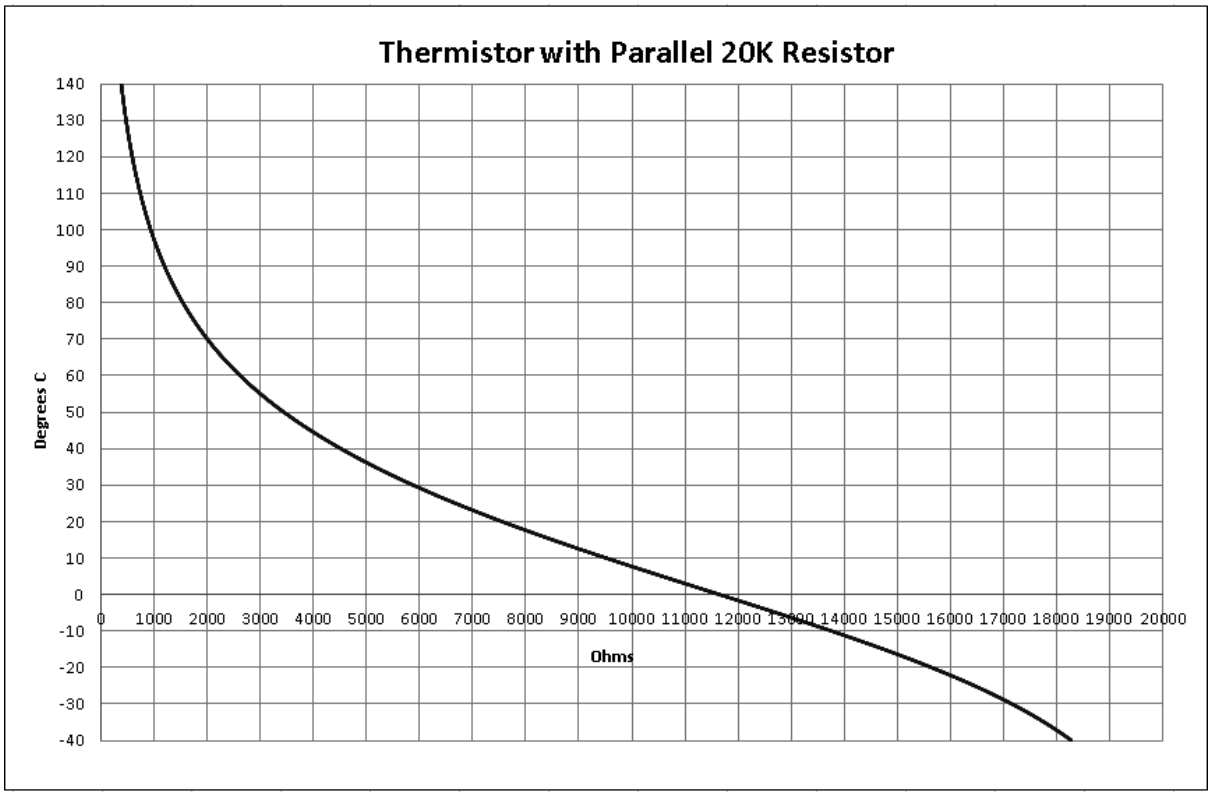
# Laureate™ Custom Curve Linearization Manual Rev. 6.0

## For use with Laureate Extended Digital Panel Meters, Counters & Transmitters

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# 1. OVERVIEW

**A custom curve** defines a user-defined non-linear scaling relationship between input counts and output counts. On an X-Y graph, the relationship is shown as a curve, not a straight line. Custom curve capability is a standard feature of all Extended Laureate digital panel meters, counters and transmitters. It is not offered with thermocouple or RTD meters, which already have built-in linearization.

### Application Examples

- Non-linear transducers of all types, such as thermistors and CdS cells.
- Altimeters, since the relationship between pressure and altitude is very non-linear.
- Rate of ascent based on successive altimeter readings.
- Fine calibration of linear transducers at their low and high ends.
- Volume of irregularly shaped tanks based on measured liquid level or pressure at the base of the tank.

### Implementation

The custom curve relationship in a Laureate meter, counter or transmitter is formatted on a PC running Laurel's executable CustCurv60.exe software, which is available from our website at no charge. X-Y data is supplied to the PC in the form of an X-Y table. The PC processes this data to create 20 spline-fit non-linear segments, whose coefficients are downloaded into the meter in the form of a compact setup file with a *.prm* suffix. The number of splines is always 20, regardless of the number of entered data points. The length and coefficients of the splines are optimized by least-squares algorithms. The 20 curved splines provide better accuracy than a larger number of straight-line segments. The typical error is from 0.1% to 0.01% of full scale, depending on the number of data points used for setup, the error in the data points, and the severity of non-linearities or discontinuities.

### Summary of Steps

1. The user creates or furnishes an Excel spreadsheet with up 240 data points, where the first column is the meter input in counts (such as ohms for a thermistor), and the second column is the desired linearized meter reading in counts (such as °C for a thermistor).
2. The user saves the Excel data as an MS DOS .txt text file in the same directory as CustCurv60.exe.
3. The user changes the .txt file extension to .raw
4. The user enters the .raw file name into CustCurv60.exe.
5. The user enters two X-Y data points into CustCurv60.exe, such as 0,0 and 20,20.

6. Following data entry, CustCurv60 processes the data and creates a number of tiles in a few seconds, including one with a .sim extension and one with a .prm extension. When opened with Notepad, the .sim extension shows the errors between the entered X-Y data points and the spline-fit X-Y data points.

7. If the .sim file shows satisfactory results, download the .prm file into the meter, as detailed in this manual.

**Prerequisites**

1. A Laureate Extended panel meter, counter or transmitter. Extended model numbers begin with L3, L4, L7, L8, LT4 or LT8.

2. If the Extended Laureate is a counter or transmitter with a model number beginning with L7, L8 or LT8, the revision number written on the microcomputer chip needs to be CTR2_32, not CTR2_33. If your revision is CTR2_33, we will swap out the micro-computer board.

3. A serial communication option board (RS232, RS485 or USB) in an Extended Laureate meter or counter for communication with a PC for setup by CustCurv54.exe. Following setup, the serial communication board can be removed and be used to set up another meter or counter. It can also be replaced by an Ethernet communication board, so that the host instrument can be operated under Modbus TCP. Laureate LT4 or LT8 series transmitters come with a serial communication port that can be set to RS232 or RS485. Laureate LTE4 or LTE8 series Ethernet port only come with an Ethernet port, but can be programmed with CustCurv54.exe by the factory using a special adapter.

4. A PC with an available COM port COM1 through COM4 for serial communications. Use Device Manager under the Windows Control Panel to rename your COM port if necessary. The PC operating system can be any version of Windows. The custom curve software has been tested with Windows 7 and 10.

**History**

CustCurve.exe was developed in 2000 using the QuickBasic that came with MS DOS, hence the classical text-based operator interface. The program was converted to QB64 in 2016 to make it compatible with all versions of Windows. Accepted encodings for input text files are now MS DOS, Windows DOS, Unicode UTF-8, Unicode Little-Endian, and Unicode Big-Endian. This manual reflects our experience with MS DOS.

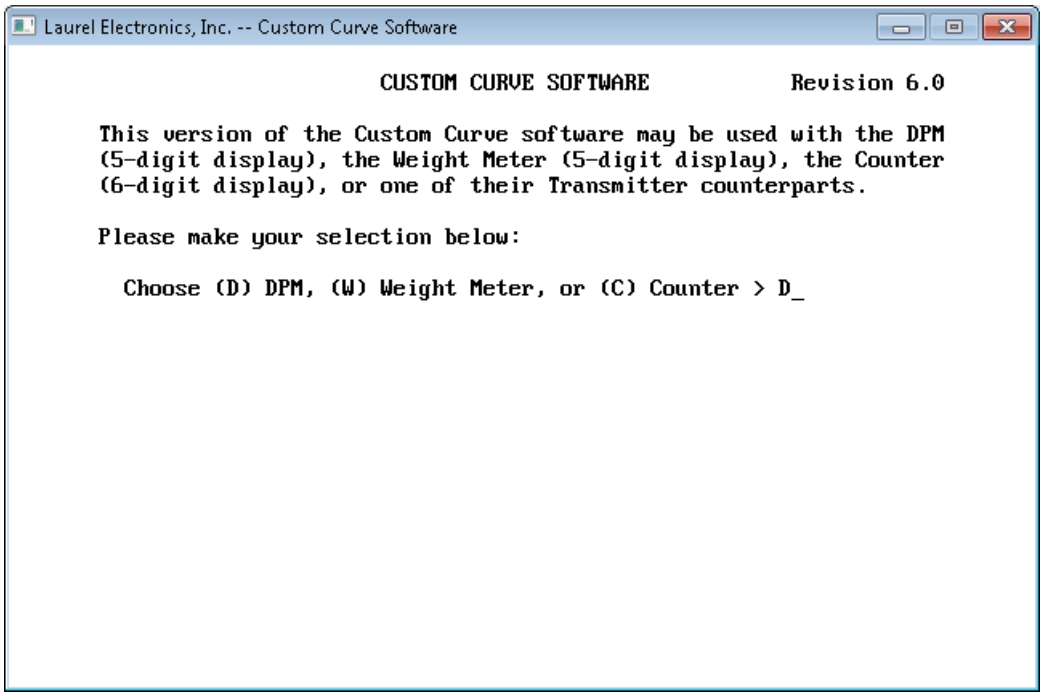
The CustCurve.exe version documented in this manual is **Revision 6.0**.

# 2. INSTALLATION & LAUNCH

Download the executable file CustCurv60.exe from Laurel's Software Downloads web page. Place the file into a directory of your choice. This directory will become your working directory and needs to hold all of your custom curve linearization data. If you wish to use multiple custom curve directories, place copy of CustCurv60.exe into each directory and click on that file to linearize the files in that directory.

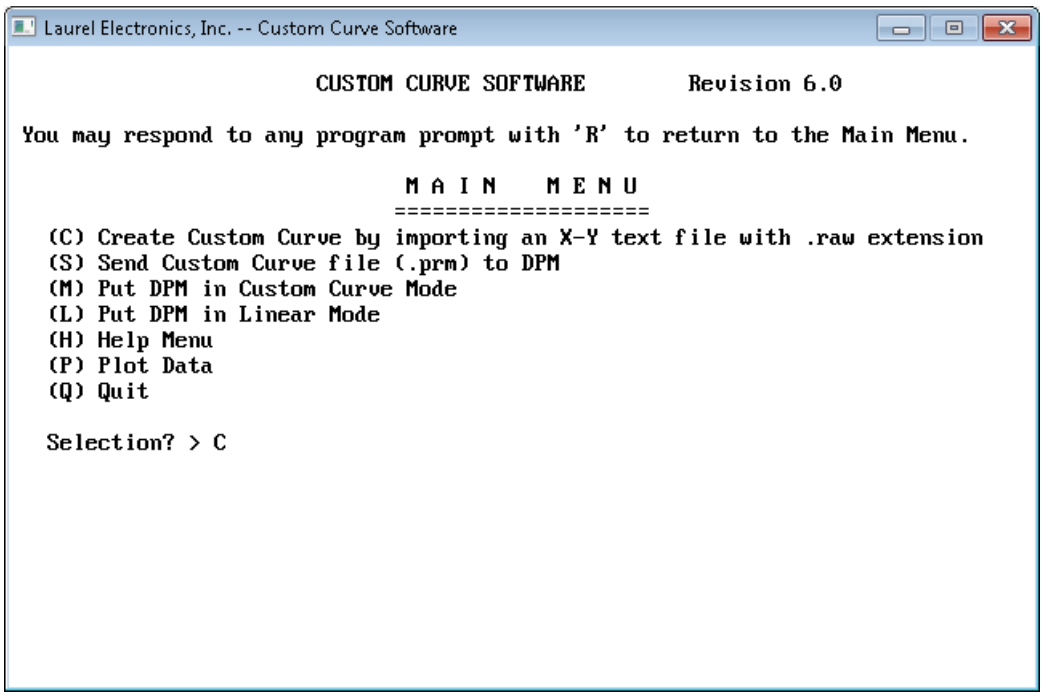
To launch, double-click on CustCurv60.exe. The first Custom Curve Software screen will open and ask you to enter **D**, **W** or **C**.

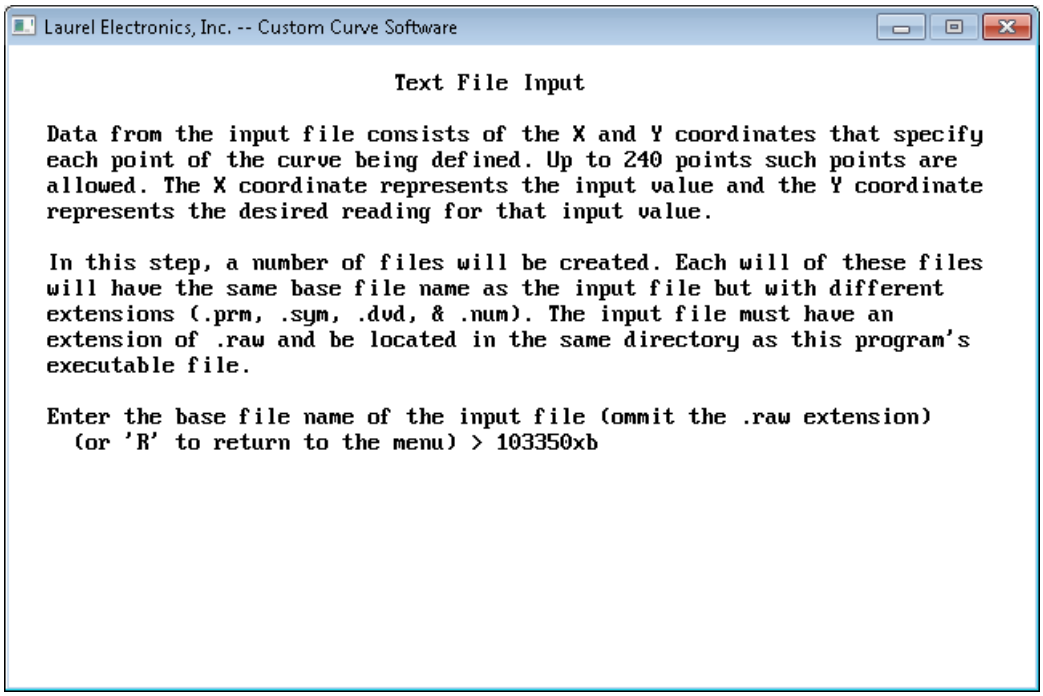
- **D** is for Laureate digital panel meters (DPMs) or transmitters with an analog input.
- **W** is for the Laureate weight meter, a DPM with special weighing firmware.
- **C** is for Laureate counters or counters with a pulse input or a VF voltage-to-frequency converter input.



# 3. TEXT FILE DATA ENTRY MODE

After entering D, W or C, the Main Menu screen will present a choice of actions. Enter **C** to "Create Custom Curve by importing an X-Y text file with a .raw extension."



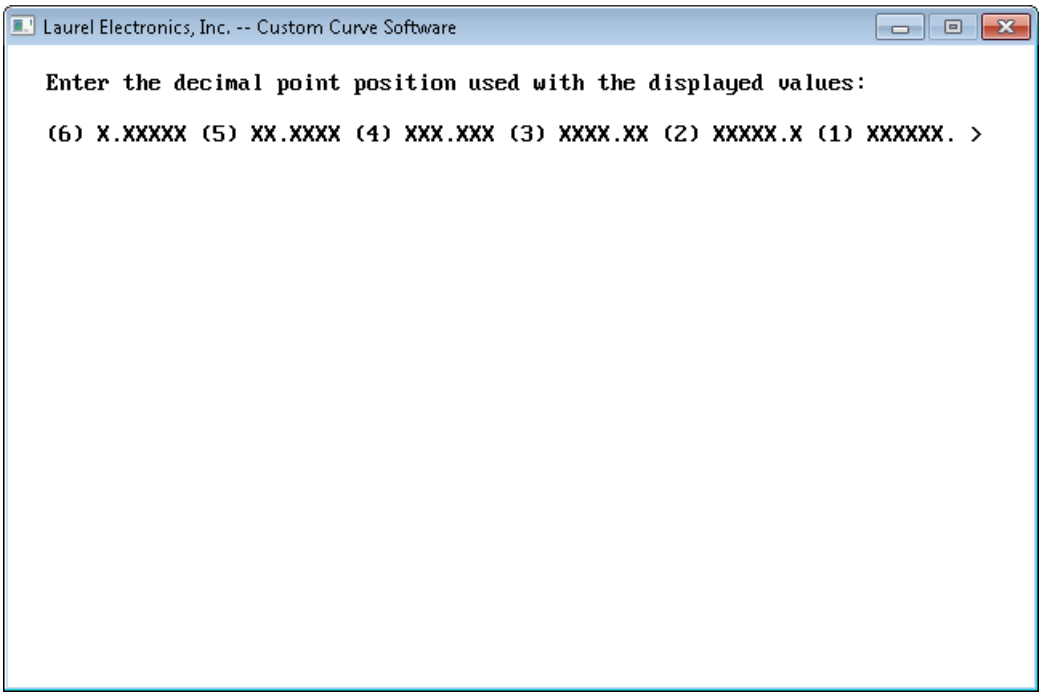
You will be asked to enter a file base name, like 103350xb in this example, which will be used for all custom curve files for your specific application. All 103350xb.* files need to be in the same directory as the executable file CustCurv60.exe. OK to mix different file base names in that directory, since Windows Explorer will sort them alphabetically.

The example file 103350xb.raw is a two-column table in .txt format, where the first (or X) column is resistance in ohms for an Ametherm DG103350 NTC thermistor with 20K ohms in parallel, and the second (or Y) column is temperature in °C. Note that placing 20K ohms in parallel with the thermistor, which has an R25 of 10K, ensures that the measured resistance in ohms never exceed 20000 ohms. This allows the Laureate 0-20000 ohm range to be used even for low temperatures where the thermistor resistance is quite high.

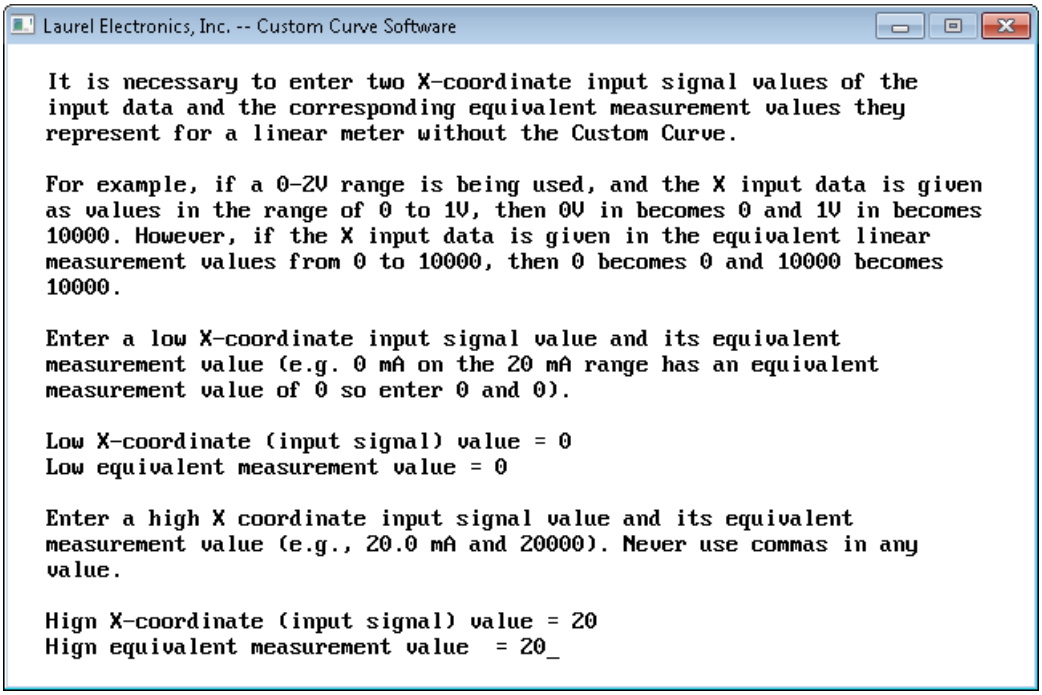
Start by creating an Excel table named103350xb.xls or 103350xb.xlsx, where first (or X) column is resistance in ohms calculated with the parallel 20K resistor, and the second (or Y) column is temperature in degrees C. Use Excel to sort the table so that the X values are ascending.

Use Excel to save your table in “Text (MS-DOS) (*.txt)” format to create the file 103350xb.txt. Then close the file. Then use Windows Explorer to change the name of the saved file to 103350xb.raw. Note that the .raw file format used by CustCurv60.exe is not related to the .raw file format used in photography.

You will be asked to specify the position of the decimal point. If you select (3) XXXX.XX, your temperature entry will be converted to units of hundredths of a °C. You can later move the decimal point using front panel keys for a meter to Instrument Setup software for a transmitter to read temperatures like 26.29°C.

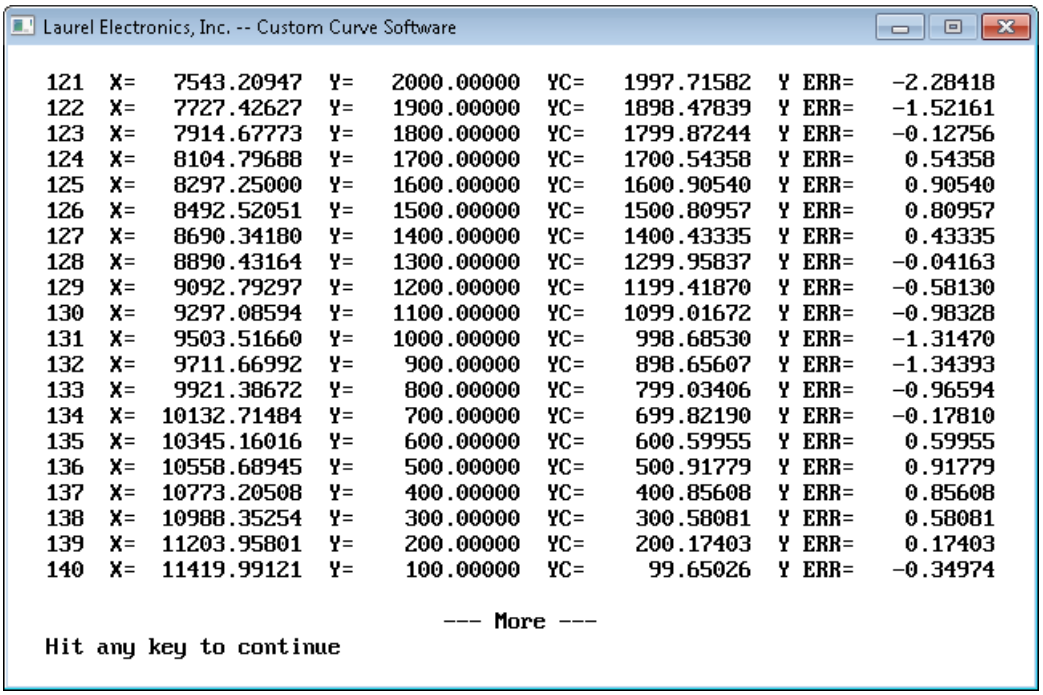


You will next be asked enter a low X and Y data point, and a high X and Y data point. As first trial, enter **0,0** and **20,20** to create a straight line with slope 1. This line will be used as the starting point for calculations by CustCurve60.exe. If this suggested set numbers does not allow the calculations to converge within seconds or produces high errors, try a different set of numbers.




Following entry of the starting values, the software will display a table of the type below. This is from the file103350xb.sim, which is automatically saved in your custom curve data directory. In our example, X is the input resistance in ohms calculated with 20K in parallel with the thermistor. Y is temperature in °C as supplied by the thermistor manufacturer, but converted to hundredths of a °C. YC is the calculated temperature in hundredths of a °C as calculated by the software for the 20 curvilinear spline fit segments. Y ERR is the difference between the input temperature and the calculated temperature, all in hundredths of a °C.

At this point assess the quality of your custom curve linearization. If errors are too large for a segment of the thermistor curve, consider narrowing temperature span over which custom curve linearization is applied. Also enter different low and high X and Y data points.



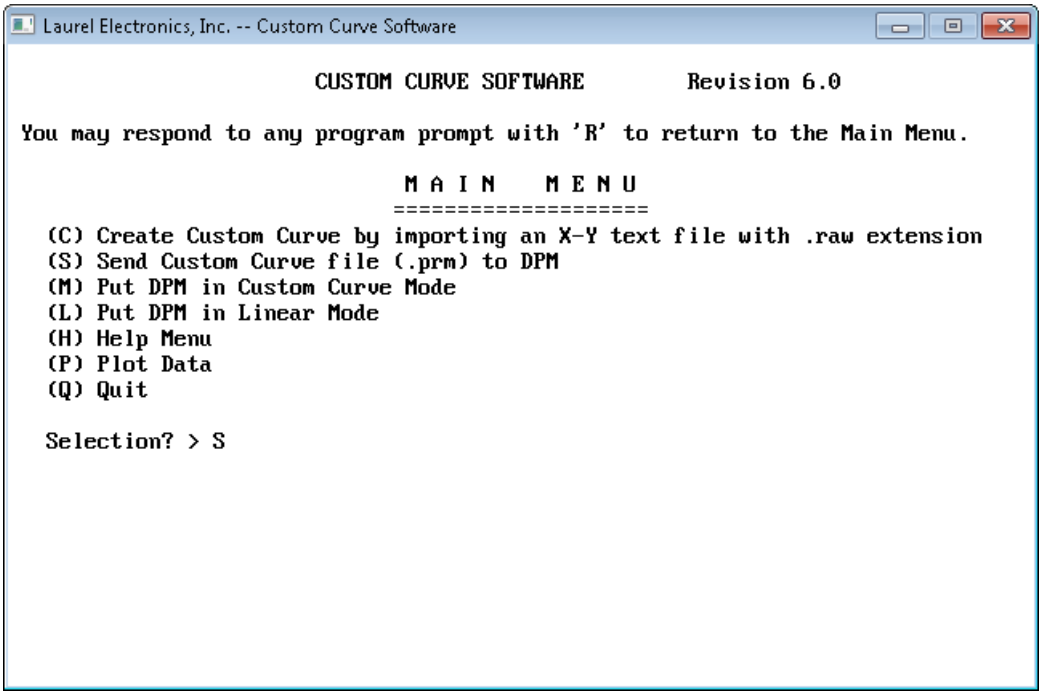

After you have hit keys to step through all table rows, you will be asked “Send Custom Curve parameters to DPM?” and “Put DPM in Custom Curve mode?” Answer **N** to both questions if you intend to download (or put) your custom curve data into your instrument later. At this point your custom curve directory already contains the file 103350xb.prm to be downloaded into your instrument. Answer **Y** if your meter is connected to the PC and is ready to accept the data file.

# 4. PUTTING CUSTOM CURVE INTO YOU DEVICE

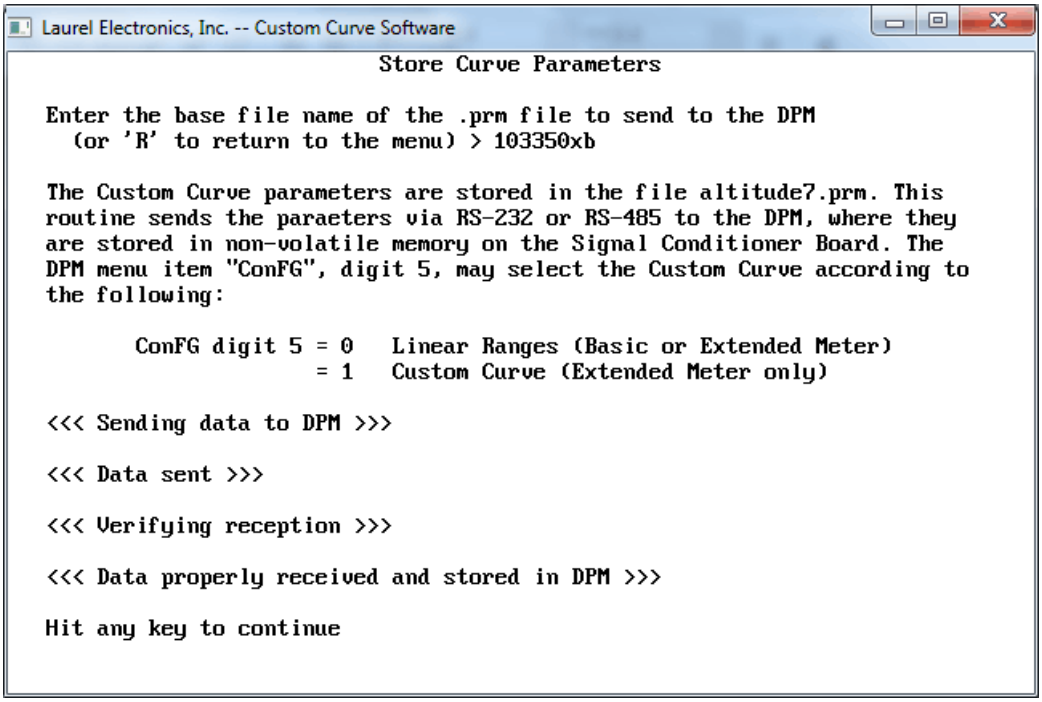
1. **Verify that your instrument is suitable** for use with CustCurv54.exe, as explained under “prerequisites” in the first section of this manual. Your instrument must be Extended and have a model number beginning with L3, L4, L7, L8, LT4 or LT8. Ethernet model numbers beginning with LTE4 or LTE8 require a special serial adapter available only at the factory.

2. **Set up serial communications** between your PC and instrument, which must be set to 9600 baud, no parity, 8 data bits, 1 stop bit (N81), and to the same COM port. Your instrument must be set to the Custom ASCII protocol (not Modbus) and address 1. Use Device Manager under the Windows Control Panel to verify that the PC’s COM port is between 1 and 4, or use Device Manager to set your PC’s COM port to a number between 1 and 4. One independent method to verify and correct communications is to use Laurel’s Instrument Setup (IS) software, which is at no charge and can be downloaded from our website. Once in IS software, do a *DPM => Get Setup* to upload the meter’s setup information to your PC. Do a *View => Setup*. Verify that the meter has been set up as Extended and for custom curve linearization. Open the *Communication* tab. Verify that the Serial Protocol is Serial ASCII, and that *Custom Address* is 1. Do a *DPM => Put Setup* to download any changes from your PC into your DPM.

3. **Launch CustCurv60.exe** by clicking on that file name. In our example, enter **D** for DPM. This will bring up the screen with the Main Menu. Select **S** for “Send Custom Curve parameters (filename).prm to DPM.”



The next screen will ask you to enter the .prm file name, which is 103350xb in our example. After that, your PC will send your file to the meter and verify data reception, thereby putting your meter into custom curve mode. Congratulations!

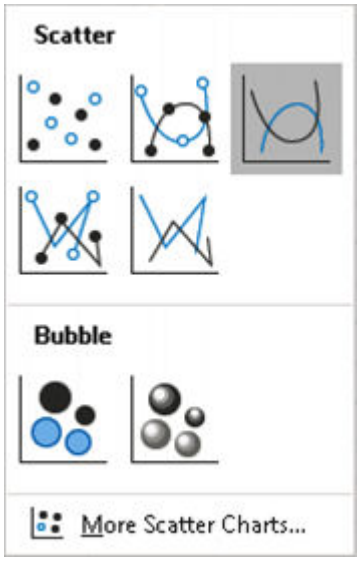


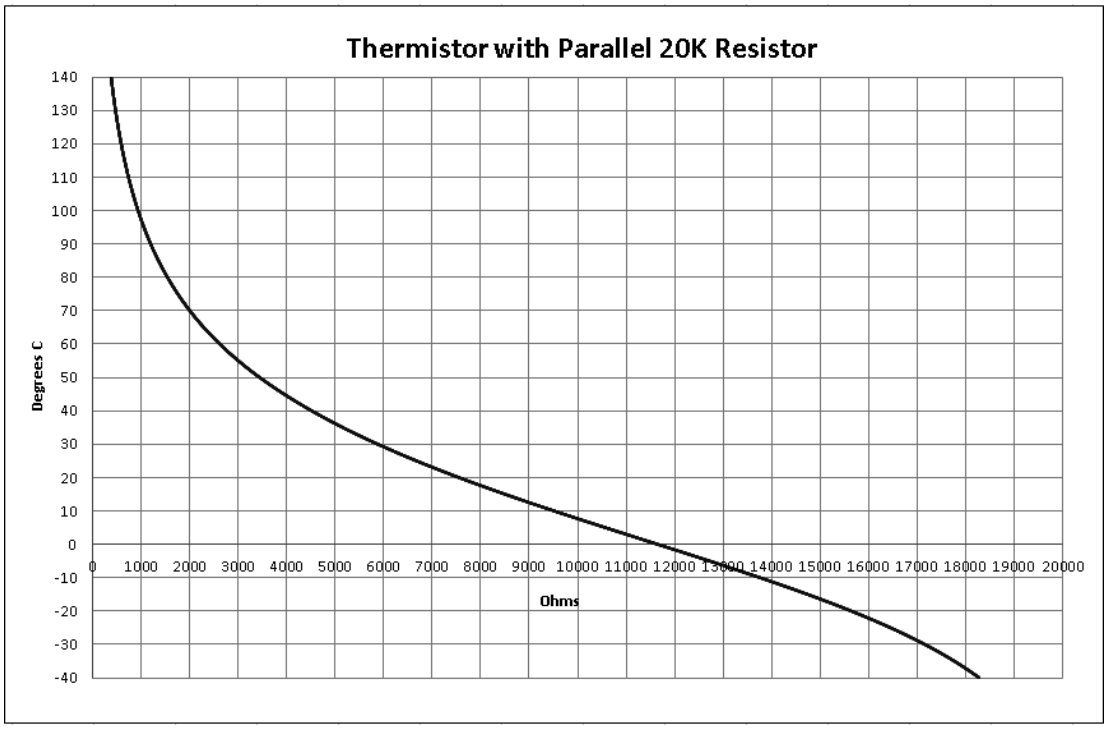

4. **Verify the custom curve performance** of your meter. Enter actual voltages or currents, or in our case resistance from a decade box, and verify that your meter readings are as expected.
5. **To return to linear mode,** use the meter front panel and change ConFG digit 5 from 1 to 0. Or use Instrument Setup software, click on the *Input+Display* tab, and set *Custom Curve* to *Disable*. To return to your programmed customer curve settings, reverse these entries.

# APPENDIX: USING EXCEL WITH CUSTOM CURVE

Microsoft Excel should be your primary means to store your custom curve input data and generate the text file for our custom curve software. Its charting functions are also a great tool to visualize your data and point out any outlier data points, which you can then correct manually. Also use Excel to graph the errors reported by your *.sim diagnostic file.

1. Enter your X input data in counts in the first table column. That can be calculated data or data measured with an accurate calibrated linear meter, which can be the meter to be custom curve linearized. In our example, the X values are the resistance in ohms of a thermistor paralleled by 20K.
2. Enter your desired Y display data in the second column. In our example, this is temperature in °C as provided by the thermistor manufacturer.
3. Use the Excel sorting function to put your date in order of ascending X.
4. Highlight the X and Y data portion to be graphed.
5. Click on *Insert* => *Insert Scatter (X, Y) or Bubble Chart* => *Scatter with Smooth Lines*.

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