, see the photos.

Further critic – I am a nasty customer, right. The X-reader head I got was defective and did not read anything. A delay of about a week getting a replacement shipped in. DROpros responded to e-mails promptly and covered all shipping costs. Reading the website of DROpros and watching the videos made the impression on me that I would get a 2 micron scale. That was not so, they don't even have 2 micron scales for mill kits, interesting isn't it. I misunderstood the info on the website.

In summary and to the best of my experience, the system did finally work, mounting it was a hassle, the Y-fixture was mostly useless, the display is nicely large, and the product I got was, in my opinion, not quite as described. (The free DVD and color manual is probably for a different DRO kit, read the "fine print" on the website. Indeed, a DVD is not required all videos are on-line.) As always, build your own opinion, your own experience may deviate from mine and provided services may change/improve over time.

By the way, before mounting anything you may run a **quick test**. Place the scales on a table, connect the sensors to the screen, move the sensors (readout heads) by hand along the

scales and see if you get a reading on the display. If yes, hurray your system will work properly. That takes 5 minutes or less, amazing that DROpros send out a defective sensor.



*Typical angle protractor. In the meanwhile available for below \$30. The 1<sup>st</sup> one I had did stop working after a month, perhaps too cold for the electronics in my shop (Fargo, ND).*

My mill has already a DRO for the **Z-axis** and **tilt**, but kits for that are also available. **Electronic angle protractors** cost \$30 (Jan 2014) or so and can just be glued-on anywhere on your mill. However, the \$30 systems I have seen have an angle accuracy of  $\pm 0.2^\circ$ , i.e., a water balance is probably more accurate. Remarkable, perhaps, looking in an old catalog from 2012, a protractor with  $\pm 0.2^\circ$  accuracy was offered for \$65 at that time. For about that price, in the meanwhile, systems with  $0.05^\circ$  accuracy are available.

A Z-axis DRO is trickier to mount depending on the design of your mill. One can get linear scales for the quill which is probably the simplest option for a drill/mill design.

Internet

#### Internet resources

##### General information

[http://en.wikipedia.org/wiki/Digital\\_read\\_out](http://en.wikipedia.org/wiki/Digital_read_out) | Brief outline of different designs and concepts  
[http://www.dropros.com/DRO\\_PROS\\_Digital\\_Readout\\_Videos.htm](http://www.dropros.com/DRO_PROS_Digital_Readout_Videos.htm) | instruction videos, watch these videos before purchasing a DRO it will save you money and stress  
[http://www.mini-lathe.com/projects/dro\\_pros/dro\\_pros.htm](http://www.mini-lathe.com/projects/dro_pros/dro_pros.htm)

##### Vendors specialized in DROs

<http://www.dropros.com/> | Extensive information & manuals online, large selection of sizes

##### Basically any machine vendor offers DROs

<http://www.cdcoools.com/> | Only glass scales (in 2013), small sortiment  
[http://stores.ebay.com/Taylor-Toolworks?\\_trksid=p2047675.l2563](http://stores.ebay.com/Taylor-Toolworks?_trksid=p2047675.l2563) | cheap  
<http://www.grizzly.com/> | Rather large variety including very much over priced pieces, manual downloads available (Grizzly style = not very helpful)  
<http://www.grizzly.com/products/H8176> | simple lathe DRO  
<http://www.shars.com/> | No manuals for download  
<https://www.littlemachineshop.com/> | Retailer selling e.g. DROpros equipment at a higher price  
<http://www.use-enco.com/>

| check eBay

**Price (in 2013/14):**

Glass scales \$400-\$800 (2 axis, mill / lathe)

Magnetic (professional system), 2 axis, starts at \$800

Rotary encoders, \$50/each

Rotary encoders lathe sets \$150-\$200

Cheapo magnetic systems start at \$25 per scale depending on scale length

In the meanwhile, a DRO costs about the same as a good mill vise and twice that of a cheapo mill vise, i.e., the costs are not too dramatic. 80% of the retailers are within \$50 for comparable products, except a few who offer really fancy systems for \$1,500 and more (Grizzly). Check the installation instructions in advance using on-line manuals. Mounting the thing can be a major hazzle. If a shop provides sloppy instructions, the product may be the same – just my opinion.



Part of the "Manual" provided by "Little machine shop" for their lathe DRO (rotary encoder). No further comment.

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*Vendors and manufacturer are invited to provide a comment. Given here is just my opinion as a customer. I don't claim that I am a particular smart or easy*



*customer. Other machinists may have other opinions or experiences with the same product.*