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SDI-AM

4 Channel Analog Input Module

Operating Manual

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Chapter 1 OPERATION

1.1 GENERAL DESCRIPTION

Forest Technology Systems' SDI-AM is an expansion module designed to provide general purpose analog inputs using the SDI-12 interface[1]. Electrical connections on the SDI-AM front panel are provided through spring clamp terminal strips for easy connection to legacy analog sensors (see Figure 1 below). I/O available on the SDI-AM includes: the main SDI-12 connector cable; four individually configurable analog input channels; two individually switched 12 V power supply outputs; two individually configurable, stable, excitation voltage outputs; and a general purpose counter input. The SDI-AM electronics are potted in a rugged plastic case to provide a compact and waterproof I/O solution. The case may be mounted to a standard keyway board using keyway studs attached on the back of the case. Alternatively, the case may be attached to any suitable object using the four mounting holes in the corners.

Figure 1-1: SDI-AM Four Channel Analog Input Module

[1] SDI-12 is a serial-digital interface standard for microprocessor based sensors (refer to http://www.sdi-12.org for more information on the SDI-12 standard).

1.2 OPERATION

The SDI-AM module is an SDI-12 device and as such has a configurable SDI address and is powered by +12 Vdc from the SDI-12 bus. Normally the module's SDI connector is connected directly to the SDI port of an FTS data logger; however, the sensor may be connected to any SDI-12 compliant controller. The SDI-AM module is configurable using SDI-12 commands. Depending on the SDI 12 command sent to the module, the module can provide several different data measurements. Command details for the module are detailed in the "Commands" section of this manual.

1.3 CONNECTION

The main connection to the SDI controller is made using the module's pigtail connector. All sensor connections to the SDI-AM are made through the module's front panel spring clamp terminal strips.

1.3.1 *SDI CONNECTOR*

The SDI-AM module's SDI connector is an environmentally sealed, bayonet mount, keyed, military style connector. This connector is waterproof even without a mating connector attached. Electrical signal connections for the SDI-12 connection are shown in Table 1 below.

Pin	Function	Wire Colour
A	+12 Vdc	Red
B	Data	White
C	Ground	Black

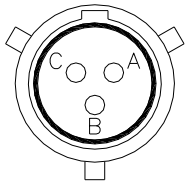

Table 1: SDI Port Signal Connections

1.3.2 *Analog Inputs*

There are four analog input channels on the SDI-AM module (Analog 1, Analog 2, Analog 3 and Analog 4). Each analog channel operates independently and can be configured as a single-ended input, a differential input, a 4 to 20 mA current loop input, or the channel can be disabled. Six input voltage ranges are available to choose from when a channel is configured as a single-ended or differential input (0 to 25 mV full scale is the lowest range and 0 to 5V full scale is the largest range). Table 2 below shows the analog signal connections for each mode. Refer to the COMMANDS section of this manual for analog channel configuration details.

Mode	Connection Points
disabled	n/a
single-ended	**V+** to **GND**
differential	**V+** to **V-** [(1)]
4 to 20 mA	**4 - 20 mA** to **GND**

[(1)] **note:** in differential mode both inputs (V+ and V-) must be referenced to ground and

Table 2: Analog Channel Signal Connections

1.3.3 *Excitation Outputs*

There are two excitation outputs (EX 1 and EX 2) on the SDI-AM module. The outputs operate independently from one another and each output can be programmed from 0 to 5 Volts. In addition, the excitation outputs can be configured to be disabled, always turned on, or only turned on for a number of seconds prior to an analog input measurement. Refer to the COMMANDS section of this manual for excitation output configuration details.

1.3.4 *Power Outputs*

There are two power outputs (POWER 1 and POWER 2) on the SDI-AM module which can supply a combined total of 520 mA at the SDI bus voltage (nominally 12V). Like the excitation outputs, the power outputs operate independently from one another and can be configured to be disabled, always turned on, or only turned on for a number of seconds prior to an analog input measurement. In addition, the power outputs can be programmed to cycle the power (i.e. off for 10 seconds, on for 2 seconds, off for 10 s, on for 2 s, etc., etc.). Refer to the COMMANDS section of this manual for power output configuration details.

1.3.5 *Counter Output*

There is one counter input (COUNTER) available on the SDI-AM module. The counter input is used to count contact closures (note: there is a 10 kΩ pull-up resistor internal to the SDI-AM module from the COUNT input to +3.3 Vdc). The counter input provides a running count, a period count, and a counter input state to the user. Refer to the COMMANDS section of this manual for counter input configuration details.

1.4 CONFIGURATION

The SDI-AM interface module is shipped with default address 0 (unless shipped as part of an integrated FTS system). Refer to the COMMANDS section of this manual for instructions on changing SDI-AM module settings.

1.5 CALIBRATION & MAINTENANCE

The SDI-AM interface module should not require recalibration; however, if anomalous readings are observed, the module should be checked and returned to the factory for recalibration if necessary.

Field maintenance required by the SDI-AM module is limited to a periodic check of the sensor cable and connectors for deterioration.

Please contact FTS technical support for information on return of the module for calibration or if the unit ceases to operate properly (refer to the inside cover page for contact information).

Chapter 2 COMMANDS

Commands implemented in the SDI-AM interface module conform to SDI-12 version 1.3. Commands can be broken into four categories: SDI general commands, SDI configuration commands, SDI data commands, and SDI factory commands. SDI-12 commands are sent from the datalogger or a controller using the appropriate software.

> NOTE: FTS touchscreen series Dataloggers have a built-in SDI-AM configuration graphical user interface which eliminates the need for low-level command programming (refer to the appropriate FTS Datalogger manual for more information).

2.1 SDI GENERAL COMMANDS

The SDI General Commands are used for housekeeping issues such as device address configuration, device identification and confirmation of device communications. General SDI-12 version 1.3 commands are as follows.

2.1.1 *Address Query*

?! This command is used to determine the address of the SDI sensor.

Example: ?!
Response: 0 : the sensor is configured for address 0

> NOTE: only one SDI device can be connected to the bus when using this command

2.1.2 *Acknowledge Active*

a! This command is used to determine that a sensor is present on the SDI bus at the specified address (a).

Example: 0!
Response: 0 : the sensor is present at address 0

2.1.3 *Change Address*

aAb! This command is used to change a sensor's SDI address from *a* to *b*.

Example: 0A3! : change the sensor SDI address from 0 to 3
Response: 3

2.1.4 ***Send Identification***

aI! This command is used to identify the specifics of the addressed sensor.

Example: 3I!
Response: 313FTS-----SDI-AM4—032729

The format is as follows:

3:	sensor SDI address is 3
13:	compatible with SDI-12 version 1.3
FTS:	manufacturer's identifier
SDI-AM:	sensor model
4:	version 4 of sensor firmware
032729:	sensor serial number

2.2 SDI CONFIGURATION COMMANDS

The SDI Configuration Commands are for configuring the SDI-AM module for operation with the connected sensors and follow the protocol for Extended SDI commands.

There are four parts of the command and each part must be separated by a space, a colon, or a slash ('/').The general form of a configuration command and its requisite parts are as follows:

aX cmd option data!

Part 1: address and extended command identifier
- **a** SDI address of unit
- **X** SDI extended command (mandatory - must be uppercase)

Part 2: the command. There are two commands**:**
- **se** set
- **g** get

Part 3: the option:
< option details are outlined with the each specific command >

Part 4: data and command delimiter:
< data details are outlined with the each specific command >

! SDI command delimiter

2.2.1 *Factory Default Settings*

This command is used to set the SDI-AM module to its factory default configuration.

option:
fds Analog Channel 1 input

data: < not used >

Example:
aX se fds! : set the module's configuration to the factory default settings

SDI-AM factory default settings are:

Channel 1:	single ended input, 5 V full scale
Channel 2:	disabled
Channel 3:	disabled
Channel 4:	disabled
Power 1:	disabled
Power 2:	disabled
Excitation 1:	disabled, output voltage set to 0.0 V
Excitation 2:	disabled, output voltage set to 0.0 V

SDI address remains unchanged
Analog module calibration remains unchanged

2.2.2 *Analog Input Configuration*

The following command options are used to configure the SDI-AM module's four analog inputs. Note that each analog input can be individually configured and that an input must be enabled before its range can be set.

option:

a1	Analog Channel 1 input
a2	Analog Channel 2 input
a3	Analog Channel 3 input
a4	Analog Channel 4 input

data:

Analog input type selection

o	off, disabled
s	enabled as single ended input
d	enabled as differential input
i	enabled as 4 to 20 mA current input

Range selection for single ended or differential inputs

25	25 mV full scale
55	55 mV full scale
100	100 mV full scale
1	1 V full scale
2.5	2.5 V full scale
5	5 V full scale

Examples:

aX se a1 s,55!	set analog input 1 to single ended and 55mV full scale range
aX se a1 d!	set analog input 1 to differential and leave the range unchanged
aX se a1 2.5!	set analog input 1 range to 2.5V and leave the input type unchanged
aX se a1 o!	disable analog input 1

2.2.3 ***Excitation Output Configuration***

The following command options are used to configure the SDI-AM module's two excitation outputs (EX 1 and EX 2). Each excitation output can be individually configured and each excitation voltage can be slaved to one or more of the analog input channels. Note that that an output must be enabled before it can be configured.

option:

ext1 Excitation Output 1 timing configuration
ext2 Excitation Output 2 timing configuration

exv1 Excitation Output 1 voltage level
exv2 Excitation Output 2 voltage level

data:

Excitation output timing selection

d disabled – always off

e enabled – always on

is time in seconds. The excitation output will be turned on this many seconds before any analog input measurement is made. The excitation output will be turned off once all measurements are complete. This time is added to the time needed to process all analog input measurements.

ax,# ax is the specific channel (a1, a2,a3, or a4) and # is time in seconds. The excitation output will be turned on this many seconds before a measurement is made on the specified channel. If more than one analog channel is specified for an excitation output and the channels are measured simultaneously using the M or M0 command, then the longest of the specified turn-on times will be used. The excitation output will be turned off once the specified channel measurements are complete. The turn-on time is added to the time needed to process the analog input measurement.

Excitation Output voltage setting

V.vvv V.vvv is the desired output voltage in Volts. This value takes effect immediately if the matching excitation output is permanently enabled, or on the next analog measurement if the excitation is tied to the conversions. The valid range is 0.000 to 5.000 Volts. Negative values will set the output to 0 V, values greater than 5 V will set the output to 5 V.

Excitation Output Configuration Examples:

aX g ext1! Get the current timing for excitation output 1

aX se ext1 e! Enable excitation output 1 to be always turned on. Note that this could significantly increase the power consumption of the unit. The excitation voltage level will be that set by the most recent exv1 command.

aX se ext2 d! Disable excitation output 2. It will never turn on.

aX se ext1 5! Excitation output 1 is automatically turned on 5 seconds before any analog input measurements start. Excitation output 1 will be turned off once all analog channel measurements are complete. The voltage level will be that set by the most recent exv1 command.

aX g exv1! Get the current voltage setting for excitation output 1.

aX se exv2 4.65! Set the output voltage for excitation output 2 to be 4.650 V.

aX se ext1 a1,5;a2,8;a4,2!

Excitation output 1 is automatically turned on:

- 5 seconds before any measurement is made for Analog Channel 1;
- 8 seconds before any measurement is made for Analog Channel 2;
- 2 seconds before any measurement is made for Analog Channel 4.

Excitation output 1 will be turned off once all analog channel measurements are complete. The voltage level will be that set by the most recent exv1 command.

If only analog channel 1 is read (M4 or C4 command) then Excitation 1 will be turned on for 5 seconds and then Analog 1 will be measured.

If only analog channel 2 is read (M5 or C5 command) then Excitation 1 will be turned on for 8 seconds and then Analog 2 will be measured.

If only analog channel 4 is read (M7 or C7 command) then Excitation 1 will be turned on for 2 seconds and then Analog 4 will be measured.

If all analog inputs are read (M or C command) then Excitation 1 will be turned on for 8 seconds and then analog inputs will be measured.

2.2.4 ***Switched Power Output Configuration***

The following command options are used to configure the SDI-AM module's two 12V power supply outputs (POWER 1 and POWER 2). Note that each output can be individually configured and that an output must be enabled before it can be configured. POWER 1 and POWER 2 simply switch the SDI bus voltage. The voltage switch from each output is not regulated. Each supply is individually capable of sourcing 500 mA; however, the combined current simultaneously sourced from both supplies cannot exceed 500 mA.

option:

p1 Power Output 1
p2 Power Output 2

data:

Power output timing selection

e enabled – always on, this setting is retained in the SDI-AM modules non-volatile memory (eeprom).

p force power on – operates the same as the **e** option except that this command will not be retained in the SDI-AM module if power cycled. Use this option (**p**) instead of the **e** option if the datalogger is controlling the switched power directly (i.e. through an X command such as: aX se p1 p) to prevent overuse of the SDI-AM module's non-volatile memory.

d disabled – always off, this setting is retained in the SDI-AM modules non-volatile memory (eeprom).

m force power off – operates the same as the **d** option except that this command will not be retained in the SDI-AM module if power cycled. Use this option (**m**) instead of the **d** option if the datalogger is controlling the switched power directly (i.e. through an X command such as: aX se p1 m) to prevent overuse of the SDI-AM module's non-volatile memory.

b,# # is time in seconds. The power output will turn on this many seconds before any analog input measurement is made. The # of seconds must be supplied with the command. The power output will be turned off once all analog measurements are complete. This time is added to the time needed to process all analog input measurements.

ax,# ax is the specific channel (a1, a2,a3, or a4) and # is time in seconds. The power output will be turned on this many seconds before a measurement is made on the specified channel. If more than one analog channel is specified for a power output and the channels are measured simultaneously using the M or M0 command, then the longest of the specified turn-on times will be used. The power output will be turned off once the specified channel measurements are complete. The turn-on time is added to the time needed to process the analog input measurement.

c,t_{ON}, t_P The power output is cycled (turned on periodically). Values for the on time (t_{ON}) and period (t_P) are in seconds and must be supplied with this command. Timing is not tied to the analog channel measurements.

Switched Power Output Configuration Examples:

aX g p1! Get the current settings for power output 1

aX se p1 d! Power output 1 is always disabled (turned off)

aX se p1 e! Power output 1 is always enabled (turned on)

aX se p2 m! Power output 2 is forced off (overrides other SDI-AM module settings).

aX se p2 p! Power output 2 is forced on (overrides other SDI-AM module settings).

aX se p1 b,12! Set power output 1 to turn on 12 seconds before any analog measurements start. Power output 1 will turn off when all analog channels are measured.

aX se p1 c,12,60! Set power output 1 to turn on for 12 seconds every 60 seconds. The first turn-on will occur at 60-12=48 seconds after this command is received. If the unit is power cycled, the same delay applies. If the supply was on when this command was received, it will be turned off and the new cycle started.

aX se p1 a1,5;a2,8;a4,2!

Power output 1 is automatically turned on:

- 5 seconds before any measurement is made for Analog Channel 1;
- 8 seconds before any measurement is made for Analog Channel 2;
- 2 seconds before any measurement is made for Analog Channel 4.

Power output 1 will be turned off once all analog channel measurements are complete.

If only analog channel 1 is read (M4 or C4 command) then Power 1 will be turned on for 5 seconds and then Analog 1 will be measured.

If only analog channel 2 is read (M5 or C5 command) then Power 1 will be turned on for 8 seconds and then Analog 2 will be measured.

If only analog channel 4 is read (M7 or C7 command) then Power 1 will be turned on for 2 seconds and then Analog 4 will be measured.

If all analog inputs are read (M or C command) then Power 1 will be turned on for 8 seconds and then analog inputs will be measured.

2.2.5 *Counter Configuration*

The following command option is used to configure the SDI-AM module's counter input (COUNTER). Use the data commands (M, C, or R) to access the module's period counter function.

option:

count Running counter value (valid range is 0 to 9,999,999)

Examples:

aX g count! Get the current running count value

aX se count 23! Set the current running count value to 23

2.3 SDI DATA COMMANDS

The SDI Data Commands are used to retrieve data from the SDI-AM module. SDI Data commands for the module are shown below.

2.3.1 *Start Measurement Command*

aM#! in which # = {0,1,2..9}

This command is used trigger a measurement on the addressed sensor. The sensor will not return data, instead the sensor will return the duration of the measurement (in seconds) as well as the number of data points returned by the measurement. The data is read using a subsequent Read Data command. Refer to Tables 3 and 4 for the specifics of the data returned from the SDI-AM module.

Example 1:

Command	3M!	: start an M measurement for module address 3
Response:	30018	: the sensor returns its SDI address (3), the measurement duration in seconds (1), and the number of data points (8) generated by the measurement

Example 2:

Command	3M2!	: start an M2 measurement
Response:	30003	: the sensor returns its SDI address (3), the measurement duration in seconds (0), and the number of data points (3) generated by the measurement

2.3.2 *Start Concurrent Measurement Command*

aC#! *in which # = {0,1,2..9}*

The concurrent measurement command allows a sensor to take a measurement while other SDI sensors are also taking measurements. The Start Concurrent Measurement Command operates in the same manner and returns the same information as the Start Measurement command.

2.3.3 *Continuous Measurement Command*

aR#! *in which # = {0,1,2..9}*

The Continuous Measurement command immediately returns the requested data (a subsequent Read Data command is not required nor is a preceding M command). Only commands capable of immediately returning the requested data are supported. The format of the data returned by an R command is similar to that of D commands; however, each R command is independent. For instance an R2 command does not need to be preceded by R1 and R0 commands.

2.3.4 *Cyclic Redundancy Check Request*

A Cyclic Redundancy Check Request (CRC) can be added to any of the previous M, C, or R commands by appending a C to the command (i.e. aMC! instead of aM! or aRC2! instead of aR2!). Requesting a CRC will cause the module to append a CRC code to the data returned by a D or R command.

SDI-AM Module Command and Data Details

Command	Command Number and Example		Number of Returned Data Points and Data Point Details	
Analog Inputs (ANALOG 1 to ANALOG 4)				
M or C (CRC optional)	blank or 0	aM!	8	**Analog Input Measurements (CHx):** CH1 value, CH1 status, CH2 value, CH2 status, CH3 value, CH3 status, CH4 value, CH4 status
M or C (CRC optional)	4	aM4!	2	**Analog Input 1 Measurement only:** CH1 value, CH1 status
M or C (CRC optional)	5	aM5!	2	**Analog Input 2 Measurement only:** CH2 value, CH2 status
M or C (CRC optional)	6	aM6!	2	**Analog Input 3 Measurement only:** CH3 value, CH3 status
M or C (CRC optional)	7	aM7!	2	**Analog Input 4 Measurement only:** CH4 value, CH4 status
Counter Input				
M, C, or R (CRC optional)	1	aM1!	3	Running Count, Period Count, Counter Input state **Period Count is unaffected** by this command.
M, C, or R (CRC optional)	2	aM2!	3	Running Count, Period Count, Counter Input state **Period Count is reset to zero** by this command.
M, C, or R (CRC optional)	3	aM3!	1	Counter Input State

Table 3: SDI-AM Module Command and Data Details

Description of Measured Data Points

Data Point	Resolution	Description
CHx Value	range dependent	Analog input x's reading in mV or mA depending on the input configuration. The number of decimal places in the reading varies with the measured value to allow maximum resolution on the 25 mV range.
CHx Status	integer value	Analog input x's reading status 0 = valid measurement xx 1 = channel is disabled 2 = over range error 3 = A/D converter error (zero returned as measured value)
Running Count	integer value	The current value of the running counter. Running Count has a range of 0 to 9,999,999 and then rolls back to 0.
Period Count	integer value	The current value of the period counter. Period Count has a range of 0 to 9,999,999 and then rolls back to 0.
Counter Input State	integer value	0 = input is closed 1 = input is open

Table 4: Description of Measured Data Points

2.3.5 ***Send Data Command***

aD#! *in which # = {0,1..9}*

This command reads data generated by the preceding Measurement (M or C) command. An **aD0!** command is always the first command sent to read the data. If additional data needs to be read, then an **aD1!** command is sent, then and **aD2!** etc. etc., up to **aD9!** (see the example below).

Example:

Command	3M!	: start an M measurement
Response:	30018	: the sensor returns its SDI address (3), the measurement duration in seconds (001), and the number of data points (8) generated by the measurement

Followed by: : read the data from the M command
Command: 3D0!
Response: 3+709.315+0+459.4809+0+684.4509+0

The module response format is as follows:

3:	sensor SDI address
709.315:	Analog Input 1 value
0:	Analog Input 1 status - valid
459.4809:	Analog Input 2 value
0:	Analog Input 2 status - valid
684.4509:	Analog Input 3 value
0:	Analog Input 3 status - valid

Followed by: : read the data from the M command
Command: 3D1!
Response: +459.9899+0

The module response format is as follows:

459.9899:	Analog Input 4 value
0:	Analog Input 4 status – valid

2.4 SDI FACTORY COMMANDS

The SDI Factory Commands are for SDI-AM module housekeeping. They follow the protocol for SDI Extended commands as shown in the previous SDI Configuration Commands section.

Factory SDI-12 commands for the module are shown below.

2.4.1 *Serial Number*

This command is used to read the SDI-AM module's factory issued serial number (~fsn~). The number reported is the same as that shown on label on the SDI-AM module.

Example:

Command	**3X g ~fsn~!**	: reads the module's serial number
Response:	354345	: the sensor returns its SDI address and its serial number (54345)

2.4.2 *Date of Manufacture*

This command is used to read the SDI-AM module's manufacture date (~dom~).

Example:

Command	**3X g ~dom~!**	: reads the SDI-AM manufacture date
Response:	32008081416	: the sensor returns its SDI address (3) and its manufacture date in year, month, day, hour format (Aug. 14, 2008 @ 16:00)

2.4.3 *Bootloader Version*

This command is used to read the SDI-AM module's low-level bootloader version (bv). Note that the bootloader version is different than the module's firmware version reported by the "Send Identification" command.

Example:

Command	**3X g bv!**	: reads the low-level bootloader version
Response:	3 3	: the sensor returns its SDI address (3) and its bootloader version (3)

2.4.4 *PCB Version*

This command is used to read the SDI-AM module's printed circuit board (pcb) hardware version. This command returns the hardware revision version to allow the SDI-AM's firmware to determine what circuitry is present. The command does not return the actual pcb revision number (the number shown on the pcb silkscreen). For example, the pcb could be a revision 3 circuit board but the circuitry on the pcb may only be hardware version 2. In this case this command would return 2 as the hardware version.

Example:

Command	**3X g pcb!**	: reads the SDI-AM hardware version
Response:	3 2	: the sensor returns its SDI address (3) and its hardware version (2)

Chapter 3 SPECIFICATIONS

3.1 GENERAL

Power Supply Voltage Range	12 Vdc nominal (range: 9.6 to 18.6 Vdc)
Standby Current Consumption	Less than 1 mA
SDI-12 Compatibility	Version 1.3
Environmental	Operating temperature: -40 °C to +60 °C Operating humidity: 0% to 100%
Physical	Shape: 17 cm x 10cm x 2 cm Weight: 0.35 kg

3.2 ELECTRICAL

All inputs and outputs are transient protected.

3.2.1 *Power Outputs*

Voltage Output	SDI supply voltage (12 Vdc nominal), current limited and short circuit protected
Current Output	520 mA maximum [(1)]

[(1)] note: combined current of both outputs

3.2.2 *Excitation Outputs*

Voltage Output	0 to 5 Vdc, current limited and short circuit protected [(2)]
Current Output	20 mA maximum
Accuracy	± 5 mV (0.1% of full scale)
Resolution	0.35 mV

[(2)] note: short circuit current varies with supply voltage (about 20 mA at 9.6 V supply and 73 mA at 16 V supply)

3.2.3 *Analog Outputs*

Maximum Input Voltage	5 Vdc, all ranges
Operating Input Voltage	
Single-ended mode	0V to full scale value of range
Differential mode	
Differential Voltage	± full scale value of range
Common Mode Voltage plus Signal with respect to ground	25 mV, 55 mV, 100 mV ranges: -0.15 V to +0.95 V 1 V, 2.5 V, and 5 V ranges: -1.5 V to +5 V
Current Sense	Resistor, 100 ohms to ground, 0.1% accuracy
Converter Resolution	24 bits
SDI Resolution	25 mV and 55 mV ranges: 10 nV 100 mV range: 100 nV 1 V, 2.5 V, and 5 V ranges: 1 uV
Accuracy	5 V range: ± 1.5 mV (0.03% of fs) 2.5 V range: ± 0.75 mV (0.03% of fs) 1 V range: ± 0.3 mV (0.03% of fs) 100 mV range: ± 0.1 mV (0.1% of fs) 55 mV range: ± 0.055 mV (0.1% of fs) 25 mV range: ± 0.0375 mV (0.15% fs)

3.2.4 *Counter Input*

Maximum Input Frequency	1 kHz (at 50% duty cycle)
Minimum Closure Time	700 microseconds, internally debounced
Counter Range	0 to 9 999 999 with automatic rollover
Pull-up Resistor	10 kΩ (to +3.3Vdc nominal)

DOCUMENT REVISION HISTORY

Revision	Date	Description
1	Jan. 7, 2009	Original issue
2	Dec. 7, 2009	Added individual channel measurement commands. Applies to SDI-AM firmware version 6 or later.
2.1	Jan. 6, 2010	Correct Switched Power Output Example
2.2	Aug. 17, 2010	Correct Power Supply Voltage Range Upper Limit
2.3	Sep. 21, 2010	Correct power output current limit Correct excitation outputs resolution Correct accuracy specs for analog inputs
3	Aug. 5, 2011	Updated CHx Status description Applies to SDI-AM firmware version 9 or later.
4	Jan 18, 2012	Updated with new enclosure
5	Apr 14, 2016	New format. Minor editorial corrections