

## 1 USB thumb (flash) drives

The computers which interface with the screw driven frames and servo frames; also digital scopes have USB ports. Bring a memory stick (USB thumb drive) to class for data export from these test frames. For security, the USB drive should be either blank (quicker) or should be scanned for viruses and worms; one member of the group should capture the data, then transmit to other members.

## 2 Oscilloscopes

For all digital scopes, adjust the horizontal and vertical controls so the waveform is as large as possible on the scope screen. The reason is the digital resolution, corresponding to the number of bits, is based on the full scale. Data from a waveform that is too small may contain an insufficient number of bits, and give rise to a bumpy curve when plotted as a graph.

### 2.1 TDS 3012 scopes

Before saving digital data, freeze the waveform on the scope screen by hitting the Run / Stop button on the scope. When done capturing both channels, hit the button again to restart the trace. For Tektronix TDS 3012 digital scopes, data export is best done via Web interface. The oscilloscopes can function as Web servers. Data can be retrieved from any computer within the Engineering firewall. Use VPN if you connect via the DoIt wireless system. The computer in the classroom worked well with Internet Explorer but an upgrade to Edge created problems. Type the scope IP address (on the top of the scope) in your Web browser. The scope trace is now viewed by hitting the top left tab, now partly blocked. The scope screen appears with image blocked. Right or control click on screen to open image in new tab. It is not refreshed. To obtain the data, hit the "Data" tab, second from left, partly blocked. Save channel 1 in spreadsheet form; similarly save channel 2.

Slow traces on the scope may appear to have the trace cut short. This is caused by the web interface causing a premature trigger. Go to the computer and set the refresh rate to be slower than the time scale on the scope.

### 2.2 DPO 3014 and TDS 2001c scopes

Before saving digital data, freeze the waveform on the scope screen by hitting the Run / Stop button on the

scope. When done capturing both channels, hit the button again to restart the trace. Tektronix TDS 2001c and DPO 3014 scopes have USB ports. Data export is via USB flash drive. Ethernet addresses are not now provided for these scopes. Horizontal scale controls are on upper right on DPO 3014 scope. Acquire allows the user to set how many data points are in the record. Mode setting allows signal averaging, direct capture of trace (sample) for both scopes; also high resolution that captures a greater number of bits (for DPO 3014). One can also obtain an x-y plot on the scope face; this is the Display button on the TDS 2001c.

To save a waveform on DPO 3014 scope, hit menu button in bottom group for save options. Hit save waveform; specify save it to external USB drive. Hit file details; save waveform in spreadsheet format, data.csv. One can edit the file name before saving. Click OK accept, then OK save. Save channel 1 in spreadsheet form; similarly save channel 2. Click menu off to remove menu; do this several times to remove all menus. To save a waveform on 2001c, hit save / recall, then second button to right of screen, save to files, then action top button, save waveform.

## 3 Digitizing analog curves

### 3.1 Image processing

If digital export does not work the way you want, take a picture of the curve on the scope screen or the screen of the control computer. Such a picture does not constitute a professional graph. One can digitize curves from image files using DataThief (<http://datathief.org/>). This is based on Java. Following instructions, click on axis labels to set the scale. Click on the data points to generate a text file of data values. One can also digitize curves in an image via image processing software such as GIMP.

### 3.2 Fall-back plan

If all else fails, look at the table of data on the computer (or the waveform on an oscilloscope). A waveform can be digitized by hand by measuring distances on it with a micrometer. Write the data down in a table (to three significant figures). Type the data into a graphics program for plotting. For most graphs, 20 well chosen points will be enough. Remember that a pencil *always* works.