# INTEGRATING ENGINEERING UNIT CONVERSIONS AND SENSOR CALIBRATION INTO INSTRUMENTATION SETUP SOFTWARE

**Benjamin Kupferschmidt**
**Software Development Engineer**
**Teletronics Technology Corporation**
**Newtown, PA USA**

## ABSTRACT

Historically, different aspects of the configuration of an airborne instrumentation system were specified in a variety of different software applications. Instrumentation setup software handled the definition of measurements and PCM Formats while separate applications handled pre-flight checkout, calibration and post-flight data analysis. This led to the manual entry of the same data multiple times. Industry standards such as TMATS strive to address this problem by creating a data-interchange format for passing setup information from one application to another. However, a better alternative is to input all of the relevant setup information about the sensor and the measurement when it is initially created in the instrumentation vendor's software. Furthermore, an additional performance enhancement can be achieved by adding the ability to perform sensor calibration and engineering unit conversions to pre-flight data visualization software that is tightly coupled with the instrumentation setup software. All of the setup information can then be transferred to the ground station for post-flight processing and data reduction. Detailed reports can also be generated for each measurement.

This paper describes the flow of data through an integrated airborne instrumentation setup application that allows sensors and measurements to be defined, acquired, calibrated and converted from raw counts to engineering units. The process of performing a sensor calibration, configuring engineering unit conversions, and importing calibration and transducer data sheets will also be discussed.

## KEY WORDS

Engineering Unit Conversions, Sensor Calibration, XML, Data Interchange.

## INTRODUCTION

One of the most important goals of every flight test program is to fly as many missions as possible in the least amount of time. Instrumentation system vendors can help to accomplish this goal by finding ways to increase the efficiency and productivity of flight test engineers. If the engineers can setup the aircraft faster then more missions can be flown in the same amount of time. To improve efficiency, a key issue that vendors can address is the need to input the same system setup information multiple times into different pieces of software. It is often the case that each software application performs a crucial task during system setup and pre-flight operations, but there is no easy way to transfer the system setup from one application to the next.

Industry standards such as TMATS attempt to address this problem by providing a data interchange format that can transfer key aspects of the system setup between software applications. While this helps to make some parts of the configuration portable, it does not completely resolve the problem for two reasons. First, data entry remains scattered across many different applications. Also, it is often difficult to use TMATS to transfer setup information between applications due to incompatibilities between different vendor's implementation of the standard.

An alternative solution is to provide the ability for the user to configure all aspects of a data acquisition system during an early stage of the system setup process. The vendor's system setup and programming application is the ideal place to add this ability. This application already includes support for standard system setup tasks such as configuring the hardware, creating measurements to sample data, placing measurements into PCM Formats and loading the configuration into the hardware. Pre-flight verification and post-flight analysis benefit greatly from the addition of the ability to assign Engineering Unit (EU) Conversions to measurements in the system setup software. It is also helpful to be able to define concatenations of multiple measurements and create derived parameters from any combination of existing measurements.

It is possible to enhance the usefulness of these new features by tightly coupling a pre-flight validation and data visualization tool to the system setup software. This tool can be used to perform sensor calibrations by acquiring real-time data via a Bit Sync and/or Decommutator. The calibration feature works by collecting a set of raw counts and a corresponding set of EU values. By using a least-squared best-fit algorithm to generate a polynomial, an Engineering Unit Conversion can be created that approximates the behavior of the sensor over a specified range of inputs. Alternatively, the raw and EU point pairs could be used as the basis for a linear interpolation.

This paper will discuss the benefits of setting up Engineering Unit Conversions and performing calibrations as part of the system setup and validation process. It will review the creation of EU Conversions and Concatenations in TTC's system setup application (TTCWare). The operation of the sensor calibration feature in TTC's pre-flight data visualization tool (TTCVision) will also be discussed. Finally, this paper will describe the methods by which the system configuration including EU Conversions, Concatenations and Sensor Calibration information can be transferred to other applications for post-flight analysis.

## BENEFITS OF INTEGRATING EU SETUP INTO THE SETUP SOFTWARE

The primary goal of integrating Engineering Unit Conversion setup into the system setup software is to reduce the amount of duplicate data entry that the user must perform in order to configure their instrumentation system prior to a test flight. Instrumentation engineers spend a great deal of time configuring data acquisition hardware and creating measurements. There are many benefits to reducing the manual re-entry of data. One benefit is simply that it takes less time to setup the system if data doesn't need to be entered multiple times. It is also safer because each time data is entered there is a chance that an error will be made. In addition, inputting the EU setup while initially creating the measurements can save time.

When the same measurements are manually created in different applications, it is very hard to make even the simplest change because the engineer must ensure that the change propagates to all of the instances of the measurement in all of the applications. This also makes it much more difficult to archive configurations because the separate project files from each application must be exported at the same time and all of them must be stored together. It is also very hard to reuse the configuration for a similar project without having to re-enter most of the setup information.

Another benefit is that inputting EU Setup and Concatenations in the system setup application helps to improve the compatibility between different test groups that are using the same data acquisition hardware but different software. This often happens when test aircraft pass from a manufacturer to one of the government test ranges. The manufacturer may be using proprietary software to manage the configuration that is not available to the plane's end-users. As long as the EU Setup is input into the vendor's configuration software, the same test projects can be used to load the system and pass the EU setup on to the data analysis group at different test ranges.

Pre-flight data validation can also take advantage of having all of the EU Setup and Concatenations defined in the setup software. It is much easier to configure limits and verify that all data acquisition systems are working properly before a flight when looking at EU converted data than when looking at meaningless raw counts. This is particularly true for data that occupies multiple words in a PCM Format and for data that is encoded in a format other than unsigned binary. It is also much easier to check one-bit status measurements when they're are assigned to concatenations rather than packed into a single data word.

An additional benefit relates to the generation of TMATS files. When EU Setup and Concatenations are defined in the system setup software, they can be included in any TMATS files that are generated by the software. This is particularly important for IRIG-106 Chapter 10 support. Chapter 10 files are self-describing because they include a TMATS entry in their first packet. The usefulness of this feature greatly increases when the attached TMATS file contains more information about the recording. Ideally, an old Chapter 10 recording will be readable in the future even if the original configuration that was used to program the hardware and make the recording is no longer available. By generating the TMATS file as part of the system compilation and programming step, the instrumentation engineer can ensure that accurate information about the data sources for the recording is contained in the TMATS packet. If EU setup and Concatenation information is included in the TMATS packet then future playback software can use this setup to decode and display the data properly. This greatly enhances the usefulness of archived recordings.

There are several issues relating to the usage of TMATS as a data interchange format between applications that can be mitigated by integrating EU setup and Calibration into the system setup software. The most common problem with TMATS is that different vendors have implemented the standard differently or have not implemented all of the features that are defined in the most recent release of the IRIG-106 standard. This can cause problems due to unrecognized tags or misinterpreted tags.

One of the biggest problems with passing TMATS files between applications occurs when the instrumentation engineer needs to chain applications together. For example, the setup software could generate the measurement list, and then another application adds the EU Setup while another adds the Calibration data points. The problem is that there is no easy way to guarantee that each application along this data path will retain all of the TMATS content that it reads from the preceding application when it exports the file to the next application. Typically, tags that are not understood will be discarded. This could force the instrumentation engineer to merge the TMATS files that are generated by the various applications by hand in order to create a complete file that represents the measurements with EU setup and calibration data points. This is a very difficult, time consuming and error prone process due to the hierarchical structure of the indexing system in TMATS files. While moving the EU Setup into the system setup software won't eliminate these issues, it will reduce the severity of the problem because the entire TMATS file can be generated from a single source.

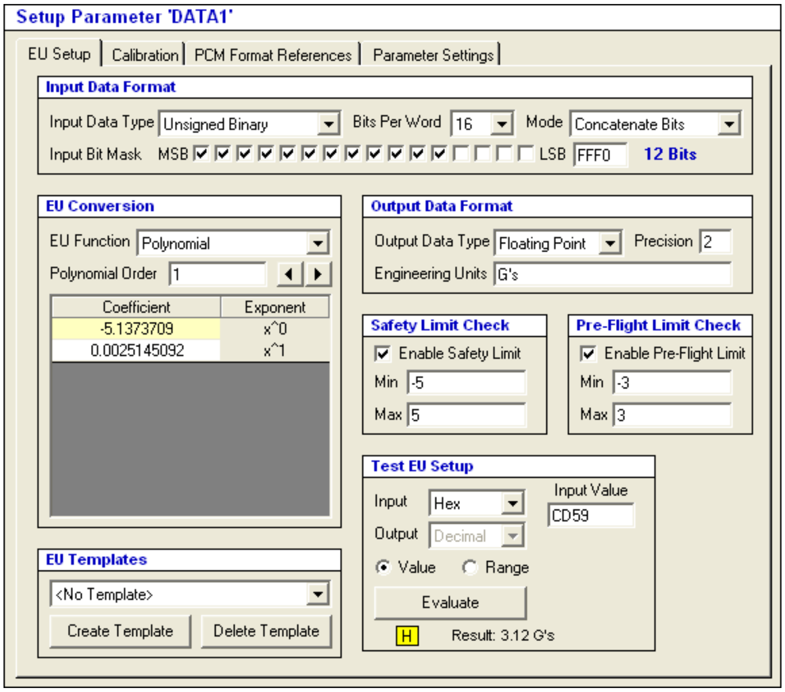
Another problem that the manual re-entry of data can cause is related to maintaining up-to-date versions of all of the various pieces of software. Often instrumentation engineers will not want to upgrade once they find a combination of applications that work together successfully. However, the addition of new data acquisition hardware or a critical software bug fix might make it necessary to upgrade one or more pieces of software. The potential for downtime due to unforeseen compatibility issues goes up greatly when upgrading software.

The final benefit of integrating EU setup and calibration into the system setup software is that it simplifies the generation of reports about the configuration because all of the information about a measurement can be reported in a single location. Exporting the configuration to other formats besides TMATS also benefits from having all of the measurement setup information in a single location.

## EU CONVERSIONS AND CONCATENATIONS

An Engineering Unit Conversion is a process by which raw data that is collected in a telemetry system is converted into a useful form for data analysis or verification. Data acquisition systems typically encode information in formats that save transmission bandwidth and recorder space. These formats must also conform to the requirements of a standard telemetry frame. While encoded, the data is not readily analyzable. During data processing, the EU Conversion is applied to the raw data to convert it into a form that can be easily understood and analyzed. The complexity of EU Conversions varies greatly and can be as simple as taking a single bit out of a 12-bit data word and interpreting a one to mean on and a zero to mean off or as complicated as a complex mathematical function involving multiple raw inputs.

Some simple examples of EU conversions that most people are familiar with are the formulas for converting from Celsius to Fahrenheit and from Meters to Inches. In the telemetry world, a typical EU Conversion might be to take a 12-bit input from a thermocouple channel and convert it from a number ranging from 0 to 4095 into an actual temperature in degrees Celsius.



**Input Data Format**

Input Data Type: Unsigned Binary; Bits Per Word: 16; Mode: Concatenate Bits

Input Bit Mask: MSB ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☑ ☐ ☐ ☐ ☐ LSB FFF0 **12 Bits**

**EU Conversion**

EU Function: Polynomial

Polynomial Order: 1

| Coefficient | Exponent |
|---|---|
| -5.1373709 | x^0 |
| 0.0025145092 | x^1 |

**Output Data Format**

Output Data Type: Floating Point; Precision: 2

Engineering Units: G's

**Safety Limit Check**

☑ Enable Safety Limit

Min: -5

Max: 5

**Pre-Flight Limit Check**

☑ Enable Pre-Flight Limit

Min: -3

Max: 3

**Test EU Setup**

Input: Hex; Input Value: CD59

Output: Decimal

● Value ○ Range

H Result: 3.12 G's

**EU Templates**

<No Template>

Figure 1: The Engineer Unit Conversion setup screen in TTCWare

The process of performing EU Conversions can be divided into a series of stages. Each stage modifies the data and passes it to the next stage. The EU Conversion process begins by selecting a data source and reading the raw data from the PCM Format. Once all of the required data words are read, a bit mask can be applied to each data word. There are two ways to apply the bit mask to the raw data. The first approach is to treat the mask as a filter. This means that the enabled bits in the mask allow the corresponding bits in the raw data to pass while deleting the disabled bits. For example, if the raw input data is $7C2_{hex}$ and the bit mask is $333_{hex}$, the result will be $32_{hex}$. The alternative approach is to perform a bitwise AND operation between the raw data and bit mask. Using the same example, the result of a bitwise AND would be $302_{hex}$. For concatenations, after the bit masks are applied to all of the input parameters, the remaining bits in each raw input are concatenated together into a single data word of up to 64 bits.

After bit masking the data, an input data type can be applied to the raw data. The simplest input data type is Unsigned Binary, which essentially treats the data as an unsigned integer from zero to $2^n - 1$ where n is the number of bits in the raw data. Another very common input data type is Two's Complement. This data type can be used to encode signed numbers by using the most significant bit as a sign bit. Some other common data types are One's Complement, Signed Magnitude and Binary Coded Decimal (BCD). Additional data types that can be supported include various floating-point formats such as IEEE-754 and MIL-STD-1750A. Another supported data type is IRIG time parameters in Straight Binary or BCD format.

Once the data has been bit masked and converted to an actual raw number by applying an input data type to the raw bits, it can be used as the input to a mathematical EU function. There are many potential EU functions. However, the vast majority of data acquisition measurements can be converted from raw counts to engineering units by applying a simple polynomial function of the form:

$$a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x^1 + a_0 x^0$$

Where n is the order of the polynomial from zero to nine, each $a_n$ to $a_0$ are user defined constants and x is the input data.

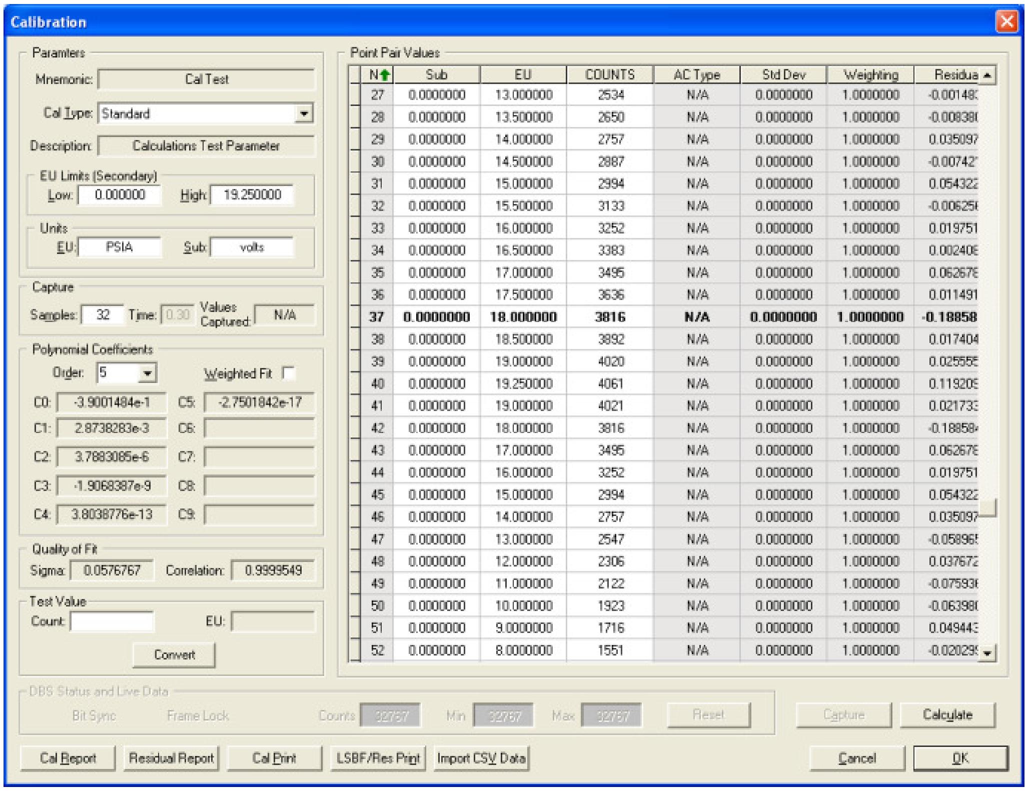
Another common EU function is the lookup table. Lookup tables are typically used when it is not possible to generate a good polynomial to represent the relationship between the raw and EU data. A lookup table consists of a set of input and output point pairs. If the raw data exactly matches an input point in the table then the exact output is returned. A linear interpolation is used to determine the output value for raw values that fall between any two input points. Some other common EU functions are bit weighted, which applies a different value to each bit in the raw data, and statistical functions like minimum, maximum, average and median, which operate on a set of raw values to produce a single output.

After the EU function is applied to the data, the resulting number can be formatted for output. As part of the formatting process, a user specified units field is appended to the output. Limit checking can also be performed at this point to verify that the data is within the desired range of values.

## SENSOR CALIBRATION

It is easy to determine the appropriate EU conversion for many types of data. For digital bus data, each bit or range of bits typically has a well-defined meaning. Embedded serial data streams, like audio and video data, can be played by an appropriate decoder. However, analog data is different because it is encoded as a digital approximation of the state of a continuous real-world measurement. In order to apply the appropriate EU conversion for analog data, it's necessary to calibrate the sensor and the data acquisition hardware. This calibration process determines the relationship between the raw counts that are collected by the data acquisition hardware and the actual EU value that the sensor samples.

Many sensors come with a Transducer Datasheet that lists the substitution voltages that the sensor generates for each real-world input. This information can also be determined empirically by taking the sensor to a calibration lab and actually trying each input to see what voltage is produced by the sensor. Alternatively, if the actual physical event that is being sampled by the sensor can be simulated on the ground, the complete system can be calibrated directly. Once a method of simulating each physical input is available for an analog acquisition channel, it is possible to use software to calibrate the sensor and determine the EU conversion that needs to be applied when processing real-world data that is collected from the sensor.



Mnemonic: Cal Test
Cal Type: Standard
Description: Calculations Test Parameter
EU Limits (Secondary) Low: 0.000000 High: 19.250000
Units EU: PSIA Sub: volts
Capture Samples: 32 Time: 0.30 Values Captured: N/A
Polynomial Coefficients Order: 5 Weighted Fit ☐
C0: -3.9001484e-1
C1: 2.8738283e-3
C2: 3.7883085e-6
C3: -1.9068387e-9
C4: 3.8038776e-13
C5: -2.7501842e-17
C6:
C7:
C8:
C9:
Quality of Fit Sigma: 0.0576767 Correlation: 0.9999549
Test Value Count: EU:
Counts: 32767 Min: 32767 Max: 32767

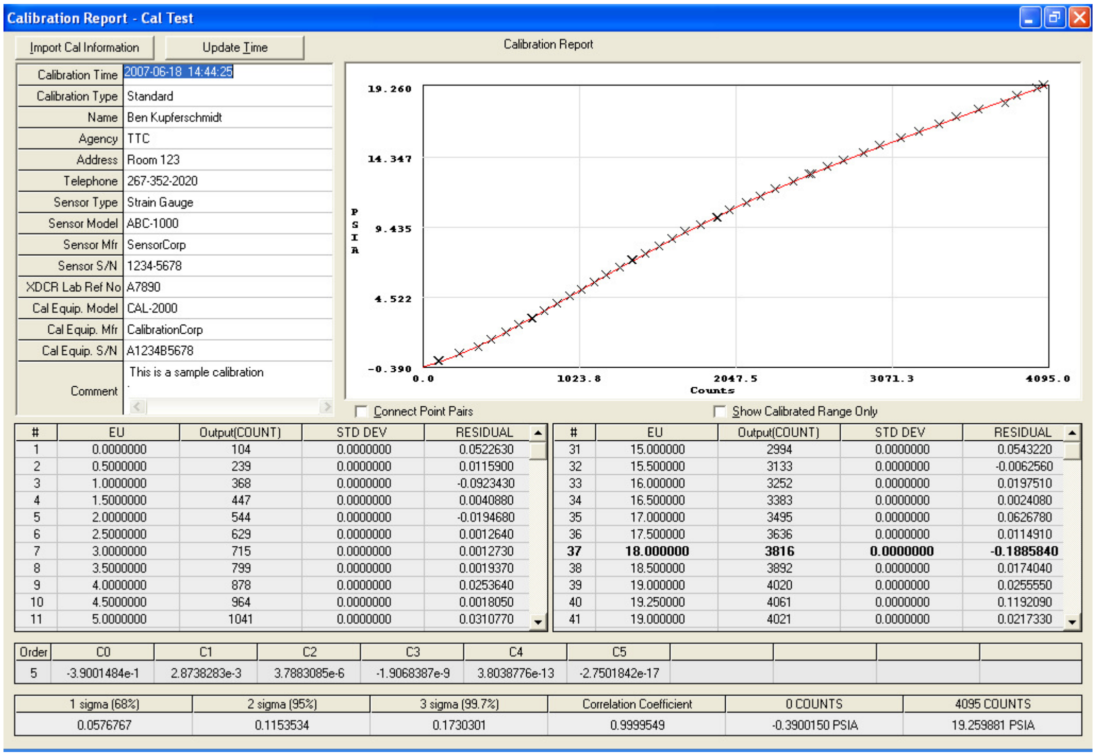
| N | Sub | EU | COUNTS | AC Type | Std Dev | Weighting | Residua |
|---|---|---|---|---|---|---|---|
| 27 | 0.0000000 | 13.000000 | 2534 | N/A | 0.0000000 | 1.0000000 | -0.00148 |
| 28 | 0.0000000 | 13.500000 | 2650 | N/A | 0.0000000 | 1.0000000 | -0.00838 |
| 29 | 0.0000000 | 14.000000 | 2757 | N/A | 0.0000000 | 1.0000000 | 0.035097 |
| 30 | 0.0000000 | 14.500000 | 2887 | N/A | 0.0000000 | 1.0000000 | -0.00742 |
| 31 | 0.0000000 | 15.000000 | 2994 | N/A | 0.0000000 | 1.0000000 | 0.05432 |
| 32 | 0.0000000 | 15.500000 | 3133 | N/A | 0.0000000 | 1.0000000 | -0.00625 |
| 33 | 0.0000000 | 16.000000 | 3252 | N/A | 0.0000000 | 1.0000000 | 0.019751 |
| 34 | 0.0000000 | 16.500000 | 3383 | N/A | 0.0000000 | 1.0000000 | 0.00240 |
| 35 | 0.0000000 | 17.000000 | 3495 | N/A | 0.0000000 | 1.0000000 | 0.06267 |
| 36 | 0.0000000 | 17.500000 | 3636 | N/A | 0.0000000 | 1.0000000 | 0.011491 |
| **37** | **0.0000000** | **18.000000** | **3816** | **N/A** | **0.0000000** | **1.0000000** | **-0.18858** |
| 38 | 0.0000000 | 18.500000 | 3892 | N/A | 0.0000000 | 1.0000000 | 0.017404 |
| 39 | 0.0000000 | 19.000000 | 4020 | N/A | 0.0000000 | 1.0000000 | 0.02555 |
| 40 | 0.0000000 | 19.250000 | 4061 | N/A | 0.0000000 | 1.0000000 | 0.11920 |
| 41 | 0.0000000 | 19.000000 | 4021 | N/A | 0.0000000 | 1.0000000 | 0.02173 |
| 42 | 0.0000000 | 18.000000 | 3816 | N/A | 0.0000000 | 1.0000000 | -0.18858 |
| 43 | 0.0000000 | 17.000000 | 3495 | N/A | 0.0000000 | 1.0000000 | 0.06267 |
| 44 | 0.0000000 | 16.000000 | 3252 | N/A | 0.0000000 | 1.0000000 | 0.019751 |
| 45 | 0.0000000 | 15.000000 | 2994 | N/A | 0.0000000 | 1.0000000 | 0.05432 |
| 46 | 0.0000000 | 14.000000 | 2757 | N/A | 0.0000000 | 1.0000000 | 0.03509 |
| 47 | 0.0000000 | 13.000000 | 2547 | N/A | 0.0000000 | 1.0000000 | -0.05896 |
| 48 | 0.0000000 | 12.000000 | 2306 | N/A | 0.0000000 | 1.0000000 | 0.03767 |
| 49 | 0.0000000 | 11.000000 | 2122 | N/A | 0.0000000 | 1.0000000 | -0.07593 |
| 50 | 0.0000000 | 10.000000 | 1923 | N/A | 0.0000000 | 1.0000000 | -0.06398 |
| 51 | 0.0000000 | 9.0000000 | 1716 | N/A | 0.0000000 | 1.0000000 | 0.04944 |
| 52 | 0.0000000 | 8.0000000 | 1551 | N/A | 0.0000000 | 1.0000000 | -0.02029 |

**Figure 2: Sensor Calibration data capture screen in TTCVision**

Sensors can be calibrated by capturing a set of measurements from a data acquisition channel while applying various input voltages to the channel. The ideal way to do this is to use the actual aircraft because the aircraft's wiring can have an effect on the relationship between the raw and EU values. There are two ways to generate the inputs for a data acquisition channel. The first is to apply a substitution voltage to the data acquisition card. This works best for things that cannot be simulated easily on the ground. The second approach is to stimulate the card directly by applying the actual conditions to the sensor. This works well for physical objects that can be manipulated on the ground like any of the moveable surfaces on an aircraft.

The sensor calibration process consists of two stages. The first stage is data collection and the second stage is calculating the polynomial for the EU conversion. The data collection stage requires the user to apply different inputs to the data acquisition channel. For each input, the software will capture a user specified number of data points and average them to produce a raw counts value. Typically, the system will capture at least 32 raw data values. To generate an accurate calibration, the user must ensure that the sensor has settled before the raw counts are captured. The user can then input the corresponding EU value based on the transducer data sheet or empirical experimentation. This process must be repeated until enough data points have been captured to cover the entire range of interest for the sensor. For example, if the input voltages on a sensor range from 0 volts to 5 volts, the user might want to capture data points at intervals of 0.5 volts.

This procedure is slightly different if the sensor outputs an AC voltage because the calibration tool must capture both the minimum and the maximum value for each input. When performing an AC calibration, the user must specify the number of seconds to sample data for instead of the number of samples to capture. This is necessary in order to guarantee that at least one minimum and one maximum sample occurs while the software is sampling the measurement. Ideally, several complete cycles of data will occur in the specified time interval to guarantee that the software has detected a genuine maximum and minimum value.



| | |
|---|---|
| Calibration Time | 2007-06-18 14:44:25 |
| Calibration Type | Standard |
| Name | Ben Kupferschmidt |
| Agency | TTC |
| Address | Room 123 |
| Telephone | 267-352-2020 |
| Sensor Type | Strain Gauge |
| Sensor Model | ABC-1000 |
| Sensor Mfr | SensorCorp |
| Sensor S/N | 1234-5678 |
| XDCR Lab Ref No | A7890 |
| Cal Equip. Model | CAL-2000 |
| Cal Equip. Mfr | CalibrationCorp |
| Cal Equip. S/N | A1234B5678 |
| Comment | This is a sample calibration |

| # | EU | Output(COUNT) | STD DEV | RESIDUAL |
|---|---|---|---|---|
| 1 | 0.0000000 | 104 | 0.0000000 | 0.0522630 |
| 2 | 0.5000000 | 239 | 0.0000000 | 0.0115900 |
| 3 | 1.0000000 | 368 | 0.0000000 | -0.0923430 |
| 4 | 1.5000000 | 447 | 0.0000000 | 0.0040880 |
| 5 | 2.0000000 | 544 | 0.0000000 | -0.0194680 |
| 6 | 2.5000000 | 629 | 0.0000000 | 0.0012640 |
| 7 | 3.0000000 | 715 | 0.0000000 | 0.0012730 |
| 8 | 3.5000000 | 799 | 0.0000000 | 0.0019370 |
| 9 | 4.0000000 | 878 | 0.0000000 | 0.0253640 |
| 10 | 4.5000000 | 964 | 0.0000000 | 0.0018050 |
| 11 | 5.0000000 | 1041 | 0.0000000 | 0.0310770 |

| # | EU | Output(COUNT) | STD DEV | RESIDUAL |
|---|---|---|---|---|
| 31 | 15.000000 | 2994 | 0.0000000 | 0.0543220 |
| 32 | 15.500000 | 3133 | 0.0000000 | -0.0062560 |
| 33 | 16.000000 | 3252 | 0.0000000 | 0.0197510 |
| 34 | 16.500000 | 3383 | 0.0000000 | 0.0024080 |
| 35 | 17.000000 | 3495 | 0.0000000 | 0.0626780 |
| 36 | 17.500000 | 3636 | 0.0000000 | 0.0114910 |
| **37** | **18.000000** | **3816** | **0.0000000** | **-0.1885840** |
| 38 | 18.500000 | 3892 | 0.0000000 | 0.0174040 |
| 39 | 19.000000 | 4020 | 0.0000000 | 0.0255550 |
| 40 | 19.250000 | 4061 | 0.0000000 | 0.1192090 |
| 41 | 19.000000 | 4021 | 0.0000000 | 0.0217330 |

| Order | C0 | C1 | C2 | C3 | C4 | C5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | -3.9001484e-1 | 2.8738283e-3 | 3.7883085e-6 | -1.9068387e-9 | 3.8038776e-13 | -2.7501842e-17 | | | | |

| 1 sigma (68%) | 2 sigma (95%) | 3 sigma (99.7%) | Correlation Coefficient | 0 COUNTS | 4095 COUNTS |
|---|---|---|---|---|---|
| 0.0576767 | 0.1153534 | 0.1730301 | 0.9999549 | -0.3900150 PSIA | 19.259881 PSIA |

Figure 3: Sensor Calibration Report in TTCVision

The second phase of the calibration process involves determining the optimal order for the polynomial and computing the coefficients for the polynomial EU. The polynomial coefficients are calculated by using a least-squares best-fit algorithm. To aid the user in selecting the best possible order for the polynomial, the software can generate a plot of the raw counts versus the EU values. The polynomial curve can be overlaid on top of the point pair plot. The software can also generate a residual plot to show which data points deviate the most from the polynomial. In addition to the graphical display, the software also calculates and displays the Standard Deviation of the curve and the Correlation Coefficient. If no polynomial provides a good fit for the data, the user can alternatively use the raw count and EU value pairs as inputs to a linear interpolation.

## EXPORTING EU CONVERSIONS AND CALIBRATIONS

In order to transfer the system configuration from the system setup software to the ground station or other data analysis software, a universal data exchange format is required. The current standard for this format is TMATS. By integrating EU Conversion setup and Sensor Calibration into the system setup software, it is possible to include this information in the TMATS file. Since the entire TMATS file can be generated directly from the system setup software, the task of creating a complete TMATS file for use by the data analysis software is greatly simplified. The file can be generated at the same time that the system is programmed to help ensure that the TMATS file matches the actual hardware setup.

The TMATS standard includes support for exporting most of the EU Setup attributes that are discussed in this paper. However, support for unusual input data types and EU functions are limited. The calculated polynomial coefficients and the set of calibration data point pairs can be exported in TMATS as part of the C-Group.

## CONCLUSION

Looking at the current state of system setup software, there are several additional enhancements that could be implemented to improve productivity and reduce duplicate data entry. One improvement would be to add the ability to store custom metadata with each measurement in the system setup software. This would allow the user to attach any information that they need to measurements. A mechanism could also be provided to link this custom information to a standard tag in TMATS or to a vendor specific tag. Alternatively, a future data interchange format such as the TMATS XML standard or the iNET Metadata could be used to transfer settings more reliably between different software applications.

There are many benefits to integrating EU Setup and Sensor Calibration into the system setup software. These features make instrumentation engineers more productive and help to save valuable setup time. They can also help the user to better diagnose problems with the system by displaying data in EU units rather than raw counts. These features also make it easier to make changes and generate TMATS files that contain EU Conversions and Calibration data points for use by other software applications. In conclusion, the integration of more aspects of the system setup into a single software application allows instrumentation engineers to configure a data acquisition system rapidly and efficiently.