User's Guide

Standard Automation Interface

Version 2.0.00

METTLER TOLEDO

Contents

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1 Introduction

This manual is one of several available that explains the Standard Automation Interface (SAI). Each manual covers SAI in a slightly different way explained in the chart below. The SAI manuals needed for use with your device can be found on the downloads page of your SAI device at www.mt.com

SAI Manual	File Name (xx = Revision)	Uses for Manual
Standard Automation Interface User's Guide [this manual]	30588288_xx_MAN_UG_SAI_EN.pdf	Explains SAI in detail in a general sense. Does not include information specific to your SAI device.
Standard Automation Interface Reference Guide – Transmitters & Terminals	30587511_xx_MAN_REF_SAI-Transmitters_EN.pdf	Explains the status information and commands supported by specific terminals and transmitters. Can be used as a reference by a programmer.
Standard Automation Interface Reference Guide – APW	305787512_xx_MAN_REF_SAI-APW_EN.pdf	Explains the status information and commands supported by specific APW high precision weight sensors. Can be used as a reference by a programmer.

2 General Overview

The Standard Automation Interface (SAI) is a protocol designed to exchange data between METTLER TOLEDO devices and automation systems. The goals of this standard are to provide:

1. A common data layout for load cells, terminals, and other devices regardless of the physical interface or automation network used.
2. A protocol that is optimized for machine-to-machine communication along with meaningful condition monitoring.
3. A protocol covering sensors with a capacity of 10g up to scales in the thousands of kilograms.
4. A single protocol for the convenience of automation integrators, control system programmers, and our automation customers
5. A tiered approach to create a flexible protocol for diverse devices.

In this document, we will refer to the METTLER TOLEDO product using SAI to communicate as "the device". The "controller", or "control system" will be used to designate an automation system such as a Programmable Automation Controller (PAC), a Programmable Logic Controller (PLC), a Distributed Control System (DCS) or an Industrial PC (IPC).

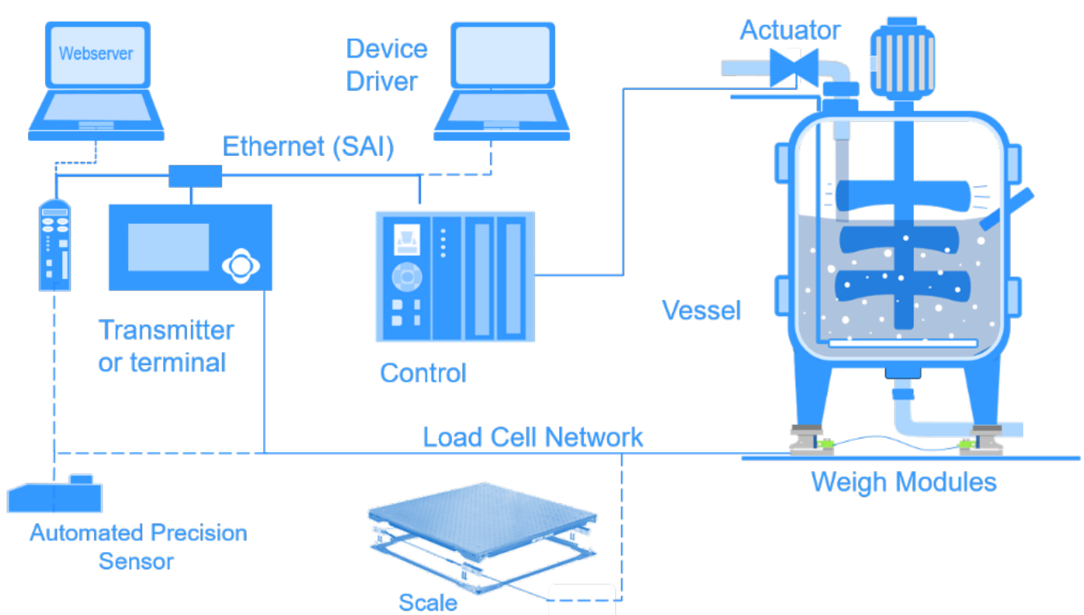

Figure 2-1: Overview of a Control System

2.1. Introduction

The SAI protocol is intended for use with weighing devices connected to control systems. The primary weight data is based on 32-bit floating point; allowing our users to use their same program no matter which sensor, transmitter, terminal, scale or software they select. SAI provides Condition Monitoring, called “status” in each cyclic message. Even though SAI is a standard, METTTLER TOLEDO products have more or less features depending on their level of performance. These features are described in each sensor's individual documentation.

Products using the SAI protocol, when configured, will immediately begin transmitting rounded gross weight as a floating-point value. Byte order called Endianness is automatically set for PROFIBUS, PROFINET and EtherNet/IP. For other controller types, there is an automatic order detection feature built-in. This eliminates the necessity to perform byte swapping in the controller.

This manual contains specific information about how SAI is constructed. METTLER TOLEDO recommends that you use the appropriate device drivers available either from ODVA, Rockwell Automation, PROFIBUS International or directly from METTLER TOLEDO. Currently, METTLER TOLEDO supports EDS (EtherNet/IP), Custom AOP (EtherNet/IP), GSD (PROFIBUS DP), GSDML (PROFINET), ESI (EtherCAT) and CSP+ (CC-Link IE Field Basic) device drivers. Sample programming code is available for selected products and control systems.

SAI is managed as a standard at METTLER TOLEDO and this protocol is tested and proven for each product as well as the target network with approved components. METTLER TOLEDO strongly recommends that automation infrastructure components, such as cables and switches, are those recommended by the automation supplier (e.g. Rockwell or Siemens) to avoid startup problems or network performance risks

2.2. General Data Types

The protocol has two primary data types – cyclic data (also known as implicit messaging) and asynchronous data (also known as acyclic or explicit messaging).

2.2.1. Cyclic Data

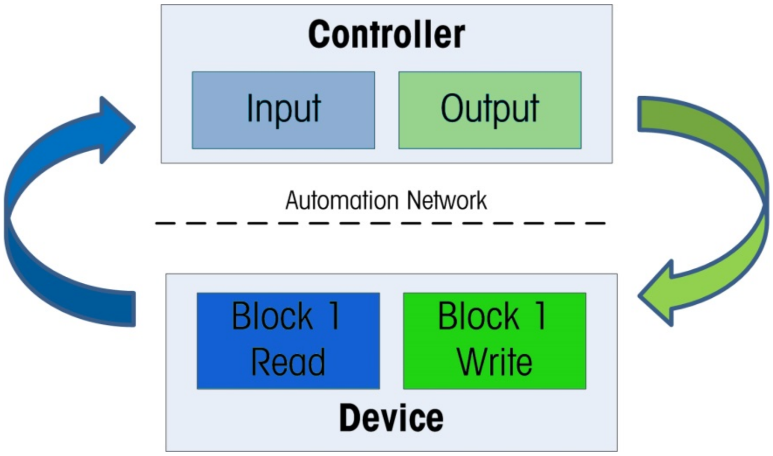

Figure 2-2: Controller/Device Read-Write Overview

Cyclic data is used when the controller requires constantly updating data from the sensor or scale. The cyclic data is refreshed by the scale or sensor at the fastest rate possible. In those instances where the data refresh rate is too high, the controller can send a command to reduce the speed. The cyclic data is broken in sections of data called blocks. Each block of data is 4 words (16 bits per word) in length. The data within these blocks expresses numeric values, string values, or individual bits representing state/command depending on the type of block specified. The number of input words (data sent from the device to the process controller) and output words (data sent from the process controller to the device) always match. This limits the number of configurations in the controller to a reasonable amount.

- Minimum size of data - 1 Block In & 1 Block Out

The three types of cyclic blocks are Measuring Block, Status Command Block, and Variable Block. Numeric values will be sent via floating-point blocks as opposed to integer or other types because the decimal point and sign are included and do not require special data handling. Status data is grouped together in 16-bit words to conserve space. These are indicated by Boolean variables in the control system.

Fixed formats are provided for applications requiring smaller amounts of data with little to no device configuration. A custom format selection is optionally provided to allow the user to select the types and number of blocks required. See Section 3 for more information on block formats.

2.2.2. Acyclic Data

Acyclic communication – also known as implicit messaging – operates in a significantly different manner compared to the other formats because it was designed for one-time read or write data that occurs outside of the normal controller scan cycle. Acyclic communication is typically used for setup data before the operation “starts” or other special information that is not needed as frequently. Acyclic messaging is typically not used for "real-time" activities and is generally used for non-repetitive or low repetition requests from a control system.

2.2.3. Acyclic Commands transmitted Cyclically

SAI supports a number of acyclic commands such as zero, tare and clear tare. At the operator’s convenience, these commands can also be sent cyclically. A caution here. Commands such as zero and tare shall only be sent once, even when transmitted cyclically, to prevent weighing errors.

3 Block Formats

Block formats are based on device/application functionality. Data type and space required are dependent on the selected format. All devices use either the 1 block format or 2 block format as their default. Any other format, such as 8 block, is optional based on a device's functional capabilities.

3.1. 1 Block Format

The SAI 1 Block Format is the smallest (lean) format and was designed with three criteria in mind:

1. Some control network interfaces have limited bandwidth.
2. Some devices have limited data and processing power.
3. Some users want limited data.

The objective is to provide basic data with little to no special coding. In addition, data size is limited to ensure high communication performance and to comply with as many automation networks as possible.

The 1 Block Format always consists of a single Read Floating-Point Block and a single Write Floating Point Block.

Block format	Write data (Control system to device)		Read data (Device to control system)
1 Block Format	Floating Point Block		Floating Point Block
	Word 0	Floating point value (32 bit), optionally used as parameter with command	Requested floating point value (32 bit)
	Word 1		
	Word 2	16 bit channel mask	16 bit device status
	Word 3	Command	Response

Figure 3-1: 1 Block Data Format Layout

3.2. Two Block (Four Word) Format

The SAI Two Block (four word) Format builds on the format structure used by the 1 Block Format; providing support for two blocks of input data and two blocks of output data. This format is designed for applications where the weighing device supports additional status information.

The cyclic data of the Two Block (four word) Format supports a single Floating Point Block (Identical to the 1 Block) and a single Status Block for each of the read and write data areas.

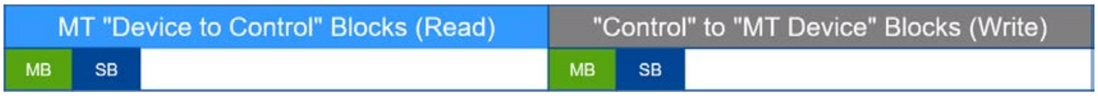

Figure 3-2: 2 Block Data Format Layout

3.3. Eight Block (Four Word) Format

The SAI Eight Block (four word) Format builds on the format structure used by the 2 Block format; providing support for eight blocks of input data and eight blocks of output data. This format was designed for applications where the users would prefer more data within one read cycle. For example, reading gross weight, tare weight and net weight all in one cycle.

The cyclic data of the 8 Block Format supports seven instances of a Floating Point Block and one instance of a Status/Command Block for each of the read and write data areas.

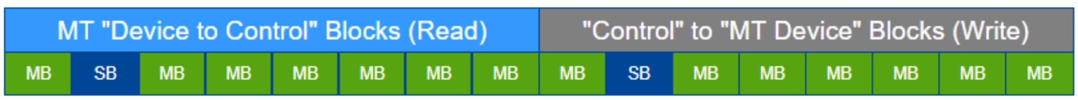

Figure 3-3: 8-Block Format Data Layout

3.4. Five Block (eight word) Long Real Format

The SAI Five- Block (eight word) Long Real Format builds on the format structure used by the 2 Block (four word) Format; however it provides support for larger blocks of input and output data. This format was designed for customers that use high precision lab and mass comparators with resolution exceeding 1,000,000d.

The cyclic data of the Five Block Long Real Format supports one instance of a 32bit Measuring Block, one instance of a Status Block and three instances of a 64bit Long Real Measuring Block for each of the read and write areas. The 64bit Long Real Measuring Blocks contain a reserved space of two status words for future use. These are shown in the Graphic below.

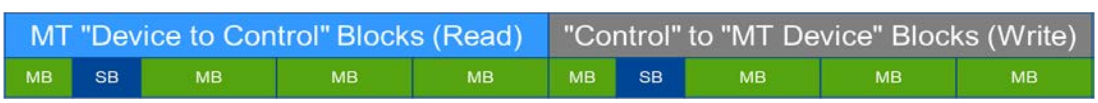

Figure 3-4: Five-Block Long Real Number Format shown in simple form

Figure 3-5: Five-Block Long Real Number Format showing reserved status

Measurement Block (Read)	
Word 0	Requested floating-point measurement
Word 1	
Word 2	Primary Scale Status
Word 3	Response

Status Block (Read)	
Word 0	Smart5 Red Alarms
Word 1	Secondary Device Status
Word 2	Inputs and Outputs
Word 3	Response

Measurement Block (Read)	
Word 0	Requested floating-point measurement
Word 1	
Word 2	
Word 3	
Word 4	Primary Scale Status
Word 5	Status Word (reserved)
Word 6	Status Word (reserved)
Word 7	Response

Measurement Block (Read)	
Word 0	Requested floating-point measurement
Word 1	
Word 2	
Word 3	
Word 4	Primary Scale Status
Word 5	Status Word (reserved)
Word 6	Status Word (reserved)
Word 7	Response

Measurement Block (Read)	
Word 0	Requested floating-point measurement
Word 1	
Word 2	
Word 3	
Word 4	Primary Scale Status
Word 5	Status Word (reserved)
Word 6	Status Word (reserved)
Word 7	Response

Figure 3-6: Example of Five Block Format in Use

4 Block Types

SAI supports four Block types:

- 32-bit Measuring
- 64-bit Long Real Measuring
- Status (condition monitoring)
- Variable.

All block formats are composed of some combination of these blocks.

4.1. (Cyclical) 32bit Measuring Block

The Measuring Block consists of a 32-bit floating-point value (2 words) and two 16-bit words:

Measuring Block (Write)	
Word 0	Optional Command Argument (32-bit) used in conjunction with Command
Word 1	
Word 2	Channel mask
Word 3	Command – specifies FP Value in Read MB

Figure 4-1: Control System to Device

Measuring Block (Read)	
Word 0	Requested floating-point value (32-bit)
Word 1	
Word 2	Primary Device Status
Word 3	Response – Identifies Command execution status

Figure 4-2: Device to Control System

4.1.1. Measuring Block Write (Control System to Device)

This block contains three parts:

1. 32 bits for a Floating Point value that can optionally be used as a “command” argument. (Words 0-1)
2. 16 bits that provide the ability to send a single command (such as zero or tare) to multiple channel scales (word 2)

3. 16 bits for the “Command” used to identify the data desired by the control system (Word 3).

4.1.1.1. Floating Point Value (Word 0 & 1)

The floating point value is single precision. Layout of floating point value bits are described in the byte order section. Note that the 32-bit precision causes truncation of the 8th most significant digit on very precise sensors and balances. For 64-bit precision, use the 64-bit Long Real Measuring Block with compatible devices.

4.1.1.2. Channel Mask (Word 2)

A Channel Mask is used to target a “command” to a particular device in multiple channel devices. If the command shall only be applied to one particular channel, the channel mask should have a “1” in the channel to be affected position. All other positions shall remain “0.” Current devices only support one chanel so channel 1 is the only channel that should be modified via the PLC. The actual command that is applied to is defined as part of the Command Word.

Channel Mask Structure	
Bit #	**Data**
0	1 = Apply command to Channel 1
1	1 = Apply command to Channel 2
2	1 = Apply command to Channel 3
3	1 = Apply command to Channel 4
4	1 = Apply command to Channel 5
5	1 = Apply command to Channel 6
6	1 = Apply command to Channel 7
7	1 = Apply command to Channel 8
8	1 = Apply command to Channel 9
9	1 = Apply command to Channel 10
10	1 = Apply command to Channel 11
11	1 = Apply command to Channel 12
12	1 = Apply command to Channel 13
13	1 = Apply command to Channel 14
14	1 = Apply command to Channel 15
15	1 = Apply command to Channel 16

Figure 4-3: Channel Mask Word

Bits 0-15 independently apply to channels 1-16 of the device as appropriate. If a command is issued for a specific device channel and includes the channel mask, all channels included in both words (the command word AND the mask) shall have the command applied to them.

For example, if a command should apply to Channel 1, Channel 2, and Channel 3, bits 0-2 should be set to 1 and all others would remain set to 0.

4.1.1.3. Command (Word 3)

This word is used to send commands to the device either to initiate a function or to select the data returned in the floating-point value. For further information, refer to Chapter 6, **Commands**, in this manual. For a complete list of commands supported by a particular SAI device, see the corresponding SAI device manual.

4.1.2. Measuring Block Read (Device to Control System)

The block consists of three parts:

1. 32 bits representing the floating point value (Words 0-1) that the Control device requested in the previous cycle
2. 16 bits to provide Scale status bits (Word 2) which are defined below
3. 16 bits for the “response value” (Word 3).

By default, if the control system sends no data in its Measuring Block Write (the write data is all zeroes), the device will send its default data for channel 1 (rounded gross weight), the scale status word for this channel, and a response value word with all bits set to 0.

4.1.2.1.1. Floating Point Value (Word 0 & 1)

The floating point value is single precision. The order of the data in the floating point value will be determined by byte order configuration of the device (big endian and little endian are also possible). The default setting of these parameters is automatically selected for Profibus, PROFINET and Ethernet/IP. There is also the capability for automatic detection of Endianness.

In certain special cases, the floating-point value may be used to send a different type of numeric data (for example, a long integer). All special cases note the expected data type with the command request.

4.1.2.1.2. Primary Device Status (Word 2) Used for Condition Monitoring

The device status is a composite status word that contains individual bits to indicate the state of various scale or device specific binary (on/off) values. This includes error and data validation bits to determine when the data received is good and can be safely used. It also contains command status bits to provide information on the state of an issued command in the Floating Point (write) Block. The following table explains the bits. For information on how a specific device implements these bits, please see the "Device Status Bits" section of the corresponding SAI device manual.

Table 4-1: Device Status Bits

Bit 0 Bit 1	**Sequence bits:** these two bits are used as command sequence indicators. As commands are sent by the control system (and recognized by the device), the device increments their binary value to indicate that a command has been seen and acted upon. These bits are used during a series of commands to ensure that there have been no sequencing errors in the request and the response of data. They are updated on every NEW command. Binary value starts at zero and increments by one. Once the maximum value (binary = 11, decimal = 3) is reached, the next command causes the sequence bits to revert to zero.

Bit 2	**Heartbeat:** confirms that the device is working as expected and updating cyclic data in Words 0, 1 and 2. The heartbeat bit is toggled between off and on states. The frequency is dependent on the specific device's ability to cycle this bit. For example, a 1-second heartbeat would be sufficient for most applications.
Bit 3	Data Ok: This bit can be configured to either follow the Simplified Data OK structure or the Legacy Data OK structure. All SAI devices must offer Simplified Data OK as the default option. Devices may choose to offer Legacy Data OK as well, but are not required to. For details on Data OK, please see section 4.1.2.1.3 for Simplified Data OK and section 4.1.2.1.4 for Legacy Data OK.
Bit 4	**RedAlert or Smart5 Red Alarm Condition**: This bit is true when the weight value or measurement is invalid. When this bit is true "1" it indicates that the control device must stop operating until the source of the alarm is evaluated and the cause of the alarm corrected. The control system may evaluate the bits in RedAlert word within the Secondary Device Status or issue a command to determine the exact cause of the alarm through a cyclic message. In POWERCELL-based systems it is also possible to evaluate non-functioning cells or broken cables
Bit 5	**Center of Zero:** This bit is true when the gross weight value is at a value of zero +/- one quarter of a weights and measures verification interval denoted as "e"
Bit 6	**Motion:** This bit is true when the weight reported by the device is unstable; the sensitivity of the motion condition is configured in the device and is additionally influenced by the filter settings.
Bit 7	**Net Mode:** This bit is true when tare is successfully completed and Net Weight is available to be read in one of the Measuring Blocks. The tare can be automatic, activated by an operator, a physical input or initiated by the control system itself.
Bit 8	**Alternate weight unit:** This bit indicates when a weight unit other than the primary weight unit is configured within the device … if this bit is set to a "1" an alternate weight unit is in use to indicate that the measurement value has changed according to the unit of measure. This is typical in systems indicating both Pounds and Kilograms.
Bit 9	**Reserved** currently a zero value
Bit 10	**Smart5 NAMUR NE107 Orange Level 4** this bit indicates that service is necessary – operation can continue; however, a service intervention is mandatory for continued, long-term operation
Bit 11	**Smart5 NAMUR NE107 Yellow Level 3** this bit indicates a wrong activity / operation, or a situation has occurred that is outside of specified tolerances, or limits.
Bit 12	**Smart5 NAMUR NE107 Orange Level 2** Calibration and / or adjustment is necessary based on time in operation, number of cycles or an event that may have compromised the device performance.
Bit 13	**Selected Scale** when a "1" denotes the current scale has been selected by an operator, via the HMI (Display), for active operation in a multi-scale configuration. For example, to perform a zero or tare function via the device keypad. The selected scale is mutually exclusive where the choices are 1, 2, 3, 4 and sum. Naturally, in a control scenario the programmer would use the channel mask (non-exclusively) for scale operations and view the results in the corresponding measuring blocks. In single scale devices, this value will always be 1.

Bit 14	**Reserved** currently a zero value
Bit 15	**Reserved** currently a zero value

4.1.2.1.3. Simplified Data OK

Simplified" is chosen to represent the current state of automation and the incorporation of Smart5™ into the specification.

This bit is set to 1 when the device is operational and must be evaluated in conjunction with bit 4 (Smart5 Red) below. METTLER TOLEDO sample programs evaluate both bits simultaneously to indicate that the weight is valid.

The following conditions cause the Data Ok bit to indicate a value of 0.

- Device is powering up
  - Device is booting
  - Device is in process of conducting power up zero operation
  - All operations the device needs to complete before a valid weight value is being transmitted
- It indicates status of an in-progress calibration and adjustment cycle
- While in setup mode and no weight transmission is possible
  - In ASM (Automatic Setup Mode on Precision Scales): while in the ASM menu, no other scale information can be transmitted.
- Device is powering down
  - As soon as the device receives shut down or restart signal
    - Internal software modules are shut down and we cannot guarantee a correct weight anymore
  - Note: we only take this into account when the device can detect power-down.
- Device is in Test Mode

4.1.2.1.4. Legacy Data OK

In the past, this bit also indicated weights and measures relevant events such as Over Capacity, Under Capacity and X10 based on OIML R76 and NTEP Handbook 44. These functions have been moved into Smart5™ to improve the stability of the system when used in automation because the weights and measures tolerances are too small for many applications because they were established for non-automatic weighing used in commercial Business to Customer transactions.

In automation indicators (terminals) the over and under capacity limits must be defined in the configuration of the unit to match the safety requirements for the device, the structure (or machine), the operators and the environment. The system safety requirements must be evaluated on a case-by-case basis by qualified personnel to ensure the structure supporting / holding the scale is structurally robust (strong) enough to carry the weight of the scale and any objects placed on/in it, including a safety factor to account for any and all worst-case overload scenarios.

When designing control algorithms, it is necessary to evaluate the vessel and scale capacities independently as a best safety practice. In most cases, the scale capacity exceeds the vessel's capacity in weight. This means that scale capacity must never be used as a method to prevent overfilling of the vessel, or any other object, because the vessel will reach its maximum capacity limit before the scale capacity limit. Instead, use an internal comparator that disables the filling mechanism / system at, or before, the vessel's maximum capacity limit in weight/volume, and add a compare function in the control system logic that prevents overfilling the object on the scale. These precautions must be taken to avoid injury to personnel and equipment damage.

Note: In safety-relevant systems both Data Ok and Smart5 red must be constantly evaluated by the control system to verify that the device is delivering valid measurements. To ensure safe operation DO NOT REMOVE THESE TWO FUNCTIONS from the sample code, or your programming code

4.1.2.1.5. Note: Evaluation for Data Ok and Smart5 Red

Data Ok	Smart5 Red	
Bit 3	Bit 4	Action
0	**0**	Wait for unit to power up and /or finish the calibration / adjustment cycle
1	**0**	Weight Data is valid and may be used for control purposes
0	**1**	Wait for unit to power up and verify that the unit is not in test mode.
1	**1**	The unit is operating but indicating a critical error. The error must be evaluated and eliminated

Functions	Legacy	Simplified	Smart5 Red Alarm	Comments
Power up	✓	✓		
Adjustment	✓	✓		
Power down	✓	✓		Difficult to detect not available on all products
A/D Limit High	✓		✓ Red Level	
A/D Limit Low	✓		✓ Red Level	
X10	✓*			Used only for repeatability doesn't affect transmitted weight value. Indicator simultaneously transmits both rounded and unrounded weight.
Over Capacity 9e	9e*			Customer defines as % of capacity
Under Zero	✓*			Customer defines as negative weight value in displayed units

4.1.2.2. Response Value (Word 3)

The Response Value is sent by the Device to indicate the type of data now present in Words 0 and 1. The response communicates if the command is in-progress, executed or there was an error.

- Once a command is successfully processed by the device, the device will update the Response to match the Command and it will increment the sequence bits 0 and 1 in the Primary Scale Status.
- An error code will be placed in the Response Value to indicate an unknown command, a condition not being satisfied, or another error condition. All error codes set bit 15 of Response to 1.

4.2. Status Block (SB)

The Status blocks are used to provide state (on/off) data. The Status blocks are structured to support three sets of Status words. Examples of data provided through Status blocks include alarms, physical I/O, target control, comparator state, or application-specific states. Refer to chapter 7 for details.

A Status Block consists of four 16-bit words.

Status Block (Write)	
Word 0	Reserved
Word 1	Reserved
Word 2	Reserved
Word 3	Command

Figure 4-4: Control System to Device

4.2.1. Status Block Write (Control System to Device)

4.2.1.1. Optional Argument (Word 0 - 2)

Two types of command structures are supported in the Status Block Write data. In the first type, a single command is sent that requests a specific pre-configured combination of status data. In order to maintain a consistent layout (input vs. output block size), words 0 - 2 are not used.

4.2.1.2. Command Value (Word 3)

Send commands to the device on a selected channel. The value used in this word is a combination of the command and the device value. This combination informs the device where the specified command should be used when more than one measurement channel is present (for example, some terminals support multiple scales). Layout of this word is described in the Command & Response Word section.

4.2.2. Status/Command Block Read (Device to Control System)

Status Block (Read)	
Word 0	Status Group 1
Word 1	Status Group 2
Word 2	Status Group 3
Word 3	Response Value

Figure 4-5: Device to Control System

4.2.2.1. Status Group 1 -3 (Word 0 - 2)

The Status Group 1, Status Group 2, and Status Group 3 words contain specially grouped bits of status information. The Command word in the Write Status Block is used by the control system to tell the device what data is desired in these words. By default, the device will send RedAlert, Scale Status Group2, and I/O Group1.

Each command used to request status data in these words represent a particular combination (refer to Appendix A, **Cyclic Commands**).

4.2.2.2. Response Value (Word 3)

Command response sent by the device to indicate the status of command execution. The structures of Response Value in the Read block and Command Value in the Write block match. The device responds as follows:

- Once a command is successfully completed by the device, the Response will match the Command issued in the Write block to indicate that the new data is available. Should the values not match, wait one or two cycles and then reevaluate the Response.
- In case of an error caused by an unknown command or an error condition, the device responds with an error code. All error codes set bit 15 of the Response to "1". The other bits indicate the exact error.

4.2.3. Command/Response Word

The command word and the command response word for all blocks follow the same structure:

- Bit 15 is always 0 to keep the overall value of this word positive unless the device cannot provide the desired data or comply with the requested command. Then this bit is set to a "1" to indicate an error. A full description of the possible error codes is described in the Commands section.
- Bits 11-14, used to indicate which channel of the device is providing the data. The channel indicator bits are intended for devices that support multiple sensors or scales, allowing an individual device to support up to a maximum of 16 channels. Single channel (scale or load cell) devices will always use 0000 as their default channel value.
- Bits 0-10, used to indicate the command or response value.

Word 3	
Bit #	Data
15	MSB always 0
14	MSB of channel
13	
12	
11	LSB of channel
10	MSB of field value
9	
8	
7	
6	
5	
4	
3	
2	
1	
0	LSB of field value

Channel Indicator	
0000	Channel 1
0001	Channel 2
0010	Channel 3
0011	Channel 4
0100	Channel 5
0101	Channel 6
0110	Channel 7
0111	Channel 8
1000	Channel 9
1001	Channel 10
1010	Channel 11
1011	Channel 12
1100	Channel 13
1101	Channel 14
1110	Channel 15
1111	Channel 16

Figure 4-6: Response Value Word Layout

The Channel bits are mapped as shown above. The Command bits 0-10 are used by the control system to select the reported data from the device data in the Floating Point (Read) Block, change device data values, or issue operational commands such as tare, zero, etc. Details of this structure are provided in the command section of this document. The Response bits 0-10 are sent by the device to indicate the status of the command or to identify the data being sent in the read block.

The value used in this word is a combination of the command/response and the channel value. This combination informs the device where the specified command should be used when more than one measurement channel is present (for example, some terminals support multiple scales) or which measurement channel is providing the data in the response.

To calculate the word's complete integer value, the command/response value should be added to the channel value:

Command or Response Word = Command or Response Value + Channel Value

4.2.3.1. Example

Send command "report rounded net weight" on channel number 3 to the device. The resulting 16- bit command word is "4098" and calculated as follows:

	Dec	Command words bits															
		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Command	2						0	0	0	0	0	0	0	0	0	1	0
Channel number 3	4096		0	0	1	0											
Command word	4098	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0

4.3. (Cyclical) 64bit Long Real Measuring Block

4.3.1. Measuring Block Write (Control System to Device)

This block contains four parts:

a) 64 bits for a floating-point value as command argument (words 0-3);

b) 16 bits to provide the ability to send a single command to multiple channel scales (word 4);

c) Two words that are intended for status but are currently reserved

d) 16 bits for the Command sent by control system (words 5 & 6). These commands can be found in the Command Section of this document.

The 64-bit Measuring block functions exactly like the 32-bit block described above in respect to the channel mask, device status and commands.

4.3.1.1. Floating-Point Value (Word 0-3)

The Floating-Point Value is an argument specified by the control system with the command value in Word 7. This means that a command value associated with "Tare" would load the device with a floating-point tare value.

The floating-point value is based on IEEE 754 and is signed meaning below zero values are indicated. The bit / byte order is automatically set in the device, during configuration, based either on 1) the default associated with the automation network. 2) a patented automatic bit order detection system available in SAI devices.

4.3.1.2. Channel Mask (Word 4)

A channel mask determines which channel a given command will be applied. For single channel devices, the value of the channel mask is always filled with zeros.

In cases where a single command is to be applied to multiple channels (for example, issuing a zero command to multiple scales), the programmer would write a 1 into the appropriate positions in the mask.

Channel	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 4-7: Channel Mask Word

Bits 0-15 independently apply to channels 1-16 of the device as appropriate. If a device only has a single channel, the channel shall be zero. If a command is issued for a specific device channel and includes the channel mask, all channels included in both words (the command word and the mask) should have the command applied to them.

For example, if a command should apply to Channel 1, Channel 2, and Channel 3, bit 0-2 should be set to 1 and all others would remain set to 0.

The channel mask should be ignored when the command issued cannot be applied to multiple channels at the same time. For example, a report weight command for the Measuring Block can only be valid for a single channel at a time.

4.3.1.2.1. Reserved Status Words 5 & 6

Currently these two words are reserved, but intended for status (condition monitoring)

4.3.1.2.2. Command Value (Word 7)

This word is used to send commands to the device either to initiate a function or to select the type of floating-point value that should appear in the next "Read" Measurement Block. in Words 0 and 1 in the next cycle. These commands relate to the capability of each product; therefore, listed separately for each product, and are included in this specification.

Measuring Block (Write)	
Word 0	Floating-point value ex. Preset Tare
Word 1	
Word 2	
Word 3	
Word 4	Channel Mask
Word 5	Status Word (reserved)
Word 6	Status Word (reserved)
Word 7	Command

Measuring Block (Read)	
Word 0	Requested floating-point measurement
Word 1	
Word 2	
Word 3	
Word 4	Primary Scale Status
Word 5	Status Word (reserved)
Word 6	Status Word (reserved)
Word 7	Command Response

Figure 4-8: 64 bit Long Real Measuring Block

4.3.1.3. Floating Point Value (Word 0-3)

The floating-point value is dual precision “real number”. The floating-point value is based on IEEE 754 and is signed meaning below zero values are indicated which eliminates the need for additional “under zero” functions / features. The bit / byte order is automatically set in the device, during configuration, based either on 1) the default associated with the automation network. 2) a patented automatic bit order detection system available in SAI devices.

In certain special cases, the floating-point value (allocated space) may be used to send a different type of numeric data (for example, a long integer). All special cases note the expected data type with the command request.

5 Acyclic Format

The SAI Acyclic Format operates significantly different from cyclic data exchange. This format was designed for one-time read or write data that occurs outside of the normal scan cycle. This is typically used for setup data before the operation “starts” or other special information that is not needed as frequently. Acyclic messaging is typically not used for "real-time" activities and is generally used for non-repetitive or low repetition requests, from a control system. Simply stated, the control system sends a request and the device responds to the request. A device can support this format along with one or more of the cyclic data formats.

5.1. Control System Integration

The asynchronous format uses special message instructions (acyclic parameter access). The actual implementation is control system dependent. Within the configuration of the instruction, several parameters are used:

- Command type: read or write instruction
- Address: according to addressing schema of control system

  Ethernet/IP: class/instance/attribute

  PROFINET: slot/subslot/index
- Buffer: control system memory space or variable used with the instruction (for write value or read response)

5.2. Access Methods

There are two methods of sending/receiving data through acyclic messages:

- Direct access through a unique name or number defined by the control system's acyclic message block

  Direct Access Level 1: mandatory instruction set required by devices supporting asynchronous data exchange. Mostly weight related data

  Direct Access Level 2: optional instruction set extending direct access level 1. Adds application data (e.g. piece counting)
- Indirect access through a variable name provided in the data structure of two generic message blocks reserved for this purpose (one for read, one for write).

5.2.1. Direct Access

Each variable is assigned its own unique address inside the address space of the control system. Example:

Variable	Ethernet/IP (hex) Class / instance / attribute	PROFINET (hex) Slot / subslot / index
Report gross weight	300 / 1 / 02	0 / 1 / 2001
Report net weight	300 / 1 / 04	0 / 1 / 2003

The data returned by the device to the control system is payload only, i.e. there is no special header. The control system can convert the returned data to the appropriate data type and directly use the data. See Appendix B of this document or the "Acyclic Command List" section of the corresponding product specific SAI manual for a full list of acyclic, direct access commands

5.2.2. Indirect Access

The indirect access method uses two acyclic messages with a dedicated address, one for writing and one for reading. Compared to direct access, the data point to be accessed on the device is encoded in the payload of the acyclic message. This way, access to every variable available from the device is supported. This method specifically suited for devices with a large number of variables. It uses the same structure for naming the variable as the variable block in the cyclic data's Custom Format.

Word 0	Read Length	
Word 1	Variable Group	
Word 2	Variable SubGroup	
Word 3	Variable Item	
Word 4	Byte 2	Byte 1
Word 5	Byte 4	Byte 2
Word 6	Byte 6	Byte 3
Word 7	Byte 8	Byte 4
Word *n*	Byte (2*n* + 2)	Byte (2*n* + 1)

Figure 5-1: Acyclic Indirect Command Response

5.3. Control System Parameters for Direct and Indirect Access

Because control systems use different methods for providing acyclic messages, the parameter used in the message block may also differ and is based on their requirements.

5.4. Profibus/PROFINET Acyclic Messages

For most control systems using Profibus DP or PROFINET networks, there are two types of commands that can be used to execute acyclic messages: RDREC (SFB52) and WRREC (SFB53). The index and length parameters within these blocks are used to specify what variable (for Direct Access) or what command (for Indirect Access) is required. To read a variable, a combination of RDREC and WRREC commands are used. To write a value to a variable, the WRREC command is used. Index numbers used are interface dependent due to the restrictions of the particular network type.

5.5. EIP Acyclic Messages

For control systems using an EthernetIP network, there are two types of commands that can be used to execute asynchronous messages: CIP Generic Message Instruction for Get Attribute Single ("e") or CIP Generic Message Instruction for Set Attribute Single ("10"). These commands use parameters called class code, instance number, attribute number and length to be configured in the message block to specify what variable for Direct Access) or what command (for Indirect Access) is required.

6 Commands

The commands available for the control system to use in Write blocks are grouped according to block type and command type. All commands are considered "one-shot" – meaning that the command is only triggered once even if it remains in the command word for multiple scans until another command is sent. In order to permit a command to be issued a second time, a no-op command is provided.

No more than one command per block is permitted (the only exception is a cancel operation command to abort the previously sent command). All other commands to this block will be ignored until its active command is completed (either successfully or not). Specifically, additional commands sent before completion are not "stored" to be acted upon completion of the prior command.

All responses to commands for the cyclic data blocks are provided through the command word. Several command values are reserved – these are used for all command types to indicate special state responses to any given command or for special sequencing commands when multiple steps are required. Bit 15 of the response word is used to indicate a failure or error in the command sent. This bit along with the value in the response bits (0-10) should be used to determine if the command was successfully executed or not; and if not, why the command failed.

The table below shows which responses are possible for each command type.

Command Type	Valid Command Response	Invalid Command Response	Unknown Command Response	Invalid Command Data Response	Timeout Command Data Response	Aborted Command Response	Step Successful Command Response	Step Successful / Next Value Command Respose	Step Failed Command Response
Measuring Block Report	x	x				x	x	x	x
Measuring Block Write	x	x	x	x		x	x	x	x
Measuring Block Operation	x	x	x	x	x	x	x	x	x
Status Block	x	x				x	x	x	x
Variable Block	x	x	x	x	x	x	x	x	x

6.1. Command Responses

6.1.1. Valid Command Response

When a valid command is received, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command.

2. Execute the command (report the data, write the value, etc.).
3. For multiple step commands only, report "step complete" when current step is finished successfully. Report "step failed" when current step is unsuccessful. Wait for Continue or Abort command from control system to start next step. Repeat as many times as required. If the process is complete, continue to step 4.
4. Update the response word to indicate successful completion of the command.
5. Increment the sequence bits in the Primary Device Status word.
6. For floating point report and status block commands only, continue to update the floating point value and/or the status bits until another command is received.

6.1.2. Invalid Command Response

An invalid command response is sent when the device determines that the command is known but cannot be executed. This might occur due state restrictions – for example attempting to zero when the scale is outside of acceptable zero range. When an invalid command is received, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate invalid command (Bit 15 = 1, error value = 1, Total Response = 0x8001)
3. Increment the sequence bits in the status word.

6.1.3. Unknown Command Response

An unknown command response is sent when the device does not support this information (for example requesting rate values from a device that does not provide rate functionality). When an unsupported command is received, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate unsupported command (Bit 15 = 1, error value = 4, Total Response = 0x8004)
3. Increment the sequence bits in the status word.

6.1.4. Invalid Command Data Response

An invalid command data response is sent when a valid write command is received with an invalid argument (for example one that is smaller or larger than the allowed value). When invalid command data is received, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate invalid command value (Bit 15 = 1, error value = 8, Total Response = 0x8008)
3. Increment the sequence bits in the status word.

6.1.5. Timeout Command Response

A timeout command response is sent when the valid command that is received by the device is unable to execute within a pre-determined time. This might occur for commands that require stable weight before execution, for example. When the command timeout occurs, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate command timeout failure value (Bit 15 = 1, error value = 2, Total Response = 0x8002)
3. Increment the sequence bits in the Primary Device Status word.

6.1.6. Aborted Command Response

If the control system chooses to abort the previous command, it can issue a special command to cancel operation of this previous command as long as its status is in process or during any step of a multiple step sequence. The device will provide a response to indicate the initial command has been aborted.

A command failed - aborted response is sent once a second command to cancel the prior command has been received and processed. This can only occur if the original command 1) permits cancellation, 2) has not already completed successfully, and 3) has not already failed. When the command abort occurs, the device should do the following:

1. Place the "abort in process" response (2004) in the response word and begin processing the command …
2. Update the response word to indicate command abort failure value (Bit 15 = 1, error value = 16, Total Response = 0x8010)
3. Increment the sequence bits in the Primary Device Status.

Commands for procedures that have multiple steps have some special responses:

6.1.7. Step Successful Command Response

A step successful command response is sent when the device determines that the command's current step has been successfully executed and requires acknowledgement to start the next step in the process. When a previous step completes and the next step in the sequence must be "started", the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate step successful when ready to execute next step (value = 2046)
3. Increment the sequence bits in the Primary Device Status word.

The control system should send one of the next step commands to continue with the next step in the process.

6.1.8. Step Successful / Next Value Command Response

A step successful / next value command response is sent when the device determines that the command's current step has been successfully executed and requires the next value and acknowledgement to start the next step in the process. When a previous step completes and the next step in the sequence requires another value to execute the next step in the process, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate step successful and next value is needed when ready to execute next step (value = 2045)
3. Increment the sequence bits in the Primary Device Status word.

The control system should send one of the next step commands with the required value in the floating point words to continue with the next step in the process.

6.1.9. Step Failed Command Response

A step failed command response is sent when the device determines that the command's current step has failed. Once the current step executes and fails, the device should do the following:

1. Place the "in process" response in the response word and begin processing the command …
2. Update the response word to indicate step failed (Bit 15 = 1, error value = 32, Total Response = 0x8020)
3. Increment the sequence bits in the Primary Device Status word.

At this point the control system will need to decide whether to abort the sequence (command = 2004), to retry the step (command = 2005), or to skip this step (command = 2006) and try to perform the next step. Not all processes will allow all three of these options – those not permitted will have an invalid command response when the next step command is sent.

6.2. Measuring Block Commands

There are three types of Measuring Block commands: report, write or operation. Each type is based on the command use and the expected response from the device. See Appendix A for a partial list of possible commands. Refer to the SAI device manual for your specific device to see all possible commands.

6.2.1. Measuring Block Report Commands

Measuring Block Report Commands are used to request the data that is sent by the device in its read Measuring Block. These commands are used to get continuously updated data for information such as gross weight, net weight, raw weight, rate, or other application numeric data values that are time critical.

6.2.2. Measuring Block Write Commands

Measuring Block Write Commands are used to write a value provided by the Measuring Block (write) Block to selected device functions. These commands are used to set common process values such as tare, target, tolerance, or other application numeric data values that are user-specified during operation. Due to speed issues, the actions triggered by these commands may, or may not, execute immediately. This means that the process response could be seen by the control system, within the cyclic message (data) before the ”commanded” action is complete.

6.2.3. Measuring Block Operation Commands

Measuring Block Operation Commands are used to trigger an operation. These commands may or may not require a sequence of responses. Simple operations may execute immediately and require no additional sequence steps. More complex operations may take multiple steps to execute and require additional commands from the control system to continue through the entire process.

6.3. Status block Commands

Status block commands are only report type. They are used to request the data that is sent by the device in its status blocks. These commands are used to get continuously updated status data for scale, target, or physical discrete input/output information. If a status block command is issued and an error response is returned, best practice is to issue a no-op command for the status block so the PLC program has visibility for when the next command completes. This is necessary for the status block and not the floating block because the status block does not have sequence bits to increment each time a command is executed.

See Appendix A for a partial list of possible commands. Refer to the SAI device manual for your specific device to see all possible commands.

6.4. Variable Block Commands

There are only two types of variable block commands: report or write. They are both used to access information directly from the device's variables and require specific knowledge about the variable (group, subgroup, item, and usage).

7 Status Block Word Types

7.1. RedAlert™ Smart5™ Alarms (default, word 0)

These status bits are critical alarm status bits sent as part of the default status block when a status block command "0" is sent. If the control system does not place any data in the Write Status/Command word, the device will send this data in word 0. For information on how a specific device implements these bits, please refer to the **RedAlert Alarms** section of the corresponding SAI device manual.

Table 7-1: RedAlert Status Bits

Bit #	Red Alert Failures
0	Calibration alarm
1	Out of A/D range over/under
2	Checksum failure
3	Weight blocked
4	Single sensor communication failure
5	Customer-defined overload
6	Customer-defined underload
7	Network failure (all cells)
8	Zero out of range
9	Symmetry errors
10	Significant Temperature Alarm
11	Weights and measures failure
12	Foreign device detected
13	Test mode
14	Temperature error operation range
15	Reserved

Bit 0 **Calibration Error**: Indicates that the weight data can no longer be trusted, could be a result of loss of calibration data or an algorithm running in the product to detect weighing irregularities

Bit 1 **Out of A/D range over/or under**: A "1" state occurs when A/D value is at or beyond its absolute maximum value or at or below its minimum value.

Bit 2 **Checksum Failure**: A checksum analysis of memory does not yield the expected result.

Bit 3 **Weight Blocked**: The weight data does not change appreciably over a defined period. The assumption is that all scales have drift and noise from the environment, a non-changing condition would indicate that the scale is not moving as expected because it is either blocked or is not responding to the MCU (under conditions when there are no proactive diagnostics available to discover the root cause).

Bit 4 **Load Cell / Sensor Comm Failure**: Many MT products contain "Smart" or networked load cells which operate independently from the MCU. This bit changes state when one or more sensors fail to respond to the MCU.

Bit 5 **Customer-Defined Overload**: The weight is equal to or greater than a "customer-programmed" limit either on the scale or individual sensor's capacity (in a multi-sensor system). Overload is a conditional limit but in many cases can lead to catastrophic errors such as mechanical breakage or personal injury

Bit 6 **Customer-Defined Under load**: The weight is under the "customer-configured" limit on the scale / sensor (under zero but still within A/D range)

Bit 7 **Network Failure**: On multi-cell networks indicates failure of the entire network. No Cells are responding

Bit 8 **Zero Out of Range**: A control system, or an operator attempts a zero command and the device does not accept the command because the weight is outside of the specified (setup) limits or the weights and measures limits. This typically occurs when the user inadvertently attempts to zero the scale when the object being measured has not been removed.

Bit 9 **Symmetry errors**: TraxDSP function that detects significant errors between load cells and their peers.

Bit 10 **Significant Temperature Alarm**: Many sensors and scales include sensors for temperature compensation of the weight value. These sensors can also indicate that the weight value is outside of acceptable tolerances and either the weight value could be affected or the components could prematurely fail (in extreme cases)

Bit 11 **Weights and Measures failure**: An algorithm in the sensor or scale detects that the product is no longer in compliance with weights and measures regulations. This is a conditional setting in the indicator / sensor and must be disabled in automated systems. This bit can be used to identify the following conditions.

- OIML / HB44 Overcapacity +9e
- OIML Under Capacity -20d
- X10

Bit 12 **Incompatible Device Detected**: A non-matching MT device or a foreign device is attached to the system.

Bit 13 **Test Mode**: This bit is set to 1 when the device is in a mode in which live data is replaced with special test data.

Bit 14 **Temperature error operation range:** This bit is set to 1 when at least one loadcell has a temperature outside the rated operation temperature range

Bit 15 Unused at this time (always 0).

7.2. Alarm Status

These status bits are application alarm bits sent when a status block command that contains this status word is sent in the Write Status word. For information on how a specific device implements these bits, please refer to the **Status Group 2 - Alarms** section of the corresponding SAI device manual.

Table 7-2: Application Alarm Status Bits

Bit #	Red Alert Failures
0	Rate of change alarm
1	Communication alarm
2	Over / under voltage(s)
3	Weight drift
4	Breach
5	Calibration expired
6	Application-defined
7	Application-defined
8	Application-defined
9	Application-defined
10	Application-defined
11	Application-defined
12	Application-defined
13	Application-defined
14	Application-defined

Bit 0 **Rate of Change**: product, application or user defines a weight / time scenario as a method of assurance that the scale is detecting weight. A typical application would be a filling system where either the material is not available for filling or a feeding system is not transporting material to the scale (slow fill timeout)

Bit 1 **Communication alarm**: relates to a device that is connected to a sensor or terminal and the necessary communication is not functioning according to specification

Bit 2 **Over or Under Voltage (s)**: relates to a device that supports dynamic measurement of system power. For example - POWERCELL CAN network voltages

Bit 3 **Weight Drift**: relates typically to a strain gage sensor that either has a broken bridge or is damaged by water or lightning. The drift weight vs. time is outside of acceptable tolerances.

Bit 4 **Breach**: the sensor's enclosure has been compromised and therefore vulnerable to outside influences such as moisture / water. In most cases, a failure will occur if the breach is not corrected or the sensor is not replaced

Bit 5 **Calibration Expired**: User / technician determines the maximum number of transactions, or a time limit to occur before a preventative service or recalibration –

the alarm will toggle on N+1 weighing transactions

Bit 6 – 15 Open (application defined if needed, 0 if not used). Refer to the **Application Specific Alarms** section of the corresponding SAI device manual for more information on these application specific alarms.

7.3. Scale Group 2 Status (default word 1)

These status bits are sent as part of the default status block when a status block command "0" is sent. If the control system does not place any data in the Write Status command word, the device will send this data in word 1. For information on how a specific device implements these bits, please see the "Scale Group 2" section of the corresponding SAI device manual.

Table 7-3: Scale Group 2 Status Bits

Bit #	Red Alert Failures
0	Unit bit 1
1	Unit bit 2
2	Unit bit 3
3	Unit bit 4
4	MinWeigh Error
5	Range bit 1
6	Range bit 2
7	In Setup
8	Power Up Zero Failure
9	Reserved
10	Selected scale or Smart5 Orange (refer to SAI device manual)
11	Open (always 0) or Smart5 Yellow (refer to SAI device manual)
12	Open (always 0) or Smart5 Yellow (refer to SAI device manual)
13	Legal for Trade switch Enabled
14	Open (always 0)
15	Open (always 0)

Bit 0-3 **Unit bits 1-4**: these bits are used to indicate the weight unit based on this chart:

Table 7-4: Weight Unit Bits 1 to 4

Bit 3	Bit 2	Bit 1	Bit 0	Value
0	0	0	0	g
0	0	0	1	kg
0	0	1	0	lb
0	0	1	1	t
0	1	0	0	ton
0	1	0	1	Reserved
0	1	1	0	Reserved

Bit 3	Bit 2	Bit 1	Bit 0	Value
0	1	1	1	Special/custom
1	0	0	0	oz
1	0	0	1	dwt
1	0	1	0	ozt
1011 - 1111				Unused

Bit 4 **MinWeigh Error**: 1 = Scale indicated value is below acceptable minimum weighing range that is configured by the user. In a normal automation system, this function is not used therefore, this indication should only appear when the user configures the system to indicate Minimum Weight. Otherwise, this bit is set to "0".

Bit 5 & 6 **Range bits 1 & 2**: these bits are used to indicate the weight range or interval based on this chart:

Table 7-5: Weight Range Bits 1 to 2

Bit 6	Bit 7	Value
0	0	Range/Interval 1
0	1	Range/Interval 2
1	0	Range/Interval 3
1	1	Reserved

Bit 7 **In Setup**: Used to indicate when scale is in setup mode

Bit 8 Power up zero failure: Used to indicate when scale has not been able to complete its powerup restore/reset of zero. This condition usually indicates that the customer must remove an object from the scale before operating it. The failure condition also indicates excessive material buildup on the scale.

Bit 9 Reserved

Bit 10 **Selected Scale**: Used to indicate which scale is "selected" and therefore in focus or seen on the device display for multi-scale devices (a single channel device will always have its scale selected).

Smart5 Orange: Certain devices use this bit to indicate if there are any active Smart5 Orange level alarms. Refer to SAI device manual to see if this bit is supported by a specific device.

Bit 11 Unused (always 0) on certain devices. See SAI device manual to see if this bit is supported by a specific device.

Smart5 Yellow: Certain devices use this bit to indicate if there are any active Smart5 Yellow level alarms. Refer to SAI device manual to see if this bit is supported by a specific device.

Bit 12 Unused (always 0) on certain devices. See SAI device manual to see if this bit is supported by a specific device.

Smart5 Blue: Certain devices use this bit to indicate if there are any active Smart5 Blue level alarms. Refer to SAI device manual to see if this bit is supported by a

	specific device.
Bit 13	Legal for Trade Switch Enabled: Set to 1 if the Legal for Trade switch on the device is enabled. When switch is enabled, it is not possible to change device settings related to legal for trade weighing.
Bits 24-15	Unused (always 0)

7.4. Target Status Group

These status bits are target application bits sent when a status block command that contains this status word in its combination is sent in the Write Status command word. For information on how a specific device implements these bits, please refer to the **Target Status Group** section of the corresponding SAI device manual.

Table 7-6: Target Status Bits

Bit #	Data
0	Feed
1	Fast Feed
2	Coarse Feed
3	Feed stage 2
4	Feed stage 1
5	Tolerance OK
6	Over Zone
7	Under Zone
8	Heavy Zone
9	Light Zone
10	Open

Table 7-7: Target Status Bit Description

Bit #	Description
0	**Feed bit**: turns ON when target feed is active (before final cutoff)
1	**Fast Feed bit**: turns ON when target fast feed is active
2	**Coarse Feed bit**: optional 3rd speed, turns ON when coarse feed is active (prior to fast feed)
3	**Feed Stage 2**
4	**Feed Stage 1**
5	**Tolerance OK**: turns ON when weight value is within tolerance of target
6	**Over**: turns ON when weight value is in Over Zone (too high) or optionally when weight value is outside of + TOL
7	**Under**: turns ON when weight value is in Under Zone (too low) or optionally when weight value is outside of – TOL
8	**Heavy**: turns ON when weight value is in Heavy Zone (acceptable high)

Bit #	Description
9	**Light**: turns ON when weight value is in Light Zone (acceptable low)
10 - 15	Unused (always 0)

7.5. Comparator Status Group(s)

These status bits are comparator application bits sent when a status block command that contains this status word in its combination is sent in the Write Status command word. For information on how a specific device implements these bits, please refer to the **Comparator Status Groups** section of the corresponding SAI device manual.

Table 7-8: Comparator Group 1 Status Bits

Bit #	Data
0	Comparator 1
1	Comparator 2
2	Comparator 3
3	Comparator 4
4	Comparator 5
5	Comparator 6
6	Comparator 7
7	Comparator 8
8	Comparator 9
9	Comparator 10
10	Comparator 11
11	Comparator 12
12	Comparator 13
13	Comparator 14
14	Comparator 15
15	Comparator 16

There are two groups of these bits. The second group contains the status of the remaining comparators.

Table 7-9: Comparator Group 2 Status Bits

Bit #	Data
0	Comparator 17
1	Comparator 18
2	Comparator 19
3	Comparator 20
4 - 15	Open

The comparator status bits turn ON for the listed comparator when the assigned comparison logic is true. For example, if a comparator were configured for less than 100 kg, when the weight value is less than 100 kg the bit would be ON.

7.6. I/O Status Groups

There are multiple commands for input and output status words. From the device perspective, these can be separated into two categories: physical and virtual.

Physical I/O can be internal or external. Devices that have no physical I/O can still have variables and logic to virtually represent inputs and outputs within the device. The I/O status groups are used to contain a combination of input and output status bits for all of these types of I/O. Since the amount of I/O varies by device, devices will provide an invalid command response to a command for any unsupported I/O groups.

The status bits for group 1 are sent as part of the default status block (in word 2). There are several other commands that can be used when various combinations of these groups are needed. The Response Value should match the Command Value sent and these status bits should be sent in one of the Read Status words. For information on how a specific device implements these bits, please refer to the **I/O Status Groups** section of the corresponding SAI device manual.

Table 7-10: I/O Group 1 Status Bits

Bit #	Data
0	In 1
1	In 2
2	In 3
3	In 4
4	In 5
5	In 6
6	In 7
7	In 8
8	Out 9
9	Out 10
10	Out 11
11	Out 12
12	Out 13
13	Out 14
14	Out 15
15	Out 16

The Input status bits reflect the state of the associated input (ON when ON, OFF when OFF). The output status bits reflect the state of the associated output (ON when ON, OFF when OFF).

The layout of Groups 2 - 14 is the same as Group 1.

7.7. Custom Application Status Group

There are two commands for custom application status words. The first command requests application bits 1-16 and the second requests application bits 17-32. Devices that support 16 or fewer application bits will provide an invalid command response to a command for the second group or an empty word (all zeroes). The usage of these status bits may differ from device to device and application to application even in the same device. Each device application will provide its own documentation on the operation of these status bits.

The custom application status bits are sent when a status block command that contains one of these status words in its combination is sent in the Write Status command word. For information on how a specific device implements these bits, please refer to the **Custom Application Status Group** section of the corresponding SAI device manual.

Table 7-11: I/O Group 1 Status Bits

Bit #	Data
0	Custom Bit 1
1	Custom Bit 2
2	Custom Bit 3
3	Custom Bit 4
4	Custom Bit 5
5	Custom Bit 6
6	Custom Bit 7
7	Custom Bit 8
8	Custom Bit 9
9	Custom Bit 10
10	Custom Bit 11
11	Custom Bit 12
12	Custom Bit 13
13	Custom Bit 14
14	Custom Bit 15
15	Custom Bit 16

Table 7-12: I/O Group 2 Status Bits

Bit #	Data
0	Custom Bit 17
1	Custom Bit 18
2	Custom Bit 19
3	Custom Bit 20

Bit #	Data
4	Custom Bit 21
5	Custom Bit 22
6	Custom Bit 23
7	Custom Bit 24
8	Custom Bit 25
9	Custom Bit 26
10	Custom Bit 27
11	Custom Bit 28
12	Custom Bit 29
13	Custom Bit 30
14	Custom Bit 31
15	Custom Bit 32

Refer to the product documentation for mapping and operation of these bits.

7.8. Last Alarm Message Status Group

There is a command to request the last alarm code message from the device. This command currently uses only Word 6 to indicate the numeric integer code of the alarm message. This 12-bit code relates to the Smart5 Alarm Code Number

Table 7-13: Last Error Message Status Group

Word 4	Reserved
Word 5	Reserved
Word 6	Alarm Code
Word 7	Response value (= 100)

In devices that support buffering more than one error message, this command also uses optional status word 4 to indicate which error message is requested. The default value (0) in word 4 and devices that only support a single error message will report the last error code. For devices that support an error code buffer, the word 4 parameter is used to indicate which message in the buffer to report. If word 4 is set to 1, the device will report the previous error code. If word 4 is set to 2, it will send the next previous error code and continue in this manner as the value is incremented. For information on how a specific device implements these bits, please refer to the **Last Alarm Message Status Group** section of the corresponding SAI device manual.

7.9. Load Cell Alarm Groups

These groups of status for POWERCELL load cells in a network indicate which cell(s) have alarms present. The benefit of this indication is that it pinpoints exactly the cause of an alarm when more than one POWERCELLs are not responding due to defective load cells, or cabling. If desired, the user may discover the cause of the alarm by requesting the last Alarm code. Each device (load cell) in the system is assigned a status bit as shown below

If fewer than the maximum possible number of attached devices are in use, any unused values should be set to 0. For information on how a specific device implements these bits, please refer to the **Custom Application Group 2** section of the corresponding SAI device manual.

Each status bit should be 0 during normal operation, then 1 when an alarm is present.

Table 7-14: Attached Device Alarm Group 1

Bit #	Attached Device (Load Cell) Alarm
0	Device 1
1	Device 2
2	Device 3
3	Device 4
4	Device 5
5	Device 6
6	Device 7
7	Device 8
8	Device 9
9	Device 10
10	Device 11
11	Device 12
12	Device 13
13	Device 14
14	Device 15
15	Device 16

8 Test Mode

In test mode, the device sends predefined data and allows toggling certain bits for verification purposes. The test mode can be also used to confirm that the device is communicating with the control system even when other parts of the device may not be configured or operational (for example, the scale not yet calibrated).

The Test Mode bit (13) of the RedAlert status bits will turn on and the Data OK bit will turn off when the device is in the test mode. In this state, the device will also accept the other test commands and respond with pre-defined test data instead of normal operational data. For example, when in test mode, the device will respond with an expected fixed weight value instead of the actual weight so that test scripts can be written against these known values. This also provides methods for the control system to force status bits to a specific state for the same reason.

8.1. Entering Test Mode

To enter test mode, the control system must place the value 2.76 (0x4030a3d7) in the floating point write value and send 80h in all four bytes of word 2 and word 3:

<table>
<tr><td>Word 0</td><td colspan="2" rowspan="2">FP value = 2.76</td></tr>
<tr><td>Word 1</td></tr>
<tr><td>Word 2</td><td>Byte 2 = 80</td><td>Byte 1 = 80</td></tr>
<tr><td>Word 3</td><td>Byte 4 = 80</td><td>Byte 3 = 80</td></tr>
</table>

Figure 8-1: Test Mode Entry

8.2. Exit Test Mode

Once the command to exit test mode is received or the device's power is cycled, it will revert to sending operational data instead of test data.

To exit test mode, the control system must send the Exit Test Mode command by sending 88h in both bytes of Word 3.

Word 0	FP value = 2.76	
Word 1		
Word 2	Byte 2 = N/A	Byte 1 = N/A
Word 3	Byte 4 = 88h	Byte 3 = 88

Figure 8-2: Test Mode Exit

If the Custom Format is used and there is no Floating Point Block, the Test Command can be sent through the Write Status Block. If both block types are present, only one command in one of the blocks is required to place the device in or out of test mode.

8.3. Byte Order Selection

If the device is configured to use automatic byte order selection, it will automatically determine which byte order the control system is using. Once the byte order has been determined through a patented process (US10025555B2,) it changes its configuration to match and should then respond to the command in same order as the command data. The response will include the sent value (2.76) so that the control system can verify that the device is sending data in the expected order. All SAI devices implementing this test feature must include patent marking information with reference to this patent number.

If a fixed byte order is selected, the control system is responsible for sending the data in the correct byte order. If there is a byte order mismatch, communication in test mode may not be possible.

8.4. Floating Point Test Commands for "Report" values

If the control system sends a floating point command to report a value when in test mode, the device will respond with fixed data instead of valid data (it may be unable to provide valid data during the test). A simple formula will be used to calculate what this fixed value should be:

5000.11 + Command Value = Reported data value for command

For example, if the command to report gross weight is sent after the device is placed in test mode, the device should provide the proper response value and its floating point value for gross weight should be 5000.11 (5000.11 + 0 = 5000.11). If Net weight is requested, the device should send 5003.11 (5000.11 + 3 = 5003.11).

8.5. Floating Point Test Commands for Scale Status bits

Special test commands are available to turn on and off the scale status bits provided in the floating point blocks when the device has been placed in test mode. See the list provided in the Commands section.

8.6. Status Block Test Commands

Special test commands are available to turn on and off the status bits provided in the status blocks when the device has been placed in test mode. A special error response is provided when a test command is sent for status bits that have not been requested. See the list provided in the Commands section.

8.7. Test Variables for Acyclic and Variable Block Test Commands

Acyclic and variable block test commands do not require the device to be in test mode. To test the acyclic Direct Access Level 1 variables, a reserved index or class/instance/attribute is used for each type of variable (See Commands). Each read variable always returns the same value and does not permit a new value to be written to it. Each write variable expects a specific value to be sent and will return an error state if any other value is sent. No special test command is assigned for Direct Access Level 2 variables.

For Indirect Access and Variable Block tests, two reserved variable names are assigned (see Commands). These variables have no other functional purpose except to respond to test read and test write commands. Each read variable always returns the same value and does not permit a new value to be written to it. Each write variable expects a specific value to be sent and will return an error state if any other value is sent.

8.8. Performance Test Commands

A special command to permit performance testing of the device's data update through the fieldbus interface is provided through the floating point data block. This command (1912) switches the device into a special mode to send a timer count at the rate specified by the value in the floating point write (0 = at A/D rate, 1 = at 1msec rate, n= n msec rate). If the device is generally not capable of providing this data or data at a particular speed, it will return a response of invalid command. It still may be possible that the device cannot reach the desired speed due to other system activity.

Once in this mode, the device will then report the updated count value in the floating point read block at the specified rate.

A. Cyclic Commands

The commands available for the control system to use in Write blocks are grouped according to block type and command type. All commands are considered "one-shot" – meaning that the command is only triggered once even if it remains in the command word for multiple scans until another command is sent. In order to permit a command to be issued a second time, a no-op command is provided.

Please note that the list of cyclic commands is not necessarily exhaustive of all possible cyclic commands. Refer to the SAI device manual for a complete list of commands supported by a specific device

All responses to commands for the cyclic data blocks are provided in the same manner – through the field indicator / channel value. During the process of receiving and executing the operation required for a command, the device will follow a defined sequence, as shown in Figure A-1.

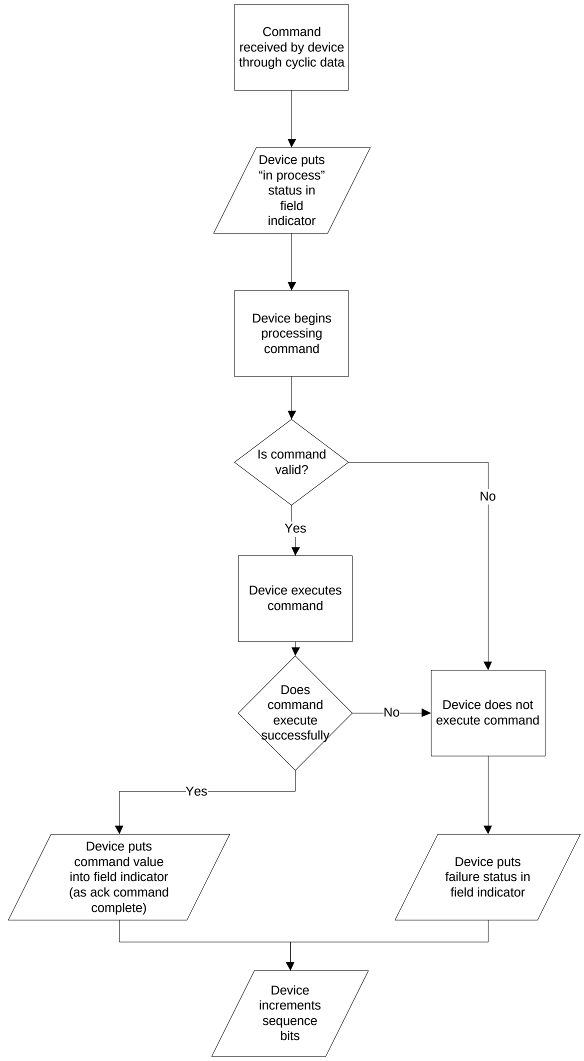

Figure A-1: Receiving and Executing a Command

If a command is aborted, it will follow the sequence shown in Figure A-2.

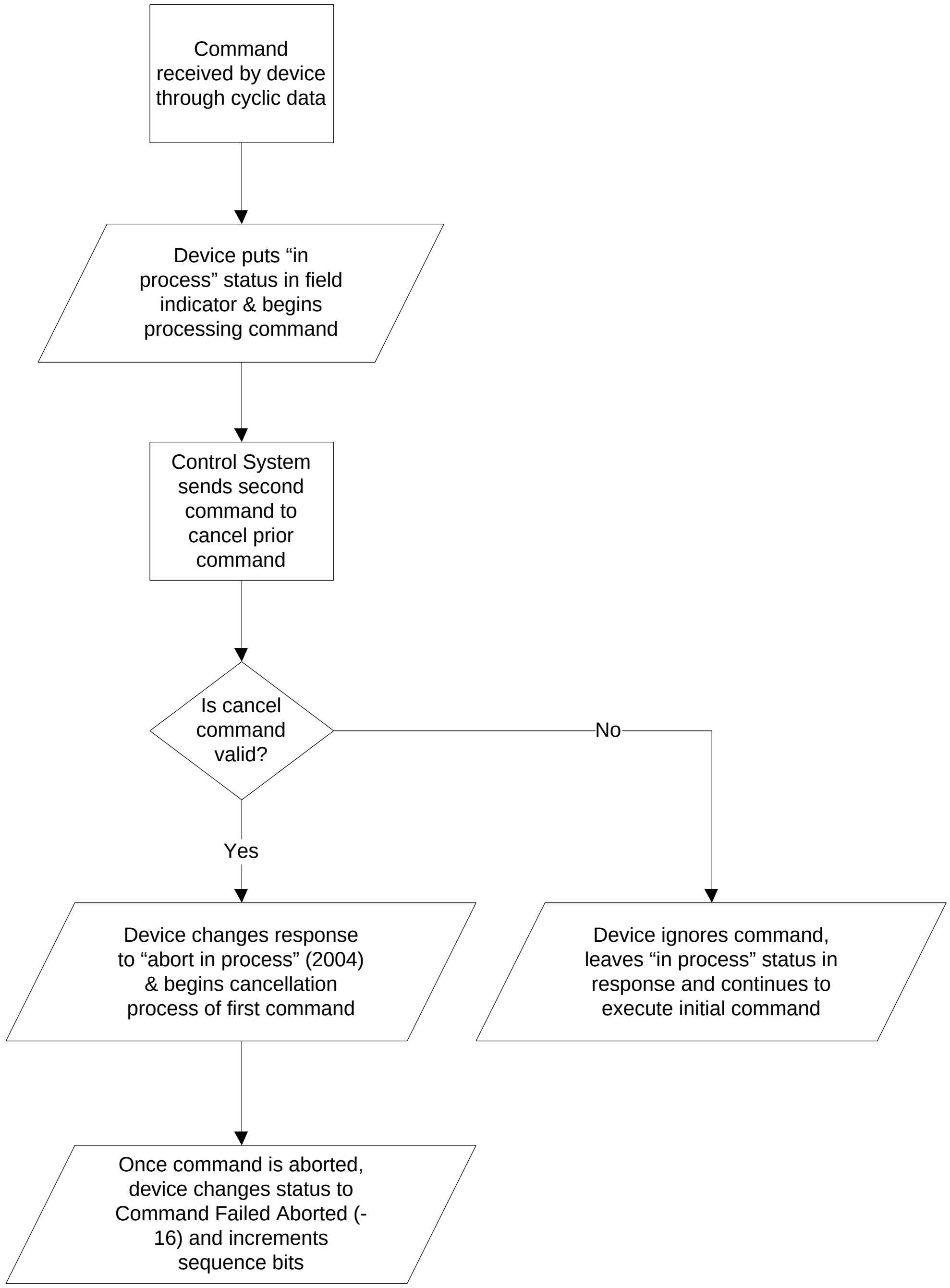

Figure A-2: Aborted Command Sequence

For multi-step commands, special commands are used to advance to the next step, to retry a failed step, or to abort the entire process. There are also corresponding status values to indicate when the device is ready to execute the next step or when the step has failed.

During a stepped procedure, the commands follow the procedure shown in Figure A-3.

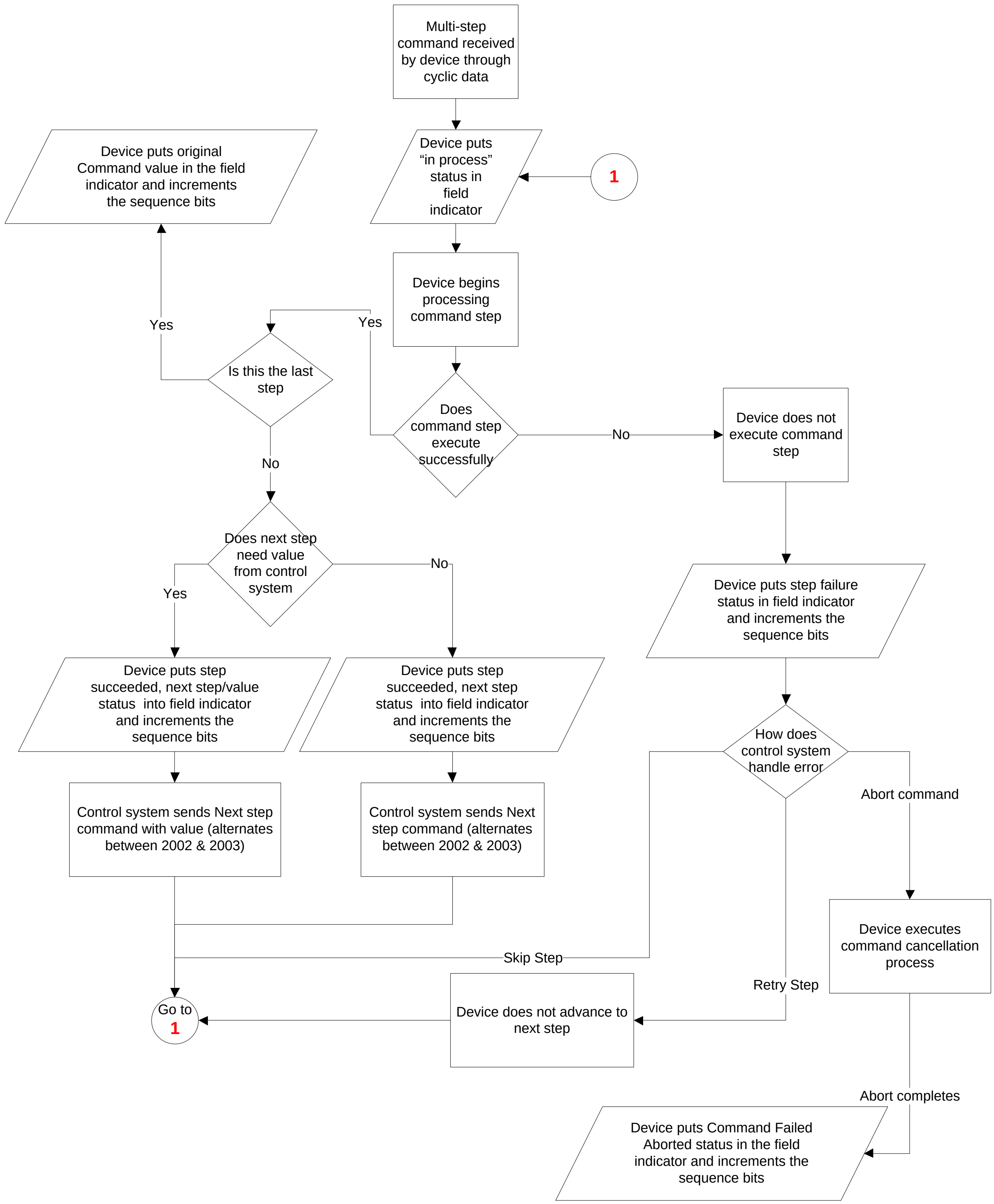

Figure A-3: Stepped Command Procedure

A.1. Special Commands

For all block types, there are some reserved commands used for unique status or command sequencing.

Command	Description	Value
Test Command	Used to determine communication works and byte/word order & enter test mode	FP = 2.76 Mask = 80h, 80h Cmd = 80h, 80h Bit 15 = 1 + … 2185 for both words
Exit Test Mode	Used to return to normal operation	FP & Mask = 0 Cmd = 88h, 88h Bit 15 = 1 + … 6553
Response only	These are used to indicate failed command status through the floating point field … each of these responses turns on bit 15 and the bit value shown in ()	Bit 15 = 1 + …
Response only	Command Failed Invalid	(1)
Response only	Command Failed Timeout	(2)
Response only	Command Failed Unknown	(4)
Response only	Command Failed Value Invalid	(8)
Response only	Command Failed Aborted	(16)
Response only	Command Step Failed	(32)
Response only	Test Command Failed	(64)

A.2. General System Commands

Command	Description	Value
Response only	Command has been received and is being evaluated (in process)	2047
Response only	Step Successful	2046
Response only	Step Successful, Next Value	2045
Response only	Calibration successful but unstable	2044
NOOP 1	No operation command – used to test command response, clear prior command, etc.	2000
Next step 1	Continue to next step in sequence	2002
Next step 2	Continue to next step in sequence	2003
Cancel operation	Abort sequence … response value means abort in process	2004
Retry Step	After step failure, retries previous step in sequence	2005
Skip Step	After step failure, skips step and advances to next in sequence	2006

A.3. Measuring Block Commands

A.3.1. Weight Report Commands

Command	Description	Value
Report Default Value	For terminals & sensors this is Gross weight data in displayed resolution	0
Report Rounded Gross Weight	Gross Weight data is displayed resolution	1
Report Rounded Tare Weight	Tare weight data in displayed resolution	2
Report Rounded Net Weight	Net weight data in displayed resolution	3
Report Rounded Rate	Rate (change in gross weight over time) in displayed resolution	4
Report Gross Weight	Gross weight data in internal resolution	5
Report Tare Weight	Tare weight data in internal resolution	6
Report Net Weight	Net weight data in internal resolution	7
Report Rate	Rate (change in gross weight over time) in internal resolution	8
Report Weight Units		9
Report raw counts	Unprocessed weight data (no filter or unit calculation)	10
Report Peak Weight	Peak Weight application value in displayed resolution	11
Report raw load cell counts	Unprocessed load cell weight data in counts. The channel value in the command is issued to indicate the load cell number.	12
Report Fast Gross Weight	Gross weight at fast update	13
Report Fast Net Weight	Net weight at fast update	14

A.3.2. Target Report Commands

Command	Description	Value
Report Target Weight		20
Report Fine Feed Weight		21
Report Coarse Feed	Coarse Feed Time/Weight value	22
Report Stage 2 Weight		23
Report Stage 1 Weight		24
Report Spill Weight		25
Report (-) Tolerance Weight		26
Report (+) Tolerance Weight		27
Report (-) Tolerance %		28
Report (+) Tolerance %		29

A.3.3. Zone Report Commands

Command	Description	Value
Report Over Zone Weight		30
Report Heavy Zone Weight		31
Report Light Zone Weight		32
Report Under Zone Weight		33

A.3.4. Comparator Report Commands

Command	Description	Value
Report Comparator 1 Limit		40
Report Comparator 1 High Limit		41
Report Comparator 2 Limit		42
Report Comparator 2 High Limit		43
Report Comparator 3 Limit		44
Report Comparator 3 High Limit		45
Report Comparator 4 Limit		46
Report Comparator 4 High Limit		47
Report Comparator 5 Limit		48
Report Comparator 5 High Limit		49
Report Comparator 6 Limit		50
Report Comparator 6 High Limit		51
Report Comparator 7 Limit		52
Report Comparator 7 High Limit		53
Report Comparator 8 Limit		54
Report Comparator 8 High Limit		55
Report Comparator 9 Limit		56
Report Comparator 9 High Limit		57
Report Comparator 10 Limit		58
Report Comparator 10 High Limit		59
Report Comparator 11 Limit		60
Report Comparator 11 High Limit		61
Report Comparator 12 Limit		62
Report Comparator 12 High Limit		63
Report Comparator 13 Limit		64
Report Comparator 13 High Limit		65
Report Comparator 14 Limit		66
Report Comparator 14 High Limit		67
Report Comparator 15 Limit		68

Command	Description	Value
Report Comparator 15 High Limit		69
Report Comparator 16 Limit		70
Report Comparator 16 High Limit		71
Report Comparator 17 Limit		72
Report Comparator 17 High Limit		73
Report Comparator 18 Limit		74
Report Comparator 18 High Limit		75
Report Comparator 19 Limit		76
Report Comparator 19 High Limit		77
Report Comparator 20 Limit		78
Report Comparator 20 High Limit		79

A.3.5. Miscellaneous Report Commands

Command	Description	Value
Report Transaction #		80
Report Sequential #		81
Report Filter Mode		90
Report Filter Environment		91
Report Low Pass Frequency		92
Report Notch Filter		93
Report Stability Filter		94
Report Zero register		95
Report current weight readability		96
Report temperature	Temperature of sensor relevant for weight result	97
Report Fast Weight Filter Frequency	Refer to SICS FCUTD	98

A.3.6. Custom Application Report Commands

Command	Description	Value
Report Custom Field 1	Application Data Field 1	101
Report Custom Field 2	Application Data Field 2	102
Report Custom Field 3	Application Data Field 3	103
Report Custom Field 4	Application Data Field 4	104
Report Custom Field 5	Application Data Field 5	105
Report Custom Field 6	Application Data Field 6	106
Report Custom Field 7	Application Data Field 7	107
Report Custom Field 8	Application Data Field 8	108
Report Custom Field 9	Application Data Field 9	109
Report Custom Field 10	Application Data Field 10	110

Command	Description	Value
Report Custom Field 11	Application Data Field 11	111
Report Custom Field 12	Application Data Field 12	112
Report Custom Field 13	Application Data Field 13	113
Report Custom Field 14	Application Data Field 14	114
Report Custom Field 15	Application Data Field 15	115
Report Custom Field 16	Application Data Field 16	116
Report Custom Field 17	Application Data Field 17	117
Report Custom Field 18	Application Data Field 18	118
Report Custom Field 19	Application Data Field 19	119
Report Custom Field 20	Application Data Field 20	120

A.3.7. Weight Write Immediate Commands

Command	Description	Value
Write Preset Tare Weight	Sets Preset Tare to Value provided	201

A.3.8. Target Write Immediate Commands

Command	Description	Value
Write Target Weight		220
Write Fine Feed Weight		221
Write Coarse Feed	Coarse Feed Time/Weight value	222
Write Stage 2 Weight		223
Write Stage 1 Weight		224
Write Spill Weight		225
Write (-) Tolerance Weight		226
Write (+) Tolerance Weight		227
Write (-) Tolerance %		228
Write (+) Tolerance %		229

A.3.9. Zone Write Immediate Commands

Command	Description	Value
Write Over Zone Weight		230
Write Heavy Zone Weight		231
Write Light Zone Weight		232
Write Under Zone Weight		233

A.3.10. Comparator Write Immediate Commands

Command	Description	Value
Write Comparator 1 Limit		240

Command	Description	Value
Write Comparator 1 High Limit		241
Write Comparator 2 Limit		242
Write Comparator 2 High Limit		243
Write Comparator 3 Limit		244
Write Comparator 3 High Limit		245
Write Comparator 4 Limit		246
Write Comparator 4 High Limit		247
Write Comparator 5 Limit		248
Write Comparator 5 High Limit		249
Write Comparator 6 Limit		250
Write Comparator 6 High Limit		251
Write Comparator 7 Limit		252
Write Comparator 7 High Limit		253
Write Comparator 8 Limit		254
Write Comparator 8 High Limit		255
Write Comparator 9 Limit		256
Write Comparator 9 High Limit		257
Write Comparator 10 Limit		258
Write Comparator 10 High Limit		259
Write Comparator 11 Limit		260
Write Comparator 11 High Limit		261
Write Comparator 12 Limit		262
Write Comparator 12 High Limit		263
Write Comparator 13 Limit		264
Write Comparator 13 High Limit		265
Write Comparator 14 Limit		266
Write Comparator 14 High Limit		267
Write Comparator 15 Limit		268
Write Comparator 15 High Limit		269
Write Comparator 16 Limit		270
Write Comparator 16 High Limit		271
Write Comparator 17 Limit		272
Write Comparator 17 High Limit		273
Write Comparator 18 Limit		274
Write Comparator 18 High Limit		275
Write Comparator 19 Limit		276
Write Comparator 19 High Limit		277

Command	Description	Value
Write Comparator 20 Limit		278
Write Comparator 20 High Limit		279

A.3.11. Miscellaneous Write Immediate Commands

Command	Description	Value
Write Transaction #		280
Write Sequential #		281
Write Filter Mode		290
Write Filter Environment		291
Write Low Pass Frequency		292
Write Notch Filter		293
Write Stability Filter		294
Write Zero register		295
Write “Weight Readability”	Refer to MT-SICS M23	296
Write Fast Weight Filter Frequency	Refer to SICS FCUTD	298

A.3.12. Custom Application Write Immediate Commands

Command	Description	Value
Write Custom Field 1	Application Data Field 1	301
Write Custom Field 2	Application Data Field 2	302
Write Custom Field 3	Application Data Field 3	303
Write Custom Field 4	Application Data Field 4	304
Write Custom Field 5	Application Data Field 5	305
Write Custom Field 6	Application Data Field 6	306
Write Custom Field 7	Application Data Field 7	307
Write Custom Field 8	Application Data Field 8	308
Write Custom Field 9	Application Data Field 9	309
Write Custom Field 10	Application Data Field 10	310
Write Custom Field 11	Application Data Field 11	311
Write Custom Field 12	Application Data Field 12	312
Write Custom Field 13	Application Data Field 13	313
Write Custom Field 14	Application Data Field 14	314
Write Custom Field 15	Application Data Field 15	315
Write Custom Field 16	Application Data Field 16	316
Write Custom Field 17	Application Data Field 17	317
Write Custom Field 18	Application Data Field 18	318
Write Custom Field 19	Application Data Field 19	319

Command	Description	Value
Write Custom Field 20	Application Data Field 20	320

A.3.13. Weight Operation Immediate Commands

Command	Description	Value
Tare	Tare executed with motion check	400
Zero	Zero executed with motion check	401
Clear Tare	Motion not checked, clear tare executed	402
Tare Immediate	Motion not checked, tare executed	403
Zero Immediate	Motion not checked, zero executed	404

A.3.14. Print / Communication Operation Immediate Commands

Command	Description	Value
Print	Demand Print executed	410
Trigger 1	Custom communication trigger 1 executed	411
Trigger 2	Custom communication trigger 2 executed	412
Trigger 3	Custom communication trigger 3 executed	413
Trigger 4	Custom communication trigger 4 executed	414
Trigger 5	Custom communication trigger 5 executed	415
Trigger 6	Custom communication trigger 6 executed	416
Trigger 7	Custom communication trigger 7 executed	417
Trigger 8	Custom communication trigger 8 executed	418
Trigger 9	Custom communication trigger 9 executed	419
Trigger 10	Custom communication trigger 10 executed	420

A.3.15. Miscellaneous Operation Immediate Commands

Command	Description	Value
Clear Alarm		430
Clear Transaction #		431
Clear Sequential #		432
Clear Peak Weight		433
Apply Filter		434

A.3.16. Target Operation Immediate Commands

Command	Description	Value
Start Target		500
Pause Target		501
Resume Target		502
Abort Target		503

Command	Description	Value
Apply Target		504
Apply Comparators		510

A.3.17. Display / Keyboard Operation Immediate Commands

Command	Description	Value
Clear Display Message		600
Display Message 1		601
Display Message 2		602
Display Message 3		603
Display Message 4		604
Display Message 5		605
Display Message 6		606
Display Message 7		607
Display Message 8		608
Display Message 9		609
Display Message 10		610
Disable Weight Display		630
Enable Weight Display		631
Disable Keypad		632
Enable Keypad		633
Reset Enter key bit		634
Select Scale	Changes the weight display focus and "selects" scale (bit in scale status becomes true) – uses channel in command to indicate which scale is selected	640

A.3.18. Select Weight Unit Commands

Command	Description	Value
Select Unit	Switches to unit selected in parameter (uses same values as found in report weight units command 9)	700
Switch to first unit	Changes to primary unit	701
Switch to second unit	Changes to secondary unit	702
Switch to third unit	Changes to third unit	703

A.3.19. Dynamic Application Commands

Command	Description	Value
Last ProcessWeight	Last dynamic weight value	800
Object length	Calculated object length	801
Report Dynamic weighments	Calculated number of dynamic weighments (counts integer)	802

Command	Description	Value
Report Max Dynamic	Maximum dynamic weight value	803
Report Min Dynamic	Minimum dynamic weight value	804
Report Average Dynamic	Mean dynamic weight value	805
Report Standard Deviation	Standard deviation of last 20 dynamic weighments	806

A.3.20. Discrete Output Operation Immediate Commands

Command	Description	Value
Turn all internal & external outputs OFF	Forces all outputs OFF	1000
Turn 1st internal Output 1 OFF		1001
Turn 1st internal Output 2 OFF		1002
Turn 1st internal Output 3 OFF		1003
Turn 1st internal Output 4 OFF		1004
Turn 1st internal Output 5 OFF		1005
Turn 1st internal Output 6 OFF		1006
Turn 1st internal Output 7 OFF		1007
Turn 1st internal Output 8 OFF		1008
Turn 2nd internal Output 1 OFF		1009
Turn 2nd internal Output 2 OFF		1010
Turn 2nd internal Output 3 OFF		1011
Turn 2nd internal Output 4 OFF		1012
Turn 2nd internal Output 5 OFF		1013
Turn 2nd internal Output 6 OFF		1014
Turn 2nd internal Output 7 OFF		1015
Turn 2nd internal Output 8 OFF		1016
Turn 1st external Output 1 OFF		1017
Turn 1st external Output 2 OFF		1018
Turn 1st external Output 3 OFF		1019
Turn 1st external Output 4 OFF		1020
Turn 1st external Output 5 OFF		1021
Turn 1st external Output 6 OFF		1022
Turn 1st external Output 7 OFF		1023
Turn 1st external Output 8 OFF		1024
Turn 2nd external Output 1 OFF		1025
Turn 2nd external Output 2 OFF		1026
Turn 2nd external Output 3 OFF		1027
Turn 2nd external Output 4 OFF		1028
Turn 2nd external Output 5 OFF		1029

Command	Description	Value
Turn 2nd external Output 6 OFF		1030
Turn 2nd external Output 7 OFF		1031
Turn 2nd external Output 8 OFF		1032
Turn 1st internal Output 1 ON		1101
Turn 1st internal Output 2 ON		1102
Turn 1st internal Output 3 ON		1103
Turn 1st internal Output 4 ON		1104
Turn 1st internal Output 5 ON		1105
Turn 1st internal Output 6 ON		1106
Turn 1st internal Output 7 ON		1107
Turn 1st internal Output 8 ON		1108
Turn 2nd internal Output 1 ON		1109
Turn 2nd internal Output 2 ON		1110
Turn 2nd internal Output 3 ON		1111
Turn 2nd internal Output 4 ON		1112
Turn 2nd internal Output 5 ON		1113
Turn 2nd internal Output 6 ON		1114
Turn 2nd internal Output 7 ON		1115
Turn 2nd internal Output 8 ON		1116
Turn 1st external Output 1 ON		1117
Turn 1st external Output 2 ON		1118
Turn 1st external Output 3 ON		1119
Turn 1st external Output 4 ON		1120
Turn 1st external Output 5 ON		1121
Turn 1st external Output 6 ON		1122
Turn 1st external Output 7 ON		1123
Turn 1st external Output 8 ON		1124
Turn 2nd external Output 1 ON		1125
Turn 2nd external Output 2 ON		1126
Turn 2nd external Output 3 ON		1128
Turn 2nd external Output 4 ON		1129
Turn 2nd external Output 5 ON		1130
Turn 2nd external Output 6 ON		1131
Turn 2nd external Output 7 ON		1132
Turn 2nd external Output 8 ON		1133

A.3.21. Custom Application Operation Immediate Commands

Command	Description	Value
Custom Application Command 1	Application Command trigger 1	1201
Custom Application Command 2	Application Command trigger 2	1202
Custom Application Command 3	Application Command trigger 3	1203
Custom Application Command 4	Application Command trigger 4	1204
Custom Application Command 5	Application Command trigger 5	1205
Custom Application Command 6	Application Command trigger 6	1206
Custom Application Command 7	Application Command trigger 7	1207
Custom Application Command 8	Application Command trigger 8	1208
Custom Application Command 9	Application Command trigger 9	1209
Custom Application Command 10	Application Command trigger 10	1210
Custom Application Command 11	Application Command trigger 11	1211
Custom Application Command 12	Application Command trigger 12	1212
Custom Application Command 13	Application Command trigger 13	1213
Custom Application Command 14	Application Command trigger 14	1214
Custom Application Command 15	Application Command trigger 15	1215
Custom Application Command 16	Application Command trigger 16	1216
Custom Application Command 17	Application Command trigger 17	1217
Custom Application Command 18	Application Command trigger 18	1218
Custom Application Command 19	Application Command trigger 19	1219
Custom Application Command 20	Application Command trigger 20	1220

A.3.22. Calibration Setup Commands

Command	Description	Value
Primary Unit	Configures primary weight unit – parameter value selects weight unit (same values as report command 9)	1700
Second Unit	Configures second weight unit – parameter value selects weight unit (same values as report command 9)	1701
Third Unit	Configures third weight unit – parameter value selects weight unit (same values as report command 9)	1702
Calibration Unit	Configures calibration weight unit – parameter value selects weight unit (same values as report command 9 but some restrictions may apply)	1703
Geo code	Configures Geo Code value (value between 0-31)	1704
Linearity Adjust	Configure linearity adjust setting – 0=none ,1= 3 pt, 2= 4 pt, 3= 5 pt	1705
Span Adjustment value (Xlow)	Only used for 5 pt linearity adjust	1706
Span adjustment value (Low)	Only used for 4 pt and 5 pt linearity adjust	1707
Span adjustment value (Mid)	Only used for when any linearity adjust is enabled	1708

Command	Description	Value
Span adjustment value (High)	Sets highest span value – used for all linearity and span adjust procedures	1709
Span counts value (Xlow)	Used with span value xlow	1710
Span counts value (Low)	Used with span value low	1711
Span counts value (Mid)	Used with span value mid	1712
Span counts value (High)	Used with span value high	1713

A.3.23. CalFREE Setup Commands

Command	Description	Value
CalFREE Cell capacity	Cell capacity value used for CalFree calibration	1720
CalFREE unit	CalFREE calibration unit	1721
CalFFREE cell output	CalFREE cell output rating	1722

A.3.24. Calibration Commands

Command	Description	Value
Zero Calibration		1500
Span Calibration		1501
Step Calibration	Triggers start of step calibration – parameter sent includes number of calibration steps to execute	1502
Step Adjustment	Triggers step adjustment – parameter value included to indicate span value for step	1503
CalFREE Calibration	Triggers CalFREE (parameters must have already been loaded via setup commands)	1504
CalFREE Plus Calibration	Triggers CalFREE Plus calibration process	1505
Save / Confirm calibration	Saves calibration	1506

A.3.25. Floating Point Status Bit Test Commands

Command	Description	Value
Alarm Bit	Turn on or off bit in scale status word when in test mode … FP = 1 to set ON or FP = 0 to set OFF	1900
Motion Bit		1901
Net Mode bit		1902
Center of zero bit		1903
Alt weight bit		1904
Device bit 1		1905
Device bit 2		1906
Device bit 3		1907
Device bit 4		1908
Device bit 5		1909
Device bit 6		1910

Command	Description	Value
Device bit 7		1911
Performance Mode	0 = send performance count at A/D rate 1 = send performance count at 1 msec interval *n* = send performance count at *n* msec interval	1912

A.4. Status Block Commands

Status block commands are unique to this block type and not ALL block types. So for example, a command value of 0 in the status/command block will report the default status words (RedAlert, I/O Group 1, Scale Group 2 Status bits).

A.4.1. Status Commands

Command	Description	Value
Report Default Status words	Default status words (see below)	0
Report RedAlert Alarm, Scale Group 2, I/O group 1	RedAlert Alarm, Scale group 2, I/O group 1	1
Report Target / Comparator Status	Target 1, Comparator group 1, Comparator group 2	2
Report Target mix 1	Target 1, I/O group 1, custom group 1	3
Report Target mix 2	Target 1, I/O group 2, custom group 2	4
Report Target mix 3	Target 1, I/O group 3, I/O group 4	5
Report Target mix 4	Target 1, I/O group 5, I/O group 6	6
Report Target mix 5	Target 1, I/O group 7, I/O group 8	7
Report Target mix 6	Target 1, I/O group 9, I/O group 10	8
Report I/O mix 1	I/O group 2, I/O group 3, I/O group 4	9
Report I/O mix 2	I/O group 5, I/O group 6, I/O group 7	10
Report I/O mix 3	I/O group 8, I/O group 9, I/O group 10	11
Report Custom / I/O mix 1	Custom group 1, custom group 2, I/O group 1	12
Report Custom / I/O mix 2	Custom group 1, custom group 2, I/O group 2	13
Report Custom / I/O mix 3	Custom group 1, I/O group 1, I/O group 2	14
Report Custom / I/O mix 4	Custom group 2, I/O group 3, I/O group 4	15
Report Comparator mix 1	Comparator group 1, comparator group 2, I/O group 1	16
Report Comparator mix 2	Comparator group 1, comparator group 2, I/O group 2	17
Report Comparator mix 3	Comparator group 1, I/O group 1, I/O group 2	18
Report Targets group 1	Target 1, Target 2, Target 3	19
Report Targets group 2	Target 4, Target 5, Target6	20
Report Alarms & Scale Group 2	RedAlert Alarm, Alarm, Scale Group2	21
RedAlert, / Comparator	RedAlert,, Comparator 1, Comparator 2	22
Alarm / Custom mix	Alarm, I/O group 1, Custom group 1	23

Command	Description	Value
Load cell error / custom mix	Load cell group 1, load cell group 2, Custom group 1	24
Report Last Error Code*	Error code structure	100
User selected status words	Command to indicate Words 0-2 should be read to determine which status words to send	256 and 257

The default for terminals and sensors is the same as command 1. This allows devices which need to support a different default to provide it at a later date.

* When the Report Last Error Code command is sent, an optional value in word 4 is used to indicate which error message is desired when the device supports buffering more than one error code message. The default value (0) will report the last error message. Any other value will request the message at n + the value's position in the buffer. For example, if 3 is placed in the word 4 value, the device should respond with the error code that occurred three spots ahead of the last error message.

When the user selected status word commands are sent, the values below are placed in Words 0 – 2 of the Write block to indicate which status words are wanted:

Optional status word selection value	Description
0	No selection
1	Red Alert
2	Alarms
3	Scale Status Group 2
11	I/O Group 1
12	I/O Group 2
13	I/O Group 3
14	I/O Group 4
15	I/O Group 5
16	I/O Group 6
17	I/O Group 7
18	I/O Group 8
19	I/O Group 9
20	I/O Group 10
21	I/O Group 11
22	I/O Group 12
23	I/O Group 13
24	I/O Group 14
31	Comparator Group 1
32	Comparator Group 2
33	Comparator Group 3
34	Comparator Group 4
35	Comparator Group 5

Optional status word selection value	Description
36	Comparator Group 6
51	Target Group 1
52	Target Group 2
53	Target Group 3
54	Target Group 4
55	Target Group 5
56	Target Group 6
71	Custom App Group 1
72	Custom App Group 2
73	Load Cell Errors Group 1
74	Load Cell Errors Group 2

A.4.2. Variable block Commands

Variable block requires only two types of commands – a read (report data) command and a write (write data) command. In addition to the command, the block includes data to refer to a specific variable within the device.

Command	Description	Value
Report Data	Reads the information from the variable specified in the class, node, instance, and attribute included in the block	82, 114
Write data	Writes the value supplied to the variable specified in the class, node, instance, and attribute included in the block	87, 119
No-op	Default command, no variable specified	0

B. Acyclic (Explicit) Commands

Asynchronous message commands are similar in structure to variable block commands. However, these are control system interface dependent. Typically these support only two types of commands: a read (or get) and a write (or set).

Please note that the list of acyclic commands is not necessarily exhaustive of all possible acyclic commands. Refer to the SAI device manual for a complete list of commands supported by a specific device.

B.1. Direct Level 1

The Direct Level 1 variables have different index or class/instance/attribute codes based on the type of control system fieldbus used. The values for PROFIBUS, PROFINET, and EIP systems are as shown in the following tables.

B.1.1. Report Weight Values

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Report Default Data	For terminals & sensors this is Gross weight data in displayed resolution	14	2000	300 , 001	Floating Point
Report Rounded Gross Weight	Gross Weight data is displayed resolution	15	2001	300 , 002	Floating Point
Report Rounded Tare Weight	Tare weight data in displayed resolution	16	2002	300 , 003	Floating Point
Report Rounded Net Weight	Net weight data in displayed resolution	17	2003	300 , 004	Floating Point
Report Gross Weight	Gross weight data in internal resolution	18	2004	300 , 005	Floating Point
Report Tare Weight	Tare weight data in internal resolution	19	2005	300 , 006	Floating Point
Report Net Weight	Net weight data in internal resolution	1A	2006	300 , 007	Floating Point
Report Tare Status	State of tare command progress	1F	2008	300, 016	Floating Point
Report Zero Status	State of zero command progress	24	2009	300 , 017	Floating Point

B.1.2. General Weighing Commands

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Write Tare (Preset tare)	Writes value provided as tare	1B	2020	300 , 008	Floating Point
Tare (with motion check)	Tare of current scale value after motion check	1C	2010	300 , 009	Binary
Clear Tare	Clear tare value (no motion check)	1D	2012	300 , 011	Binary
Tare Immediate	Tare of current scale value (no motion check)	1E	2011	300 , 010	Binary
Read Zero register	Read current zero value	20	2007	300 , 012	Floating Point
Write Zero register	Write value in to zero value	21	2021	300 , 013	Floating Point

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Zero (with motion check)	Zero scale after motion check	22	2013	300 , 014	Binary
Zero Immediate	Zero scale (no motion check)	23	2014	300 , 015	Binary
Select Scale (Channel)	Selects scale/channel if device supports multi-channel/multi-scale operation	32	200B	300, 019	Integer

B.1.3. General Device Information

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Report ID1	Device identification information #1	2B	2050	303 , 001	String
Report ID2	Device identification information #2	2C	2051	303 , 002	String
Report ID3	Device identification information #3	2D	2052	303 , 003	String
Report Software version	Device software OS version	2E	2053	303 , 004	String
Report Fieldbus version	Device fieldbus stack version	2F	2054	303 , 005	String
Report Software app version	Device application software version	30	2055	303 , 006	String
Report SAI version	Device supported SAI version	31	2056	303 , 007	String

B.1.4. Miscellaneous Commands

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Clear Alarm	Resets alarms	25	2030	30001	Binary
Turn OFF all outputs	Disables all outputs (turns to OFF state)	26	2031	30002	Binary

B.1.5. Status Group Information

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Report Scale Status Group 1	Reports scale status bits (group 1)	27	2040	302 , 001	Bit Level
Report Alarm Status Group	Reports alarm status bits	28	2041	302 , 002	Bit Level
Report RedAlert Status Group	Reports RedAlert status bits	29	2042	302 , 003	Bit Level
Report Scale Status Group 2	Reports scale status bits (group 2)	2A	2043	302 , 004	Bit Level

B.1.6. Test Commands

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Read Floating Point	Reports test floating point value (123.45) no write	A	5000	30F , 001	Floating Point
Write Floating Point	Allows write and read for test purposes - FP	B	5001	30F , 002	Floating Point
Read Integer	Reports integer value (9876)	C	5002	30F , 003	Integer
Write Integer	Allows write and read for test purposes - INT	D	5003	30F , 004	Integer
Read String	Reports string value (ABCD)	E	5004	30F , 005	String
Write String	Allows write and read for test purposes - STR	F	5005	30F , 006	String
Read Long Integer	Reports long integer value (98765)	10	5006	30F , 007	Long
Write Long Integer	Allows write and read for test purposes – Long INT	11	5007	30F , 008	Long
Read Byte	Reports byte value (56h)	12	5008	30F , 009	Byte
Write Byte	Allows write and read for test purposes - byte	13	5009	30F , 010	Byte

B.2. Direct Level 2

The direct level variables are application and device specific and provided as part of the device documentation.

B.3. Indirect Variables

The indirect access method uses a small set of index and class/instance/attribute codes to provide access to all variables. The variable used is "named" within the data sent to the device.

B.3.1. Indirect Commands

Command	Description	Profibus Slot 1 index (hex)	ProfiNET Slot,subslot = 0,1 index (hex)	EIP class, instance, attribute (hex)	Data Type
Read Variable	Read a variable specified by prior Request Read	0	0 and 1, 3000	310 , 001	Varies by type of variable
Write Variable	Write value into variable specified	1	1 and 3001	310 , 002	Varies by type of variable
(Write) Request Read Variable	Specify variable that will be used in Read command	2	2 and 3003	310 , 003	Varies by type of variable

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