MAKING FLIGHT TEST INSTRUMENTATION SETUP EASIER

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ABSTRACT

Modern Flight Test Instrumentation systems are highly customizable and complex. This complexity has steadily increased as data acquisitions systems have grown larger, and more data has been collected on each test flight. While it is desirable for data acquisition systems to be very flexible, that flexibility makes configuring the data acquisition system harder for the end-user. Flight Test Instrumentation systems are also monitoring a larger variety of data source during a typical test flight. Many of these new data sources are digital buses where there are many possible messages that can be sampled. This leads to the desire to reconfigure the data acquisition system more often to accommodate the unique needs of each test flight. These factors contribute to making it more difficult to configure Flight Test Instrumentation systems. While complexity has increased, the flight test industry is facing challenges as experienced engineers retire. Thus, there is a strong need to make Flight Test Instrumentation setup easier. This paper explores how Curtiss-Wright approached this problem and made setting up a Flight Test Instrumentation system easier through improvements in our TTCWare setup software.

INTRODUCTION

Flight Test Instrumentation systems have evolved over the years from very simple systems that collected a few basic analog measurements into complex systems that collect data from many different sources at the same time. To support a wide variety of data sources and provide the end-user with the required flexibility to accomplish their flight test goals, modern Flight Test Instrumentation devices are often highly customizable. The combined complexity of the system and the flexibility of the devices makes system configuration more complicated.

Early systems had limited flexibility, so no setup software was needed. Instead, the desired data acquisition configuration was hard coded into Flight Test Instrumentation system. Over time, the ability to reconfigure the data acquisition system for different behavior was added and this led to the introduction of setup software to manage the configuration. The complexity of the setup software has grown in lock step with the increasing size and feature set of the Flight Test Instrumentation systems.

Another challenge facing the Flight Test industry is the retirement of many experienced Flight Test Engineers. These experienced engineers often have decades of experience and a deep understanding of how their Flight Test Instrumentation system works. Their replacements are often new college graduates who are less familiar with the unique terminology and historical design decisions that are embedded in most Flight Test Instrumentation hardware. This change in the Flight Test Engineering workforce contributes to the need to reduce the complexity of the setup software.

IMPROVING FLIGHT TEST INSTRUMENTATION SETUP SOFTWARE

Over the past few years, the TTCWare team at Curtiss-Wright has spent a considerable amount of time thinking about ways to improve the Flight Test Engineer's productivity by streamlining the configuration and use of our Flight Test Instrumentation systems. Part of this effort has been dedicated to re-evaluating why features work the way they do and considering ways to improve them. We have also endeavored to identify aspects of the system setup that can be automated so that the software ensures that the Flight Test Instrumentation hardware is configured properly.

We have identified five key principles that have guided our efforts to improve our Flight Test Instrumentation setup software. First, we decided to focus on making commonly performed operations easier to do. Second, we saw the need to improve the consistency within the setup software. Our third principle was to focus on the scalability of the software with particular attention paid to large real-world configurations rather than small, idealized test cases. Fourth, we redirected our focus to the actual data acquisition measurements instead of the data acquisition hardware. And finally, the fifth principle was to retain backwards compatibility with existing user projects. By applying these five principles, we have created a new and improved main user interface for TTCWare.

To make common operations easier and to improve the visual consistency of the setup software, we reviewed the setup screens for our most popular products. We identified several issues during this process. Many of the screens had been created over 10 years ago and they often used dated user interface design concepts and were designed around low-resolution monitors. There were also cases where the setup screens did not provide good visibility into the overall setup of the hardware. Instead, the focus was on the setup of a single channel or a single aspect of the configuration at any given time. For example, our original setup screens for thermocouple cards only showed the configuration of one channel at a time. Another example was on our signal conditioner cards where the user was able to set the gain for all of the channels on the card at the same time, but the rest of the setup information was not visible simultaneously. This forced the user to remember the other settings like the filter type and desired cutoff frequency when configuring the gain.

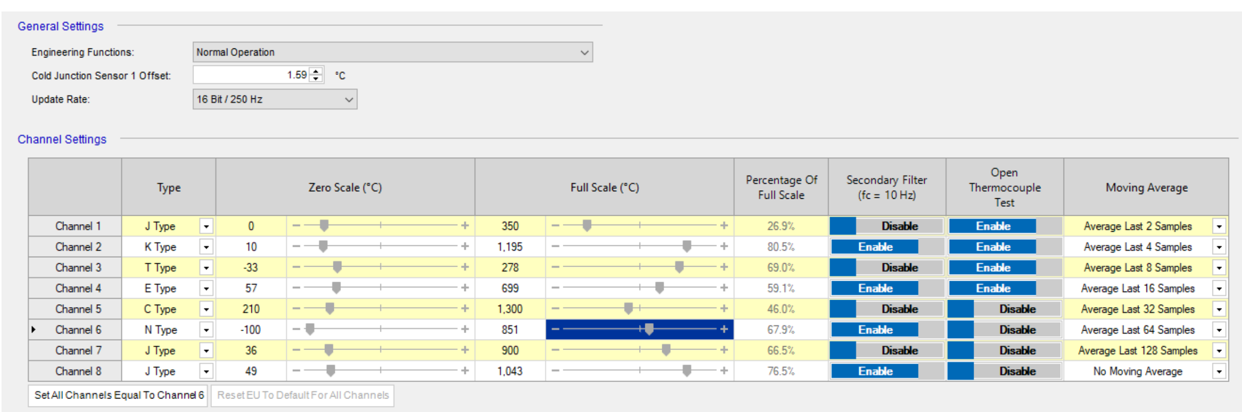


Figure 1 - Revised Thermocouple Card Setup screen (MTCD-208B-1)

To address these issues, we redesigned the setup screens to place the settings into grids. Each grid shows all the channels on the card at the same time and allows easy and consistent access to the settings. The design of these grids is shared between cards so that all screens operate in the same manner. The grids are designed to be keyboard friendly to enable the user to rapidly change settings and move to different cells using the arrow keys or by pressing “Tab” and “Enter”. In many cases, this ability significantly reduces the number of mouse clicks needed to change settings. The design of the grids also allows us to add some features like the ability to copy a channel’s settings to all the other channels on a card as a standard operation.

Switching to a grid view also makes it possible to display helpful metadata to the user. On our signal conditioner cards, this includes the ability to show the name of the parameter that samples each channel and useful information like the channel’s cutoff frequency and filter delay. This information is displayed alongside the actual card settings. This metadata is updated in real-time as the settings are changed so that the Flight Test Engineer can easily see the impact of changing the filter setup on the cutoff frequency and filter delay.

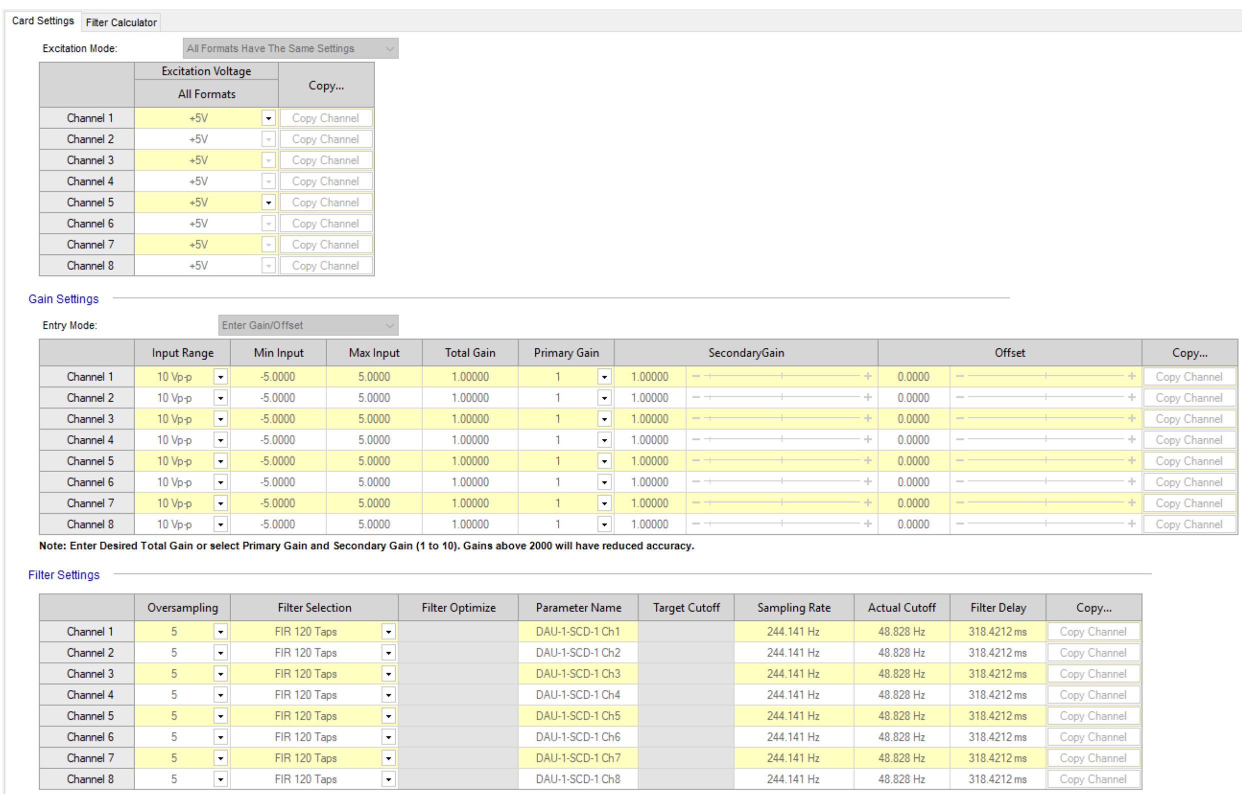


Figure 2 – Revised Signal Conditioning Card Setup screen (MSCD-108D-1)

We also carried this concept of displaying useful metadata about the setup over to the PCM Format Generation screen in TTCWare. We have traditionally shown only basic information about the selected parameter like its sampling rate and periodicity. As part of the effort to make the software easier, we applied the concept of providing useful metadata to the Flight Test Engineer and expanded the area of the screen that showed the sampling rate to also show other useful information about the parameter, such as what channel it samples, the type of filter, the cutoff frequency, and the filter delay.

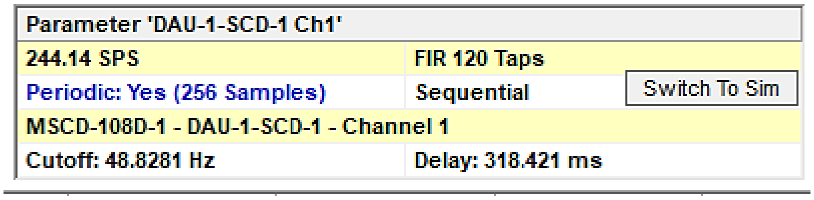
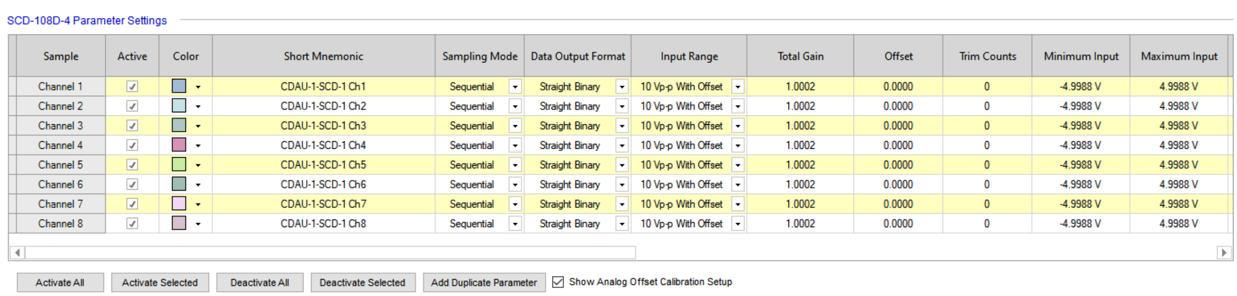


Figure 3 - Format Generation Screen Information Area

In a Flight Test Instrumentation system, the way that parameters work on the data acquisition cards can generally be categorized into two groups. One group of cards has a fixed set of items that can be sampled by the parameters. These are generally cards that acquire analog measurements or provide a fixed set of information like a GPS card. The other group of cards has a variable set of items that can be sampled. Some examples of cards with a variable set of items that can be sampled are digital bus cards like a MIL-STD-1553 or ARINC-429 bus monitor.

We decided to focus our efforts to improve the parameter setup screens in TTCWare on the first group of cards, those with a fixed set of items that can be sampled by parameters. The big advantage that these cards have over the digital bus cards is that the complete set of items that can be sampled is relatively small and it is known in advance. This allowed us to make several useful changes that make configuring the parameters on these cards easier and faster. First, we decided to add a feature to TTCWare that automatically created and named all of the possible parameters when the card is initially added to a system. The parameter names were assigned based on the card's unique name, which the user could change, and the item that was being sampled. For example, channel 4 on a thermocouple card might have a default name of "DAU-1-TCD-1-Ch4" based on the card's name "DAU-1-TCD-1" and the channel's name "Ch4". The Flight Test Engineer might still want to change the default name to something more meaningful in their instrumentation system, but the default name is at least usable. We also recognized that some users might not want to have parameters automatically created so we made it possible to easily turn this feature off.


SCD-108D-4 Parameter Settings

Sample	Active	Color	Short Mnemonic	Sampling Mode	Data Output Format	Input Range	Total Gain	Offset	Trim Counts	Minimum Input	Maximum Input
Channel 1	✓		CDAU-1-SCD-1 Ch1	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 2	✓		CDAU-1-SCD-1 Ch2	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 3	✓		CDAU-1-SCD-1 Ch3	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 4	✓		CDAU-1-SCD-1 Ch4	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 5	✓		CDAU-1-SCD-1 Ch5	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 6	✓		CDAU-1-SCD-1 Ch6	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 7	✓		CDAU-1-SCD-1 Ch7	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V
Channel 8	✓		CDAU-1-SCD-1 Ch8	Sequential	Straight Binary	10 Vp-p With Offset	1.0002	0.0000	0	-4.9988 V	4.9988 V

Activate All | Activate Selected | Deactivate All | Deactivate Selected | Add Duplicate Parameter | ✓ Show Analog Offset Calibration Setup

Figure 4 – Revised Parameter Screen (SCD-108D-4)

The second major change that we made to the parameter setup screens was to apply the same grid design that we used for the card setup screens so that all parameters on a card could be displayed and configured at the same time. This dramatically raises overall awareness of the parameter's configuration while simplifying their setup. It also makes it much easier to spot mistakes such as a parameter that is set to sample the wrong channel number.

As an example of the speed increase that this new approach allows, consider the case where you have a card with eight parameters, and you need to rename all eight of them. Using the original user interface, this would require at least 31 mouse clicks in addition to typing the new parameter names. The interface where all of the parameters are configured in a single grid makes the same operation possible with only three mouse clicks. The user would start changing the parameter names on Channel 1 and use the arrow keys or “Enter” key to move to the next parameter.

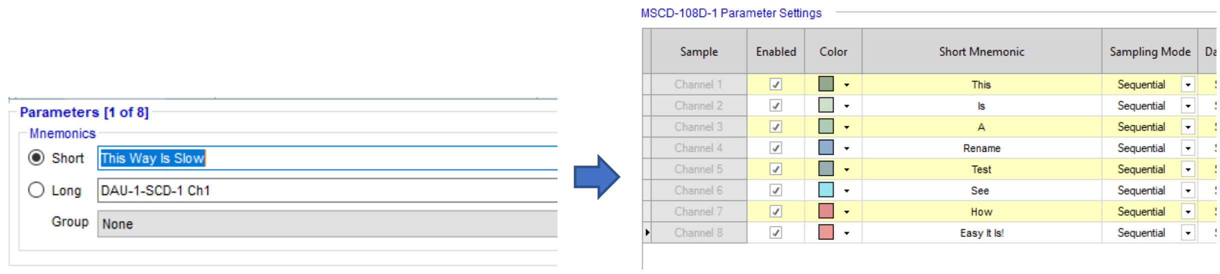


Figure 5 - Renaming All Parameters Example

One of the most important screens in the setup software is the Network Topology screen. This is the screen that is used to manage the devices and cards that are in the Flight Test Instrumentation system. The Flight Test Engineer essentially creates a virtual representation of their physical hardware on this screen. Our previous design for this screen placed all the devices and cards into a single large tree. This is a common approach for displaying Network Topology, but it suffers from scalability problems when the network becomes very large. When the Flight Test Engineer is looking at the cards for a data acquisition unit that has 30 slots, it is possible to lose track of what portion of the network is being configured. It can also be challenging to find a particular card in a large system.

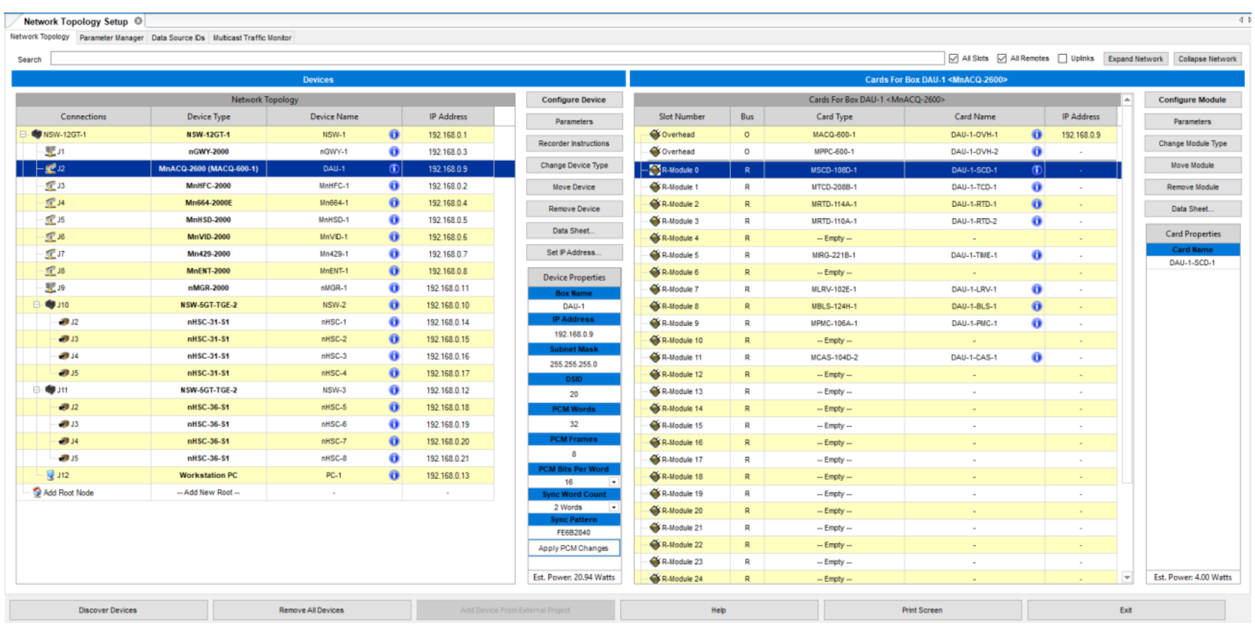


Figure 6 - Two Column Network Topology Screen

To make it easier to navigate large systems, we made several changes to the Network Topology screen in TTCWare. The most significant change was to split the display into two columns. On the left side, we show a tree containing only the DAUs, switches, recorders, and other devices. The devices are organized based on how they are connected. On the right side, we show the cards that are in the selected device. This allows the Flight Test Engineer to easily navigate a large system.

EASY BULK IMPORT AND EXPORT

One of the most challenging and time-consuming aspects of configuring a modern Flight Test Instrumentation system is inputting the large number of digital bus parameters into the setup software. Digital bus monitor cards can collect data for thousands of parameters and configuring them by hand quickly becomes very tedious and error prone. In many cases, the list of messages that need to be collected already exists in an electronic form, so it is valuable to the Flight Test Engineer to be able to directly import the existing electronic list into the setup software either with no or minimal processing.

Over 15 years ago, Curtiss-Wright introduced our XML exporter and importer feature in TTCWare to address this issue. The XML importer allowed Flight Test Engineers to take their bus catalogs and write software to convert them into the XML format that TTCWare understood. This is a powerful capability, but it still requires the Flight Test Engineer to write their own code to manipulate the setup information and this is not always possible. To solve this issue in TTCWare, we have introduced the Excel Wizard. The Excel Wizard allows the setup for different types of digital bus monitor cards to be exported and imported to Excel / CSV files. These files can be easily manipulated with Microsoft® Excel® or similar spreadsheet tools, and they do not require any software development knowledge from the Flight Test Engineer.

One of the key design goals of the Excel Wizard is to support symmetrical export and import operations so that everything that can be exported can also be imported. This makes it easy for Flight Test Engineers to discover how to use the Excel Wizard since they can simply configure a few parameters manually and then export them to an Excel file to see what the format looks like.

CONCLUSION

During Curtiss-Wright's efforts to improve our setup software, we have focused on making our Flight Test Instrumentation system setup faster and easier. By following the five key design principles that are outlined above, we have streamlined common operations in TTCWare so that they are much more efficient and work in a consistent manner throughout the software application. We have also focused our efforts on ensuring that TTCWare scales well to handle large real-world Flight Test Instrumentation systems with many DAUs, hundreds of data acquisition cards, and thousands of parameters. Throughout the effort to make these improvements, we have also focused on maintaining backwards compatibility with the many existing TTCWare projects that have been created over the past 20 years. Together the effect of these improvements is to make the overall setup process more straightforward and simpler, despite the increasing complexity and power of the Flight Test Instrumentation system.