APPENDIX C

FLIGHT DECK I/O CALIBRATION TABLES

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CALIBRATION TABLES

A calibration table is composed of three or more lines or records. Each record contains eight values or fields. The eight fields are defined as follows: ID, x1, y1, x2, y2, slope, offset, and comment.

The ID field is just a numerical value from 1 to n where n represents the maximum number of records in the calibration table.

The (x1,y1) and (x2,y2) pairs represent two points that are necessary to define a line segment. The slope and offset fields are the slope and offset of the line segment defined by these two points. The slope is computed as m = (y2-y1)/(x2-x1). The offset is equal to b = y2 - m*x2.

Taken together the individual line segments form a piece-wise linear fit to a non-linear curve.

For calibration tables used with analog outputs the x-values represent the variables sent by the host to the FDKIO and the y-values represent the analog voltage output by the FDKIO to the instrument. One important thing to note is that the analog voltages are in their offset binary form. In other words, -10 VDC is represented by a decimal 0, 0 VDC is represented by a decimal 32767, and +10 VDC is represented by a decimal 65535. The voltages are written this way to save the FDKIO the time required to perform this one additional conversion.

It is important that entries in analog output calibration tables are sorted in ascending order by their x1 values. The need for this will become apparent when we discuss how the FDKIO processes these files below.

Another important use of calibration tables (aside from performing a piece-wise linear fit to a curve) is to safely handle values outside the normal operating range of the instrument. For this reason, each calibration table has entries for upper and lower limits. These entries begin with host values of +9999 or -9999, respectively. The +9999 and -9999 satisfactorily represent plus and minus infinity.

To better understand calibration tables let's look at an actual table and discuss how it will be processed by the FDKIO. We will use the table for the accelerometer as an example.

ACCEL.CAL

ID	x1	y1	x2	y2	slope	offset	comment
1	-9999	0	-2.5	0	0	0	lower limit
2	-2.5	0	-1	8025	5350	13375	-2.5 g
3	-1	8028	0	13376	5348	13376	-1 g
4	0	13401	1	18723	5322	13401	0 g
5	1	18743	2	24074	5331	13412	1 g
6	2	24084	4	34773	5344.5	13395	2 g
7	4	34766	6	45475	5354.5	13348	4 g
8	6	45448	8	56173	5362.5	13273	6 g
9	8	56163	9.75	65535	5355.42	13319	8 g
10	9.75	65535	9999	65535	0	65535	upper limit

Let's say the host passes the FDKIO a value of +3.0g to be displayed on the accelerometer. The FDKIO will take the value of 3.0 and compare it to entry 1 in the calibration table and ask the question is x1 < 3.0 < x2? In other words, is 3.0 greater than -9999 and less than -2.5? In this case the answer is 3.0 is greater than both x1 and x2 so the FDKIO will proceed to the next entry in the table and perform the same test.

Eventually, when it reaches entry 6 the test will pass and the FDKIO will use the corresponding slope and offset (5344.5 and 13395) to compute the analog voltage to send to the hardware. In this case the value will be y = 5344.5*3 + 13395 = 29429. Sending a value of 29429 in offset binary to the analog output results in a voltage of approximately -1.02 VDC being applied to the instrument, which will cause the instrument to display +3.0g.

If the host computer accidentally sends a value beyond the range of the instrument, say –5.0g, the calibration table will intercept that value and safely command the instrument to display its maximum value of -2.5g.

Hopefully, this brief explanation of calibration tables will help you to better understand how they are used by the FDKIO and allow you to make adjustments to the line segments where needed.

Adjusting Calibration Tables

Sometimes it becomes necessary to make adjustments to the calibration tables. No two instruments are exactly alike. If an instrument fails, its replacement will most likely not exhibit the same characteristics as the original. In this case it may be necessary to adjust the values in the calibration table to accommodate the new instrument. This procedure describes how to do just that.

As an example let’s assume the accelerometer has failed and has been replaced with a new instrument. For the most part it is working properly, but when the host commands the accelerometer to display +2.0g, the instrument displays +2.5g instead. We will need to adjust the breakpoints at or around this value.

Start by selecting the Signals window on the FDKIO GUI. Perform a search for “ACCEL”. You should find the label called “ACCELEROMETER_DRIVE”. Put the FDKIO into the Debug mode and enter a value in the Status field for this label. You might start with something like 24084.0.

Note how the accelerometer is driven by this value. If it’s driven above +2.0g then reduce the value and try again. If it’s driven below +2.0g then try increasing the value. Continue adjusting the value in this manner until the accelerometer displays exactly +2.0g. Then record this value for use later on. Repeat this procedure for +1.0g and for +4.0g. Record your values.

Next compute the slope and offsets for the new values using the equations mentioned above. Lets say you recorded a value of 25150 for +2.0g and a value of 36200 for +4.0g. The slope for this segment would be m = (y2-y1)/(x2-x1) = (36200-25150)/(4-2) = 5525. The offset would be b = y2 – m*x2 = 36200 – 5525*4 = 14100. Repeat this for the other line segments that require adjustment. Record all your results.

Now you need to enter these new values into the calibration table for the accelerometer. All of the calibration tables are kept in a subdirectory named “cal” on the FDKIO computer’s hard drive. You can access these files using the simple text editor provided with the FDKIO GUI.

1. Select Tools->Editor from the menu bar on the FDKIO GUI. The simple text editor will open.

2. Select File->Open from the menu bar on the simple text editor. The File Open dialog box will open.

3. Double-click on the “cal” folder.

4. Double-click on “accel.cal”. The accelerometer calibration table will be displayed in the simple text editor.

Before making any changes to the original calibration table you should make a backup.

1. Select File->Save As. The File Open dialog box will open.

2. In the “File name” field type “accel.bak” and then click “OK”.

3. Now, close this file using the File->Close menu option, but answer “NO” when prompted to save your changes.

Now, select Tools->Editor again and double-click on the “cal” folder. This time you should see both an “accel.cal” and an “accel.bak”. Select the “accel.cal” file as before.

Use the mouse and arrow keys as usual to edit the appropriate fields. When you have finished close the file. You will be prompted to save your changes. Click the “Yes” button. Now you need to reboot the FDKIO and test your changes.

After the FDKIO has rebooted select the Variables window from the FDKIO GUI. Search for “ACCEL” again as before. Put the FDKIO into the debug mode. Enter several values for ACCELEROMETER_DRIVE. Try +2.0g and verify the accelerometer correctly displays +2.0g. Try some other values. If the accelerometer correctly displays all the values you are finished. If the accelerometer needs further adjustment repeat the above procedure until the accelerometer displays correctly.

If you have totally screwed-up the “accel.cal” file use the following procedure to restore the original file using the backup you created.

1. Select Tools->Editor.
2. Select File->Open.
3. Double-click the “cal” folder.
4. Double-click on “accel.bak”.
5. Select File->Save As.
6. Change the filename to “accel.cal” and click OK.
7. Select File->Close and answer NO to the prompt to save your changes.

Now you can start fresh with the original file as described above.

Good Luck.