PLC Integration

Scale Operation 101

For PLC Integration

For safe and reliable functionality between scales and automation systems, it is necessary to understand METTLER TOLEDO scale operation. Such knowledge leads to easier integration with Distributed Control Systems (DCS), Programmable Automation Controllers (PAC) or Programmable Logic Controllers (PLC), referred to as PLC for brevity throughout the rest of this document.

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METTLER TOLEDO

i Introduction

Understanding Scales

For safe and reliable functionality between scales and automation systems, it is necessary to understand METTLER TOLEDO scale operation. Such knowledge leads to easier integration with Distributed Control Systems (DCS), Programmable Automation Controllers (PAC) or Programmable Logic Controllers (PLC), referred to as PLC for brevity throughout the rest of this document. Understanding Zero & Tare operation, reading Net weight, and monitoring the scale status are typical functions discussed in this document.

Not all features, parameters and communication protocols listed in this technical note are available in every product. In addition, selected features and settings differ between products. Refer to the applicable product-specific documentation for details.

The intention of this technical note is to be an overview of general terms and a brief tutorial for scale operation. It is not a substitute for the complete product documentation listed below.

Product Documentation

Refer to the following manuals for essential details. Note that not all manuals exist for every model. All manuals are product-model specific. Manuals are available for download from **www.mt.com**.

User Guides – explain menu navigation, configuration, calibration, adjustment and scale operation.

PLC Interface Manuals – detail METTLER TOLEDO legacy protocol data definitions and PLC interface set up. This documentation is only available for products that support the METTLER TOLEDO legacy protocol.

SAI Reference Manuals – detail the METTLER TOLEDO Standard Automation Interface (SAI) protocol data definitions. This documentation is only available for products that support the SAI protocol.

Shared Data Reference Manuals – list data available to PLCs via acyclic messaging.

Installation Manuals – detail physical installation, wiring and commissioning requirements.

1 Scale Terminology

Scale Values

Gross weight – the entire weight applied to the scale, container and contents, regardless of the weight displayed. Gross does not include the preload (permanent vessel and fixtures) Zero adjustment completed during setup.

Zero weight – the weight that accumulates from fallen material, debris, snow or rain that is either automatically or manually zeroed (electronically added to or removed from the displayed weight to achieve a zero indication). This value is limited to +2% in applications where weights-and-measures regulations are in force. In other applications, it is limited up to 100% of scale capacity. Zero must not be used to electronically eliminate an empty container weight. Use a Tare command instead.

Tare weight – weight subtracted from the Gross weight. Invoked by sending a Tare command, the stored Tare weight is then subtracted from the Gross weight to result in Net weight. The Tare weight does not extend the scale capacity. Tare plus Net cannot exceed the scale capacity. In some instances, Tare is inhibited during motion (unstable weight readings); motion sensitivity is selectable on many products. A "Tare immediate" command ignores motion. A Tare value will remain until the scale reaches a Zero Gross state (setup dependent) or a "Clear Tare" command is issued by the PLC.

Net weight – the result of subtracting the Tare weight from the Gross weight. This weight will be indicated as Net in the display and in the PLC data. If Net weight is important, then Net and Gross weight must be monitored by the PLC because the PLC-read Gross weight will not change state when a Tare command is issued. In contrast, Net weight will indicate zero when a Tare command is issued and increase as weight is added. If the programmer only wants to read one weight value, then they should monitor Displayed weight.

Displayed weight – this will be the Gross weight while in Gross mode or the Net weight while in Net mode. The mode is indicated on the scale terminal/transmitter display with B/G (Gross) or Net (Net). When a PLC is monitoring Displayed weight, the PLC will read exactly what an operator would see on the display.

	Operation Results				
Scale Operation	Gross Weight	Net Weight	Displayed Weight	Display Indicator	Net Mode Status Bit
Add 950 kg container	950 kg	0 kg	950 kg	Gross	0
Tare from keyboard or PLC command	950 kg	0 kg	0 kg	Net	1
Add 50kg	1,000 kg	50 kg	50 kg	Net	1
Clear Tare from keyboard or PLC command	1,000 kg	0 kg	1,000 kg	Gross	0

Rate – the calculated rate of weight change as defined in setup. This is a value in units/time, not a rate-control output.

Comparator – a threshold value, which is logically compared to weight and produces a change of discrete output or PLC status. Comparators are not latched, meaning that their state will change should the weight drop below their threshold value. If latching is required, it must be performed by the PLC program or the use of a Target is recommended. Comparators can be assigned to discrete outputs and monitored by the PLC program.

Target – a cutoff (setpoint) weight used by the scale terminal for material transfer control. This latched control requires a "start" command to activate. After the cutoff value has been reached, the control will not turn on again until another start command is initiated. Targets can be assigned to discrete outputs and monitored by the PLC program.

Scale Commands

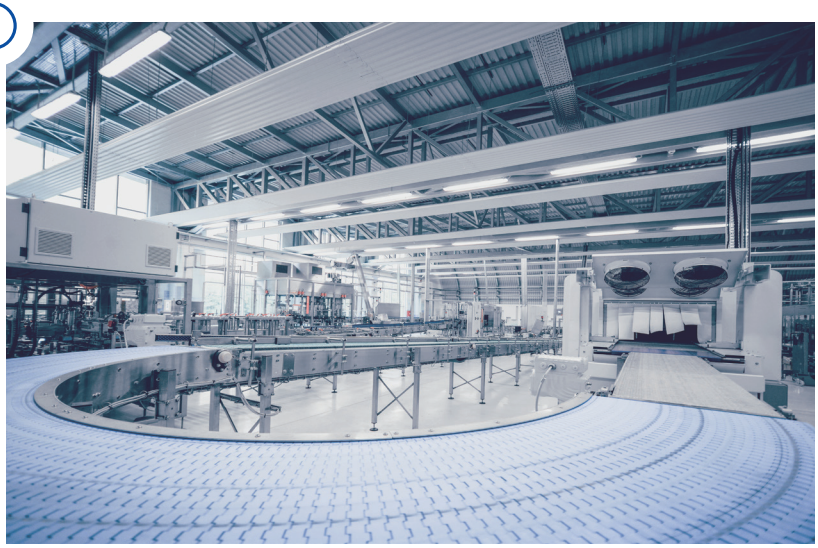
Note: Scale function commands should not be maintained. An explanation appears in the Operation section later in this paper.

Tare command – instructs the scale to subtract current Gross weight. The Gross weight must be a stable, positive, non-zero value to process. Results in a displayed weight of 00000 Net and the Net mode status bit is set to a 1. Same as pressing Tare on a terminal keypad. A Tare Immediate command will allow a Tare operation while the scale is in motion.

Clear [Tare] command – instructs the scale to eliminate the stored Tare value from memory and restore the Displayed (Net) weight back to Gross weight. A successful Clear command restores the Net mode bit to a 0. Clear can be configured to operate or be inhibited while the scale is in motion.

Zero command – instructs the scale to capture a new Gross zero. Can only be performed while the scale is in Gross mode (no Tare), stable (no motion) and only within a limited, accumulated range – the Zero (capture) range is a percentage of scale capacity from the adjusted zero derived during the initial setup / calibration / adjustment. The default is ± 2% and is adjustable in scale configuration. For example, a 1000-kilogram scale will allow +/- 20 kilograms for the Zero range when using the default setting. If a Zero command fails, it is commonly due to accumulated material that exceeds this Zero range. A Zero Immediate command will allow a Zero operation while the scale is in motion.

METTLER TOLEDO components are quickly configured via a web browser that allows backup, unit to unit cloning and restoration of these important files.



Scale Statuses

Motion – status bit = 1, indicating the weight is changing (material is being added/removed or the scale is unstable). The Motion status bit sensitivity is defined in setup (configuration). Terminal displays indicate Motion with a tilde (~) symbol.

Gross mode – status (implied) when there is no Tare. Indicated when Net mode status bit = 0. Scale terminals display a Gross indication.

Net mode – status bit = 1, indicating a Tare command was executed. Scale terminals display a Net indication.

Discrete I/O – optional discrete I/O statuses (states) can be read by a PLC interface or discrete outputs available on selected products.

Scale Setup (configuration)

Scale capacity – the maximum configured, adjusted weight value indicated on the scale platform's data plate and as the standard limit of the display. Many products indicate weight above this limit, but this weight shall not be used as a "true" weight value because its measurement uncertainty is very high due to the value being outside the calibrated limit. This is not the total load cell capacity. Scale capacity should be less, and is often much less, than the total combined load cell capacity.

Increment size – the smallest displayed division of weight. Also known as resolution. Also known as readability, recommended readability, or approved readability.

Resolution – the capability of a product to parse the maximum weight into discernable units, but it differs from readability in that it may contain electrical and mechanical noise. Resolution is not accuracy.

Scale Faults

Over Capacity – condition where the Gross weight exceeds a preset point above the scale capacity. This point is adjustable in setup.

Under Capacity – condition where the Gross weight exceeds a preset point below Gross Zero. This point is adjustable in setup.

METTLER TOLEDO provides cyclical condition monitoring data including heartbeat and RedAlert™ alarms that notify your control systems in real time that weight is wrong.

2 Scale Interface to PLC Terminology

Status Bits – Legacy and SAI protocol

Data OK – status bit = 1, indicating the scale is not in a faulted state following initial startup of the device. Common triggers that set Data OK to a 0 include Over Capacity, Under Capacity or the scale terminal is in setup. All data must be considered invalid if the Data OK bit = 0.

Status Bits – Legacy protocol only

Data Integrity 1 & 2 – these bits change to the opposite state every interface update cycle and should have the same value as each other. If they do not have the same value as each other, data is invalid and the PLC program should ignore all of the data and re-scan it. Data Integrity bits cannot be used as a heartbeat.

Command Acknowledge 1 & 2 – together these two bits count 0 to 3 (decimal) with each command received and then return to zero and repeat the count up.

Floating Point Input Indicator 1-5 – the Floating Point Input Indication bits are used to determine what type of data is being sent in the floating point value. These bits correspond to a decimal value of 0-31 that represents a particular data value. See the Floating Point Input Indication Table in the applicable PLC interface manual to determine the data value.

Status Bits – SAI protocol only

Heartbeat – status bit that toggles at 1 hertz indicating the device is capable of sending data and is not locked in a mode where an invalid weight value is being retransmitted. This heartbeat can also be used a mechanism to identify potential security issues.

Sequence Bit 1 & 2 – together these two bits count 0 to 3 (decimal) with each command received and then return to zero and repeat the count up. Their purpose is to indicate when a valid command has been received and the corresponding value has been updated. If this value has not been updated, the programmer should wait for the next cycle before reading the new value. For example, when a command has been issued in the "0" sequence the next valid read would be in the "1" sequence. If the read indicates the "0" sequence it indicates that the scale has not processed the instruction.

Alarm condition – the alarm condition indicates a system error. The nature of the error can be determined by reading the RedAlert™ Alarms and Command response.

Cyclic Data – Legacy protocol only

Message slots – each message slot can convey a distinct value or command.

Cyclic Data – SAI protocol only

Cyclic blocks – blocks come in various predefined types and each block can convey distinct values or commands.

3 Working Scale Requirement

METTLER TOLEDO scale terminals and transmitters require that the weight sensor or scale is transmitting valid weight data in order to process / transmit usable weight values to the PLC. If the scale stops transmitting to the terminal, a scale error will appear in the status word that the terminal makes available to the PLC. Therefore, PLC program testing on a terminal must be performed with a functional scale connected to the terminal. The actual platform or load cell(s) used in the final installation are not always available or practical for program development and testing. A load cell simulator fills this gap.

The following load cell simulators are available for purchase from METTLER TOLEDO. The analog (strain gage) or PDX simulator type must match the actual scale type:

- P/N 68000624 analog load cell simulator with 10 turn potentiometer and a 1-meter cable.
- P/N 61044431 PDX POWERCELL load cell simulator with a 1-meter cable.
- Digital precision platforms require that an actual sensor be used.

4 Scale Setup (configuration)

Note: Scale configuration is always necessary for proper weight sensor and scale operation.

- Configure the scale for the desired units and ensure unit-switching capability is disabled. Unit switching must never be used in an automation system.
- Configure the scale capacity and increment size (readability). High-precision bases and digital cells store those parameters (within the cell) and are factory configured for their default capacity and increment size. These are indicated on the data plate.
- Approximate calibration or adjustment with the actual scale base or a simulator is likely necessary to produce weight values useful for program testing. High-precision bases and cells are factory adjusted.
- Zero command functionality and range limits set for the use case or application.
- Tare command functionality, including chain (repeated) Tare, Auto-Tare or Auto Clear Tare.
- PLC data size is affected by the data format and number of message slots/blocks. EtherNet/IP and ControlNet Add-On Profiles for Rockwell Automation controllers have settings that match the scale menu selections, simplifying the data size setup in the PLC.
- PLC communication settings. The EtherNet/IP, Modbus TCP or PROFINET port settings are in the Setup > Communication > PLC menu. Do not confuse them with the Ethernet TCP/IP port setting in the Setup > Communication > Network menu.
- Connect the fieldbus network cables. Connect the Ethernet network cables as follows.

  - Do not confuse the Ethernet TCP/IP port connector (on models so equipped) with the EtherNet/IP, Modbus TCP or PROFINET port connector. Refer to the product documentation to determine the correct connector to use

  - Products that support DLR or MRP have two identical ports with built-in Ethernet switch. Either connector may be used for the end of the line. The port used is irrelevant in daisy-chained or ring topologies.

METTLER TOLEDO components enable setting the system to the "last known good state" to enable fast serviceability and troubleshooting either at device or remotely through a protected connection.

5 Operation

Note: Perform any of these scale operations using cyclic or acyclic commands. Test scale functions using the terminal keypad if experiencing trouble with Zero, Tare or Clear commands.

Scale function commands (Zero, Tare, Clear Tare and writing values to the scale) should be sent only until an appropriate response is received. Maintained commands will preclude other commands and prevent normal operation. Monitor command acknowledgement and command response statuses. Verify execution by testing the reported weight value and net mode status.

Weight value requests can be maintained indefinitely

Reading weight – many METTLER TOLEDO weighing instruments continuously send Gross weight by default. Request other values by sending the appropriate command. Requesting Net weight will always return Net or Gross weight with the Net Mode status bit and Floating-Point Indicator bits identifying the value sent.

Zero the scale – the scale Zero command captures a new Zero reference point. This can be used to compensate for material build up or other changes in the Zero point. Do not use Zero to remove a container weight; use Tare instead.

Capturing Zero – while the scale is in motion is not recommended and it is not available in many products. When sending the Zero command on most products while the scale is in motion, the command is executed if motion stops within the stability timeout period (default is three seconds and is adjustable). Upon timeout, the terminal displays and sends a command failure status. A Zero Immediate command will allow a Zero operation while the scale is in motion.

Tare the scale – use the Tare command to remove container weight or prior material weight when weighing multiple materials. The Tare function places the scale into Net mode. The displayed weight value will be 0 Net. Tare has a range limited by the scale capacity. The Zero reference is not affected by a Tare.Taking a Tare while the scale is in motion is not recommended and it is not available in many products. When sending the Tare command while the scale is in motion, the command is executed if motion stops within the stability timeout period (default is three seconds and is adjustable). Upon timeout, the terminal displays and sends a command failure status. Tare is not possible when the Gross weight is 0 or negative. A Tare Immediate command will allow a Tare operation while the scale is in motion.

Tare acts on the Gross weight. When the scale is already in Net mode, the current Gross weight (Net and Tare) is removed. The scale remains in Net mode; it does not briefly switch to Gross mode and then back to Net mode. Send a Clear command prior to the Tare command to toggle the Net mode status bit.

Clear the Tare – the Clear command clears the current Tare and places the scale back in Gross mode. Motion is ignored and the command is executed on the next A/D cycle.

Sending values – sending a specific comparator value, Tare value or target value requires placing the value in the output value word and simultaneously sending the appropriate command to load that value.

Motion – a normal condition during some processes that can temporarily disable functions when stability is required. Motion-sensitivity parameters are configurable in some weighing instruments.

Multiple scales – scales must be assigned to separate message slots.

6 Failure Modes

Note: This general document is not intended to address all failure possibilities in any process or application. METTLER TOLEDO equipment shall not be used as a safety device.

It is the responsibility of the PLC programmer to anticipate potential failures in the process and take appropriate action to ensure safe operation.

Data OK – should be = 1. Ignore the weight value and status bits any time the Data OK = 0. Common triggers include Over Capacity, Under Capacity or the scale terminal is in setup. Data OK will also be set = 0 by an ACM500 that has lost communication with an IND560x. Data OK will not be set = 0 if communication to the PLC is lost. See Communication Loss below.

Data Integrity (legacy protocol) – Data Integrity bits must be equal to each other. Ignore the weight value and status bits any time the Data Integrity bits are not equal to each other.

Heartbeat Loss (SAI protocol) – the loss of the Heartbeat indicates the scale is not capable of communicating due to power failure, network connection failure or internal device failure.

Alarm Condition (SAI protocol) – the Alarm Condition status bit indicates the presence of any one of several alarm conditions: application fault, predictive maintenance alarm or command received cannot be executed as requested. Read the Red Alert Alarms and Command response to identify the specific Alarm Condition cause.

Red Alert Alarms (SAI protocol) – the Red Alert alarm status bits identify specific alarm conditions. Act upon each individual RedAlert™ Alarm individually as required.

Command Failure – verify proper execution of all commands sent to the scale. Various external factors may result in command failure. Do not assume commands will always work without fail.

Communication Loss – a communication loss can have several causes including loss of power to the scale or network infrastructure, or simply a damaged cable. Such a communication loss results in frozen data in the PLC input buffer. Data OK or Heartbeat status bit, along with all data, would remain at its last state prior to the communications failure. There is no way for the scale to tell the PLC that the scale cannot communicate with the PLC. It is up to the PLC program to monitor network communications and/or use a watchdog circuit to detect a communication loss and take appropriate action.

i Additional Resources

METTLER TOLEDO makes Engineering Notes, Technical Notes and other tutorials available as supplements to the previously listed manuals. PLC configuration files and sample programs are also available. These files are available from the following web sites.

METTLER TOLEDO for manuals, EDS, GSD and GSDML files, Add-On Profiles (AOPs), Add-On Instructions (AOIs) and PLC sample programs.
www.mt.com

The Rockwell Automation Knowledgebase for METTLER TOLEDO FAQs and technical notes.
rockwellautomation.custhelp.com/app/answers/list

The Rockwell Automation Sample Code Library for CompactLogix and ControlLogix AOPs, AOIs and PLC sample programs.
search.rockwellautomation.com

The Open Device Vendors Association for ControlNet, DeviceNet and EtherNet/IP EDS files.
www.odva.org

PROFIBUS International for GSD and GSDML files.
www.profibus.com

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