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Example CPP Configuration for a daily zero-span calibration and a multipoint calibration

In air quality monitoring applications, usually a daily zero-span calibration is needed, and periodically a zero-multipoint span calibration is needed. This Tech Note specifically addresses an API SO2 analyzer using an API model 700 calibrator, but the concept can be readily extrapolated to other instruments and calibration schemes.

Lets assume that we wish to conduct a daily zero check and a daily 80% span check. Periodically we wish to conduct a 5 point multipoint span, 20%, 40%, 60%, 80%, and 100%. We will assign our output bits as follows;

Bit 1 = 00% span - zero
Bit 3 = 20% span - span 2
Bit 4 = 40% span - span 3
Bit 5 = 60% span - span 4
Bit 2 = 80% span - span 1
Bit 6 = 100% span - span 5

For subsequent discussions, we have purposely selected output bits that come with an associated relay. However, the bit selection is arbitrary, and if an actual contact closure is not needed then any output bit can be used. Those without actual relays installed in the CPP are referred to as virtual output bits.

CPP Setup
For calibrations the CPP requires that,

1. the instruments be assigned to channels,

2. that digital I/O bits that indicate the presence of a calibration be tied to these instrument channels,

3. something (such as an internal sequence) to set/reset the digital I/O bits as necessary to conduct the desired calibration.

4. initiation of serial commands be tied to the digital I/O bits,

5. generally assign a purge bit to allow instrumentation to equilibrate to ambient conditions before including data values into the collected data base.

Assignment to CPP channels
Following set up techniques described in the CPP manual, section 2.6, assign the SO2 instrument to CPP channel number 2, and the model 700 to CPP channel number 10. The use of channels numbers 2 and 10 are arbitrary and channel assignment is usually determined by all parameters being monitored. The instrumentation has to be initialized into a CPP channel to set up Baud rates, comm ports, and any instrument ID's being used.

Assignment of Digital I/O calibration bits to CPP channels
Section 2.11 of the CPP manual, describes tying the digital I/O bits into CPP channels to indicate calibrations. For clarity we will set up the calibration I/O as indicated below. From the Main Menu select Calibration Set Up. The CPP responds as follows.

Digital Cal Set Up
Number of Spans = 1 **5<cr>**
Digital (D) or Serial (S) = **D<cr>**

Chan # = 2<cr>
Cal on Digital I/O
Outputs (1), Inputs (2), Both (3), Disable (0) = 0 **1<cr>**

Zero on
(1 - 8) . . . . . **Z . . . . . .<cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Zero = 0.000E+0 **<cr>**

Span #1
(1 – 8) . . . . . **. S . . . . . .<cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Span #1 = 0.000E+0 **4.000E+2<cr>**

Span #2
(1 – 8) . . . . . **. . S . . . . . <cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Span #2 = 0.000E+0 **1.000E+2<cr>**

Span #3
(1 – 8) . . . . . **. . . S . . . . <cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Span #3 = 0.000E+0 **2.000E+2<cr>**

Span #4
(1 – 8) . . . . . **. . . . S . . . <cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Span #4 = 0.000E+0 **3.000E+2<cr>**

Span #5
(1 – 8) . . . . . **. . . . . S . . <cr>**
(9-16) . . . . . **<cr>**
(17-24) . . . . . **<cr>**
(25-32) . . . . . **<cr>**
(33-40) . . . . . **<cr>**
Span #5 = 0.000E+0 **5.000E+2<cr>**

Chan # = **<cr>**

The above sets up the CPP digital output bits to indicate the previously defined span concentrations.

Set Up Internal Sequence to Initiate Calibrations
This will consist of two sequencers, one for the daily zero-span checks, and one for the periodic multipoint calibration. Section 2.10 Of the CPP manual provides full detail in setting up the sequencers in the CPP. This section details the setting up of the timing to conduct the calibrations in conjunction with the I/O bits. Assume that a 15 minute period is to be used for all concentrations. The periods do not have to be the same, but is simplifies the discussion. Since they are not being used, not all output bits are presented.

The calibrator sequence in the API calibrator, Seq SO2, should be set up to generate 15 minute concentration gasses as follows.

Calibrator Set Up

Start	0%
15 min later	80%
15 min later	20%
15 min later	40%
15 min later	60%
15 min later	100%

Daily Calibration Sequence

T1 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **1xxxxxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T2 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **01xxxxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T3 Duration 00:00:00 **R<cr>**

At the start time this sequence sets output bit number 1. In the serial command set up section this bit transition sends a command to the calibrator to start seq SO2, which initially generates zero air. The Boolean sets bit 21 is set up to send a command to the analyzer to close the zero solenoid. Closing the instruments zero solenoid directs the calibration gasses to the instrument. Fifteen minutes later when bit number 1 goes false, the CPP captures the zero value, and bit number 2 is set true. Fifteen minutes later when bit number 2 goes false, the CPP captures the span #1 value. Since both bits #1 and #2 are not set, bit #21 resets which instructs the CPP to send a command to the instrument to open the zero solenoid, which redirects sample gasses into the instrument.

Multipoint Calibration Sequence

T1 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **1xxxxxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T2 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **x1xxxxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T3 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **xx1xxxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T4 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **xxx1xxxx<cr>**
(9-16) xxxxxxxx **<cr>**
T5 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **xxxx1xxx<cr>**
(9-16) xxxxxxxx **<cr>**
T5 Duration 00:00:00 **001500<cr>**
(1 – 8) xxxxxxxx **xxxxx1xx<cr>**
(9-16) xxxxxxxx **<cr>**
T6 Duration 00:00:00 **R<cr>**

At the start time this sequence sets output bit number 1. This sends a command to the calibrator to generate zero air. The Boolean sets bit 21 is set up to send a command to the analyzer to close the zero solenoid. Fifteen minutes later when bit number 1 goes false, the CPP captures the zero value, and bit #2 is set true. Fifteen minutes later, when bit number 2 goes false, the CPP captures the span #1 value, and bit #3 is set true. Referencing the Boolean set up below, anytime bits number 1, 2, 3, 4, 5, or 6 are

true bit #21 remains set. The initial setting of bit #21 sends the serial command to the instrument to close the zero input solenoid.

The sequence sequentially closes bits number 1, 2, 3, 4, 5, and 5 for fifteen minutes each. This is synchronized with the fifteen minutes gas concentrations being generated by the calibrator.

Serial Calibration Setup

This section ties the CPP digital I/O bits into a routine that will send serial commands to connected instruments and calibrators to conduct a calibration. The actual calibration set up can take on various appearances depending on how the system is physically plumbed. Figure 1 below depicts the arrangement for inputting Sample, Zero, and Span gasses to an API instrument. When using a calibrator it is quite common to introduce all calibration gasses over only one of the ports offered, e.g., the zero air input. This is depicted in figure 2, and is the configuration discussed in this Tech Note.

Figure 1
Figure 2

We need to keep the zero solenoid in the analyzer closed during the entire calibration sequence. As is usual this can be done in several ways. One would be to set the solenoid on the rising (true) transition of digital output bit #1 (Zero), and open the solenoid on the falling (false) transition of digital output bit number 2 (Span #1). Another would be to use the Boolean function in the CPP to provide this needed control. Yet another would be to set this control bit in the sequencer set up, when it needed to be set and reset.

Although using the Boolean to provide this control requires the use of another output bit, it does offer an advantage over just using output bits 1, and 2. If a calibration were aborted before bit #2 was set, then the zero solenoid would remain closed until the next calibration was conducted and completed, because bit #2 would never have a falling transition. Using the Boolean functions eliminates this condition.

So, from the Main Menu, we set up a Boolean function as follows.

If O01+O02+O03+O04+O05+O06<cr>
Ten Set O21<cr>

This Boolean statement says that anytime any of our calibration bits are set, the output bit number 21 is set. Bit 21 will set as soon as any of the calibration bits are set, and will reset when none of the calibration bits are set. We now set up our serial commands as follows.

Bit 21 True

Digital (D), Serial (S) = S<cr>

Bit # (xxT-F,C) = 21T<cr>
Cmd #1
Chan # = 00 = 2<cr>
API 100A SO2
01 = Str Zero
02 = Stp Zerp
03 = Set Zero
04 = Str Span
05 = Stp Span
06 = Set Span
Selection = 00 = 1<cr>

Cmd #2
Chan # = 00 = <cr>

Bit 21 False

Bit # (xxT-F,C) = 21F<cr>
Cmd #1
Chan # = 00 = 2<cr>
API 100A SO2
01 = Str Zero
02 = Stp Zerp
03 = Set Zero
04 = Str Span
05 = Stp Span
06 = Set Span
Selection = 00 = 2<cr>

Cmd #2
Chan # = 00 = 10
API Model 700
01 = Seq Zero
02 = Seq SO2
03 = Seq Nox
04 = Seq CO
05 = Seq O3
06 = Seq HC
07 = Seq GPT
08 = Seq SPC01
09 = Seq SPC02
10 = Standby
Selection = 00 = 10<cr>

Bit 01 True

Bit # (xxT-F,C) = 01T
Cmd #1

Chan =00 = 10
API Model 700
01 = Seq Zero
02 = Seq SO2
03 = Seq Nox
04 = Seq CO
05 = Seq O3
06 = Seq HC
07 = Seq GPT
08 = Seq SPC01
09 = Seq SPC02
10 = Standby
Selection = 00 = 01<cr>

Bit 02 True

Bit # (xxT-F,C) = 02T
Cmd #1
Chan =00 = 10
API Model 700
01 = Seq Zero
02 = Seq SO2
03 = Seq Nox
04 = Seq CO
05 = Seq O3
06 = Seq HC
07 = Seq GPT
08 = Seq SPC01
09 = Seq SPC02
10 = Standby
Selection = 00 = 02<cr>

To review the above, when output bit #1 is set, the calibration sequence is started. Output bit number 1 going True sends a serial command to the calibrator to start generating zero air. Bit #1 being set results in bit #21 being set by the Boolean. The True transition of bit 21 sends a command to the calibrator to start generating a zero air. Thus we will have zero air introduced into the analyzer.