Technical Data Sheet No.: **TD-TIO-0911 Rev C**
Date of Issue: **January 2013**

OPERATING MANUAL

TIO

Totalizer-Input/Output
Flow Monitor/Controller

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1. UNPACKING THE TIO TOTALIZER

1.1 Inspect Package for External Damage

Your TIO Totalizer-Input/Output Flow Monitor/Controller was carefully packed in a sturdy cardboard carton with anti-static cushioning materials to withstand shipping shock. Upon receipt, inspect the package for possible external damage. In case of external damage to the package, contact the shipping company immediately.

1.2 Unpack the TIO Totalizer

Open the carton carefully from the top and inspect for any sign of concealed shipping damage. In addition to contacting the shipping carrier, please forward a copy of any damage report to your distributor or to Aalborg® directly. When unpacking the instrument make sure that you have all the items indicated on the Packing List. Please promptly report any shortages.

1.3 Returning Merchandise for Repair

Please contact your distributor's customer service representative, or Aalborg® if you purchased your TIO instrument directly. Request a **Return Authorization Number (RAN). Equipment returned without an RAN will not be accepted.** Aalborg® reserves the right to charge the customer a fee for equipment returned under warranty claims if the instruments are tested and found to be free from warrantied defects. Shipping charges are borne by the customer. Instruments returned "collect" will not be accepted! **It is mandatory that any equipment returned for servicing be purged and neutralized of any dangerous contents including but not limited to toxic, bacterially infectious, corrosive or radioactive substances. No work shall be performed on a returned product unless the customer submits a fully executed, signed SAFETY CERTIFICATE. Please request form from the Service Manager.**

2. SAFETY INSTRUCTIONS / INTRODUCTION

⚠ **AALBORG® warranties and all other responsibilities by direct or implied are voided if users fail to follow all instructions and procedures described in this manual.**

⚠ **LIFE SUPPORT APPLICATIONS: The TIO is not designed for use in life support applications where malfunctioning of the device may cause personal injury. Customers using or selling this device for use in such applications do so at their own risk and agree to be fully responsible for any damages resulting from improper use or sale.**

⚠ **Some of the IC devices used in the TIO are static-sensitive and may be damaged by improper handling. When adjusting or servicing the device, use of a grounded wrist strap is recommended to prevent inadvertent damage to the integral solid-state circuitry.**

The TIO Totalizer-Input/Output Flow Monitor/Controller is a microcontroller-driven device designed to linearize the flow meter/controller flow curve and to display instantaneous Flow Rate, Total and Accumulated Total. This product is designed to be used primarily with Aalborg® series GFM/GFC analog flow meters/controllers but can be also used with any commercial flow meters/controllers with analog 0-5 (0-10) Vdc or 4-20 mA interface.

The following functions and features are supported:

- Built-in Flow Linearizer (10 point linearization of the flow curve).
- Up to 47 different volumetric and mass flow engineering units (including user-defined).
- Graphic LCD with large 13mm (0.51") digits for Flow Rate and 5.5mm (0.21") for Total.
- User-adjustable LCD back light and contrast level.
- Digital RS-232 or RS-485 interface (multidrop capability for up to 64 devices).
- Compact design for unit mount, panel mount, wall mount or field mount applications.
- Two independent programmable Totalizers.
- User-programmable, optically-isolated pulse output.
- Two programmable optically-isolated digital outputs for different events.
- Low and High Flow Alarms with programmable Action Delay.
- Flow controllers Set Point command control via local LCD or digital interface.
- Programmable Set Point table with ramping up/down capability for up to 16 steps.
- Free Configuration and Monitoring Utility Software.

3. SPECIFICATIONS

ADC/DAC RESOLUTION: 12 bit.

ACCURACY: ±0.1% F.S.

ANALOG INPUTS: 0-5 Vdc, 4-20 mA, 5-10 Vdc (jumper-selectable), 0-10 Vdc (special order).

ANALOG OUTPUTS: 0-5 Vdc, 4-20 mA (jumper-selectable), 0-10Vdc (special order).

LCD: 128x64 graphic LCD with instantaneous Flow reading and Total volume indication. Adjustable LCD contrast and back light. Refresh rate 10 times/sec.

KEY-PAD: Local 6 tactical push buttons.

DATA PROTECTION: EEPROM backup of all settings, backup Totalizer #1 every one second. Data retention at least 10 years. Password protection for configuration data.

PULSE OUTPUT: User-programmable, optically-isolated, with preset active low time interval (10 – 6550 ms), UCE ≤ 40Vdc, ICE ≤ 150 mA (Voltage Isolation: 250 Vrms).

DIGITAL OUTPUT: Two programmable, optically-isolated. UCE ≤ 40Vdc, ICE ≤ 150 mA (Voltage Isolation: 250 Vrms).

DIGITAL INTERFACE: RS-232 or RS-485 (multidrop capability up to 64 devices).

Protocol:	Proprietary ASCII software interface command set.	
Speed:	1200 - 2400 - 4800 - 9600 -19200 – 38400 – 57600 – 115200 baud (user-selectable). Default 9600 baud.	
Configuration:	Stop bit:	1
	Data bits:	8
	Parity:	None
	Flow Control:	None
	Addressing:	Maximum 255 addresses, default address 11 hex. (for RS-485 option only).
	Type:	RS232 or RS485 2-wire.

POWER REQUIREMENTS: 12 – 26 Vdc, 100 mV maximum peak-to-peak output noise (up to 60 mA maximum load).

INTERFACE CONNECTORS: Process I/O signals and digital RS-232/RS-485 interface: miniature 9 pin female D-SUB connector. Digital optically-isolated outputs: TERMINAL BLOCK HEADER 4POS 3.5MM male pins, Shrouded (Mated connector: Tyco Electronics P/N: 284510-4).

ENVIRONMENT: Installation Level II; Pollution Degree II.

ELECTROMAGNETIC COMPATIBILITY:
Compliant ref. 89/336/EEC as amended. Emission. Standard: EN 55011:1991, Group 1, Class A. Immunity Standard: EN 55082-1:1992.

OPERATING TEMPERATURE: -10 °C to +70 °C (14 °F to +158 °F).

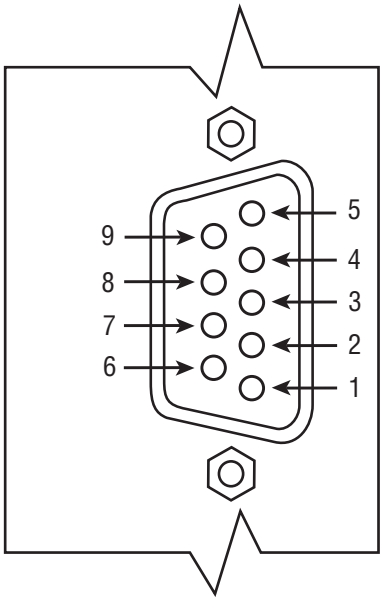
DIMENSIONS: 86.4 x 76.2 x 19.1 mm (3.4" x 3.0" x 0.75") - W x H x D.

WEIGHT: Approximately 125g / 0.3 lbs.

4. ELECTRICAL CONNECTION

PIN	FUNCTION	NOTE
1	Power supply, common	Power input
2	Power supply, positive	Power input 12 – 26 Vdc
3	RS232 RX, Optional RS485 (+)	Communication (RS-232 – input, RS-485 – input/output)
4	Analog Input (+), PV input	Input
5	Analog Output (+), PV set point	Output
6	RS232 Signal GND (RS-485 GND Optional)	Communication reference
7	RS232 TX, Optional RS485 (-)	Communication (RS-232 – output, RS-485 – input/output)
8	Analog Input/Output reference (common for pins 4 and 5)	
9	+5Vdc reference input (for 5-10 Vdc interface only)	

Figure 4.1 - TIO 9 PIN "D" CONNECTOR CONFIGURATION



The power supply (PS), process variable (PV) input, set point (SP) control output, and digital communication interface signals are connected to the TIO via miniature 9 pin female D-SUB connector.

4.1 Power Supply Connections

The power supply requirements for TIO are: 12 to 26 Vdc, (unipolar power supply).

DC Power (+) ---------- pin 2 of the 9 pin "D" connector
DC Power (-) ---------- pin 1 of the 9 pin "D" connector

⚠ **CAUTION: Do not apply power voltage above 28Vdc. Doing so will cause device damage or faulty operation.**

⚠ **Make sure power is OFF when connecting or disconnecting any cables or wires in the system.**

4.2 Process Variable (PV) Input Signal Connections

Depending on the jumper J2 configuration Input signal can be set to 0-5, 5-10, 0-10 Vdc or 4-20 mA.

⚠ **CAUTION: When connecting the external signals to the input terminals always check actual jumper J2 configuration. Do not exceed the rated values shown in the specifications (see Table 4.1). Failure to do so might cause damage to this device. Be sure to check if the wiring and the polarity of the power supply and PV signals are correct before turning the power ON. Wiring error may cause damage or faulty operation.**

Figure 4.2 - TIO Input/Output Configuration Jumpers

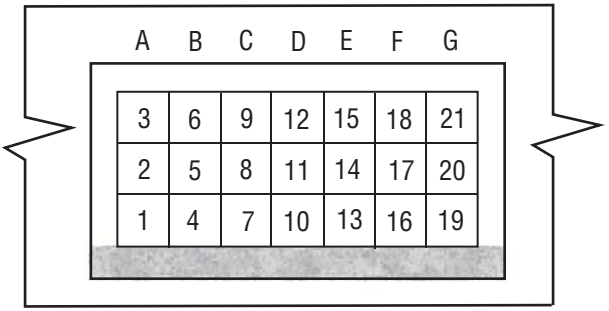


Table 4.1 Maximum rated values for PV input signals

PV INPUT TYPE	J2 JUMPER CONFIGURATION			MAXIMUM SIGNAL LEVEL	NOTE
	J2D	J2E	J2F		
0-5 Vdc	10 -11	14 -15	17-18	≤6 Vdc	
5-10 Vdc	11 -12	14 -15	17-18	≤11 Vdc	+5Vdc reference signal must be used (GFM/GFC option)
0-10 Vdc	11 -12	14 -15	17-18	≤11 Vdc	Special Order option! (PCB hardware must be changed)
4-20 mA	10 -11	13 -14	16-17	≤25 mA	(249 Ohm passive, not isolated current input)

PV input (+) ---------- pin 4 of the 9 pin “D” connector.
PV input (-) ---------- pin 8 of the 9 pin “D” connector.

4.3 Set Point (SP) Output Signal Connections

Set Point (SP) output signal connection is required only if TIO is mated to the flow controller and will be used as a source for a Set Point control signal. Depending on the jumper J2 configuration, SP output signal can be set to 0-5, 0-10 Vdc or 4-20 mA.

⚠ **CAUTION: When connecting the load to the output terminals always check actual jumper J2 configuration. Do not exceed the rated values shown in the specifications (see Table 4.2). Failure to do so might cause damage to this device. Be sure to check if the wiring and the polarity of the power supply and SP signals are correct before turning the power ON. Wiring error may cause damage or faulty operation. Do not connect external voltage source to the SP output terminals.**

Table 4.2 Maximum rated load impedance for SP output signals

SP OUTPUT TYPE	J2 JUMPER CONFIGURATION			MAXIMUM LOAD IMPEDANCE	NOTE
	J2A	J2B	J2C		
0 - 5 Vdc	2 - 3	5 - 6	8 - 9	≤1000 Ohm	
0 - 10 Vdc	2 - 3	5 - 6	8 - 9	≤5000 Ohm	Special Order option! (PCB hardware must be changed).
4 – 20 mA	1 - 2	4 - 5	7 - 8	≤900 Ohm (24 Vdc PS)	Self-powered (non-isolated) current loop. For 12 Vdc PS the load impedance should not exceed 400 Ohm.

PV output (+) ---------- pin 5 of the 9 pin "D" connector
PV output (-) ---------- pin 8 of the 9 pin "D" connector

⚠ **WARNING: The 4-20 mA current loop output is self-powered (non-isolated). Do not connect an external voltage source to the output signals.**

4.4 Digital Communication Interface Connections

The digital interface operates via RS-232 (optional RS-485) and provides access to all applicable internal configuration parameters and data.

Communication Settings for RS-232/RS-485 communication interface:

Baud rate: default 9600 baud (user-selectable. See specification section).
Stop bit: 1
Data bits: 8
Parity: ..... None
Flow Control: ..... None

RS-232 Communication Interface Connection:

Crossover connection must be established:

RS-232 RX
(pin 2 on the host PC DB9 connector)------pin 7 of the 9 pin "D" connector (TX-)

RS-232 TX
(pin 3 on the host PC DB9 connector)------pin 3 of the 9 pin "D" connector (RX+)

RS-232 SIGNAL GND
(pin 5 on the host PC DB9 connector)------pin 6 of the 9 pin "D" connector

RS-485 Communication Interface Connection:

The RS485 converter/adapter must be configured for: multidrop, 2 wire, half duplex mode (See Figure 4.3). The transmitter circuit must be enabled by TD or RTS (depending on which is available on the converter/adapter). Settings for the receiver circuit should follow the selection made for the transmitter circuit in order to eliminate echo.

RS-485 T(-) or R(-)	----------	pin 7 of the 9 pin "D" connector (TX-)
RS-485 T(+) or R(+)	----------	pin 3 of the 9 pin "D" connector (RX+)
RS-485 GND (if available)	----------	pin 6 of the 9 pin "D" connector

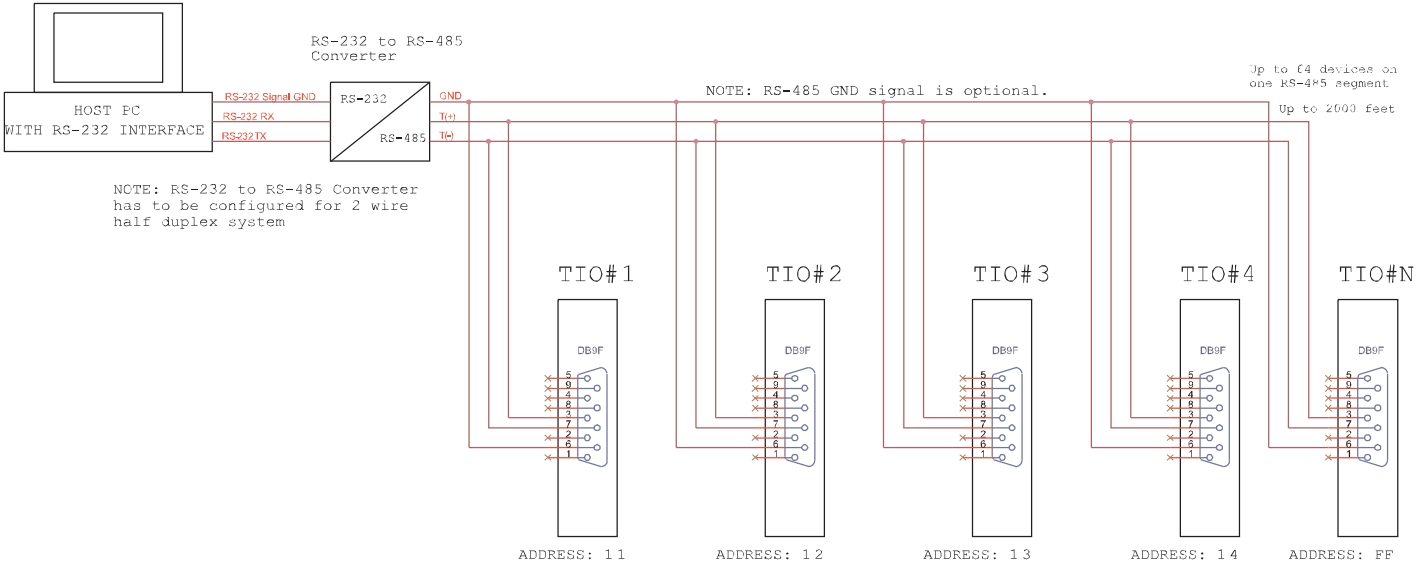


Figure X-X

Figure 4.3 RS-485 Multidrop Half Duplex Two Wire System

When the TIO device is set as the last device on the RS-485 bus segment and 220 Ohm bus termination is required, set the jumper J2G to position 19-20. This will result in connection 220 Ohm resistor between RS-485 (+) and (-) terminals.

4.5 Digital and Pulse Optically-Isolated Outputs Connections

TIO is equipped with two programmable digital optically-isolated outputs. Each output can be assigned to any one of many different system events or configured as a pulse output (see Paragraph 5.3.9).

Digital optically-isolated outputs use dedicated 4 position 3.5mm male terminal block header J1 located on the top side of the TIO enclosure (see Figure 6.1). (Mated interface connector: Tyco Electronics P/N: 284510-4).

Optocoupler #1 - Terminal J1 (pins 1 and 2):

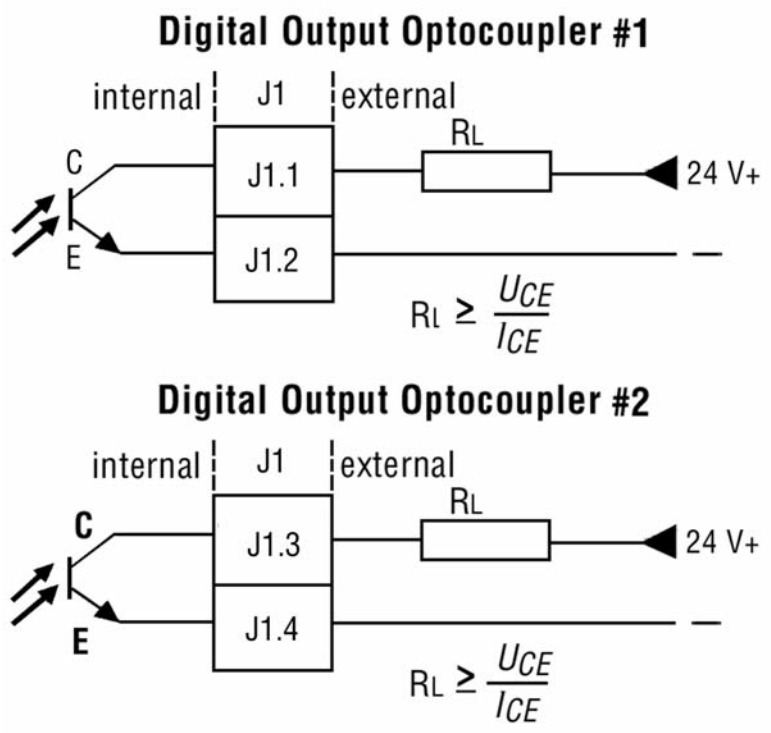
Plus (+) (passive) ---------- Terminal J1 pin 1
Minus (-) (passive) ---------- Terminal J1 pin 2

Optocoupler #2 - Terminal J1 (pins 3 and 4):

Plus (+) (passive) ---------- Terminal J1 pin 3
Minus (-) (passive) ---------- Terminal J1 pin 4

⚠ **WARNING: Optically-isolated outputs require application of external DC voltage across terminals. Do not exceed maximum allowed limits for voltage and current provided below:**

2 V < UCE < 40 V
0.2 mA < ICE < 150 mA



⚠ **WARNING: Optically-isolated outputs have maximum absolute voltage rating 250 Vdc RMS. Do not exceed maximum allowed limits for voltage. Doing so may cause personal injury or damage to this device.**

5. LCD KEY-PAD OPERATION: DATA ENTRY AND CONFIGURATION

5.1 Display Indications

Initially, after the power is first turned on, the Banner Screen is shown for 2 seconds, then device firmware and EEPROM data base table revisions on the first line, communication interface type on the second line, baud rate and RS-485 hexadecimal address value on third and fourth lines are shown for another 2 seconds. Subsequently, the actual process information (PI) is displayed.

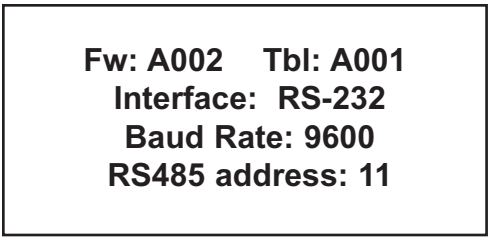


Figure 5.1: TIO Firmware and Communication Interface Info Screen

NOTE: Actual content of the LCD screen may vary depending on the model and device configuration.

Based on device configuration (Device Function as flow meter or flow controller), different parameters may be displayed in the Process Information (PI) screen by pressing the **UP** or **DN** pushbuttons.

Process Information screens can be configured to be static or dynamic (see Paragraph 5.3.11 “Display Menu”). Using Screen Mask settings user can enable (unmask) or disable (mask) up to 4 different process information combinations (see Figure 5.4). In the Static Mode the **UP** button pages through the PI screens in the forward direction, the **DN** button pages through the PI screens in the reverse direction. When the last PI screen is reached, the firmware “wraps around” and scrolls to the initial PI screen once again.

In the Dynamic Display Mode, firmware initiates automatic screen sequencing with user- adjustable screen Cycle Time (see Paragraph 5.3.11 “Display Menu”). When the last PI screen is reached, the firmware “wraps around” and scrolls to the initial PI screen once again.

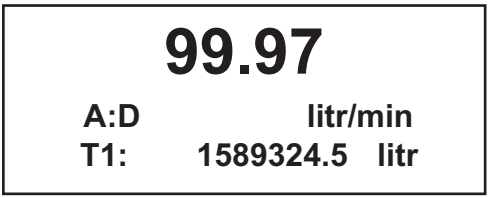


Figure 5.2: TIO Initial PI Screen (Device Function: Flow Meter)

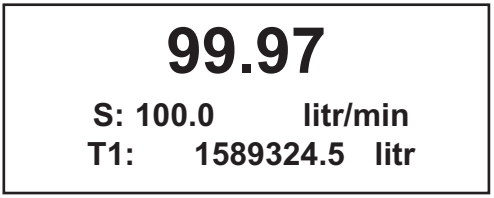


Figure 5.3: TIO Initial PI Screen (Device Function: Flow Controller

NOTE: Actual content of the LCD screen may vary depending on the model and device configuration.

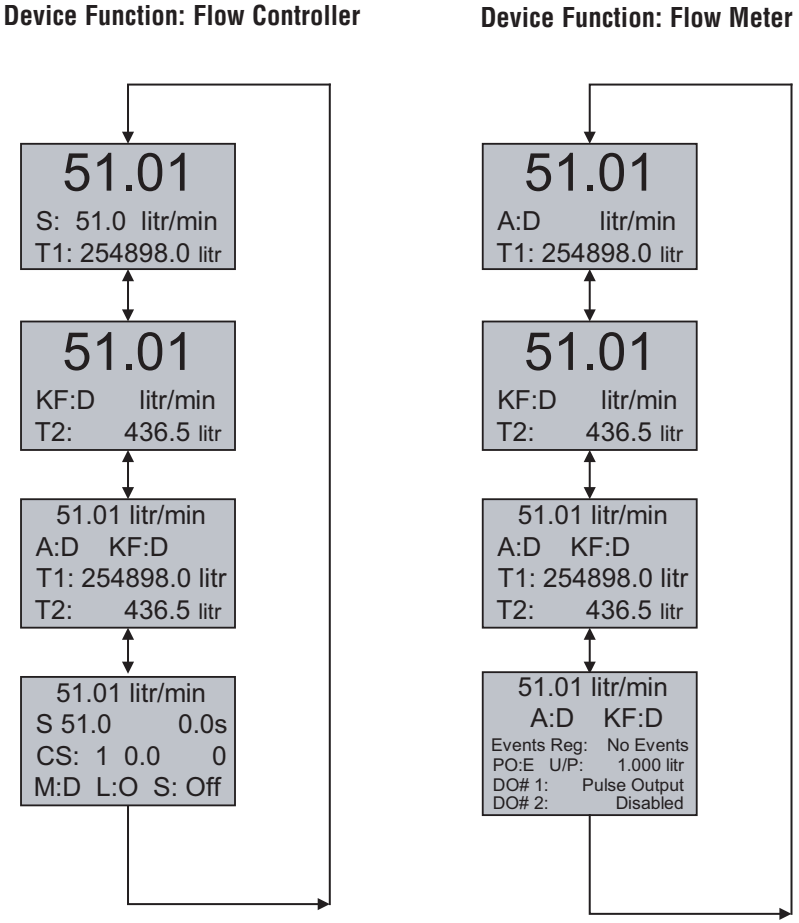


Figure 5.4: TIO PI Screen (based on device function)

5.1.1 Set Point Control (only for devices set as controller)

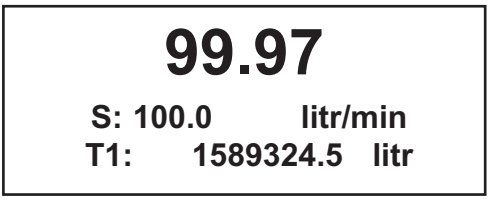
When TIO is configured as controller it can be used to control set point value for mated flow controller using analog output interface.

NOTE: Your TIO device input / output jumpers were factory configured according to your order. Make sure the mated flow controller has an analog input interface compatible with the TIO analog output configuration. Before applying the power and process signals make sure the input /output jumpers are installed in the correct position (See Table 6.5).

The Set Point value can be adjusted locally using LCD/keypad, remotely via RS-232/RS-485 digital interface or can be programmed in advance using user-preset programs of up to sixteen steps (Program Set Point Mode).

a) Adjusting Set Point value using local LCD/keypad

Current Set Point value is displayed on the second line of the main PI screen, next to the 'S' character.



Pressing the **ENT** button while in the main PI screen will activate Set Point adjustment mode. The first character of the Set Point value will start to flash. Use **UP** or **DN** button to increment / decrement digit value from 0-9. Use **RIGHT** or **LEFT** button to move cursor to another digit position. When desired Set Point value is entered use the **ENT** button to accept (save in the EEPROM) new Set Point value.

NOTE: Since the Set Point value entered via local LCD/keypad is stored in the non-volatile memory (EEPROM), it will be executed on the next device power up event.

If at the end of the Set Point value entry the **ESC** button is pressed instead **ENT**, the original Set Point value will be restored and Set Point adjustment mode will be deactivated. To exit from the Set Point adjustment mode before Set Point value is accepted, press the **ESC** button.

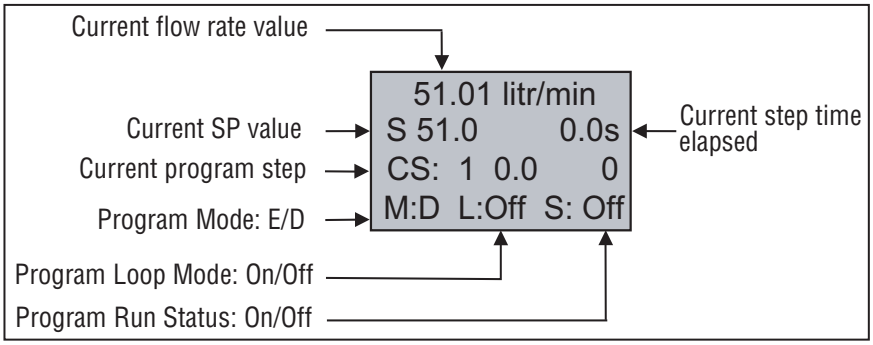
NOTE: If the Program Set Point mode is enabled and the program is running, the Set Point value can be changed at any moment by the execution of the next active step. The Set Point entered via local LCD/keypad can be also changed via digital RS-232/RS-485 interface.

b) Controlling Set Point value using Program Set Point mode

To activate Program Set Point mode the following must to be done:

1. Program Set Point mode must be Enabled (see paragraph 5.3.16 a).
2. Program Loop parameter must be set to desired value (On/Off).
3. Program Run parameter must be set to "On" (default settings is Off).

NOTE: Before executing, the program should be entered in the program table (see Paragraph 5.3.16)



As shown in the above drawing the Program Run parameter can be toggled “On” or “Off” by pressing the **RIGHT** and **LEFT** keypad buttons, while PI screen #4 is active. If Program Run status parameter is set to “Off”, the program execution will pause and current SP value will freeze until Program Run status parameter is set to “On”.

NOTE: While Program Set Point mode is running, the current Set Point value also can be changed from local LCD/keypad and digital RS-232/RS-485 communication interface. In this case, new Set Point value will be kept only until the next successive program step is executed.

5.2 Menu Structure

The diagram on the Figure 5.7 gives a general overview of the standard top-level display menu structure when running firmware version A001. The **ESC** pushbutton is used to toggle between the Process Mode (PI screens) and the Setup menus.

UP and **DN** buttons must be used to move through the menu items. When the last item in the menu is reached, the menu “wraps around” and scrolls back to the beginning of the menu items list. Similarly, when the first menu item is highlighted and the **UP** button is pressed, the menu “wraps around” and scrolls down to the end of the menu item’s list.

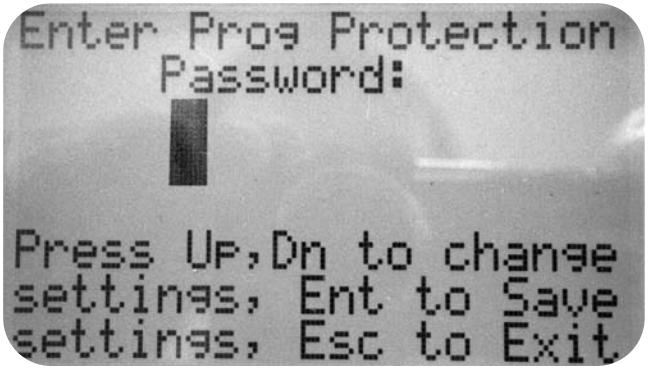
All process configuration parameter’s settings are password-protected. In order to access or change them, Program Protection should be disabled. Each time the device is powered up, the Program Protection is enabled automatically. By default, the device is shipped from the factory with the Program Protection (PP) password set to Zero (PP Disabled). If PP password is set to Zero (Disabled), entering a PP password is not required. A subsequent screen will appear and the Program Protection menu item will be selected:

Figure 5.5

Pressing the **UP** or **DN** button to select the Disabled option and then the **ENT** button to save settings will disable program protection.

If PP password is set to any value more than Zero, the firmware will prompt with **"Enter PP Password"** (see Figure 5.6). User must enter up to 3 digits program protection code, in order to be able to access password protected menus. Once the correct password is entered, Program Protection is turned off until the unit is powered up again.

Figure 5.6



5.3 Parameter Entry

There are two methods of data entry:

- Direct numerical number entry.
- Tabular Input from a table menu.

If the menu with direct numerical entry is selected use the **UP** or **DN** button to increment / decrement digit value from 0-9. Use the **RIGHT** or **LEFT** button to move the cursor to another digit position. When the desired value is entered, use **ENT** button to accept (save in the EEPROM) the new value.

NOTE: During data entry the input vales are checked for acceptability. If data is not acceptable, it is rejected and a message is generated indicating that the new data has not been accepted.

If the menu with tabular entry is selected, the available menu options can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

5.3.1 Submenu "Change PP Password"

In order to get access to "Change PP Password" menu, Program Protection must be disabled. If PP password is set to Zero (Disabled), entering PP Password is not required and PP can be disabled from "Program Protection" menu (see Figure 5.5). If PP Password is set to any value more than Zero, the firmware will prompt with "**Enter PP Password**" (see Figure 5.6). User must enter program protection code (up to 3 digits). If PP password is lost or forgotten, contact the factory or your distributor.

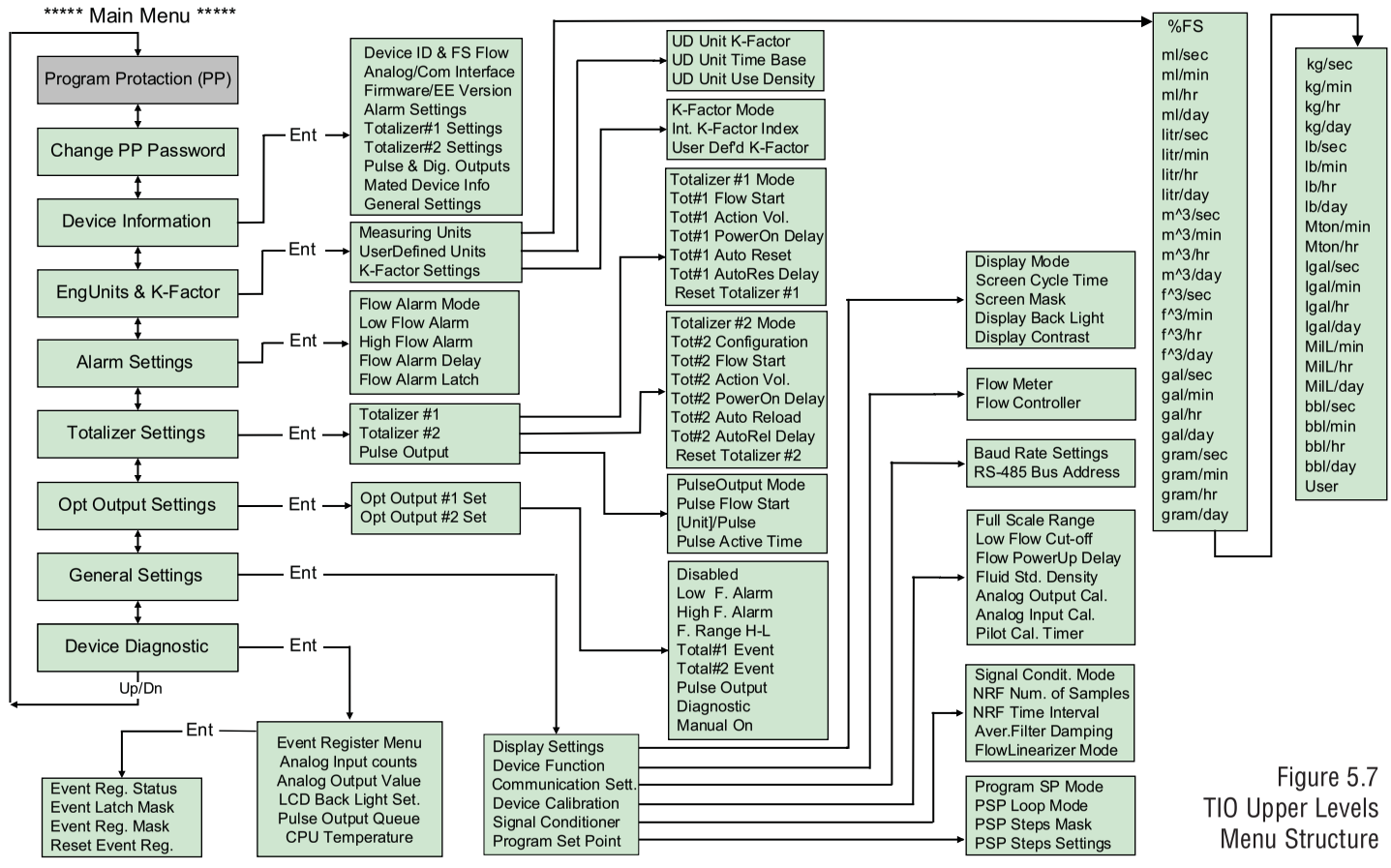
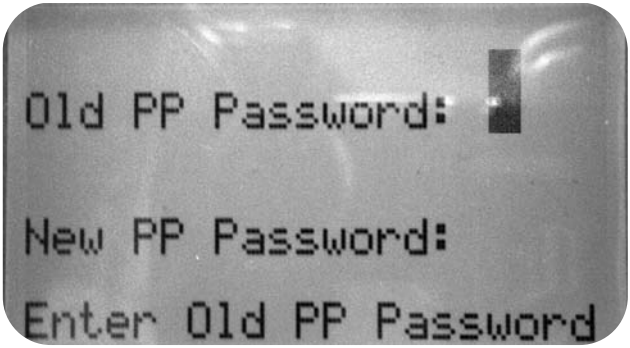


Figure 5.7
TIO Upper Levels
Menu Structure

Once “Change PP Password” menu is selected, the following screen will appear:

Figure 5.8

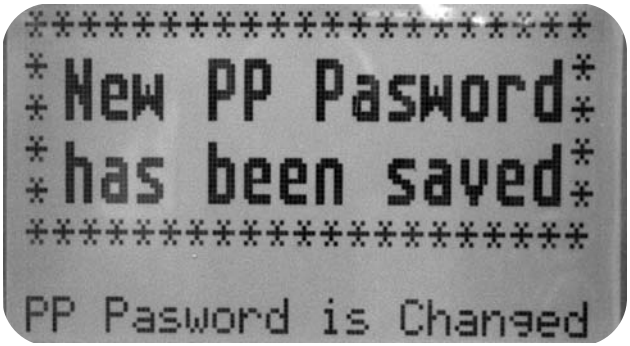


In order to protect device configuration parameters when changing the PP password, the old PP password must be entered.

NOTE: By default the device is shipped from the factory with Program Protection (PP) password set to Zero (PP Disabled).

Once old and new passwords are entered the firmware will prompt with a confirmation message (see Figure 5.9) that the new password has been saved.

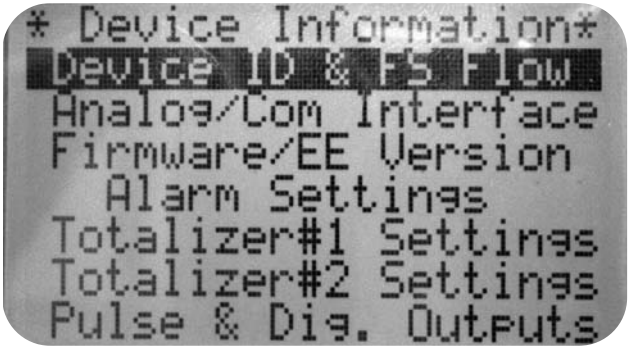
Figure 5.9



5.3.2 Submenu “Device Information”

This submenu contains information about the device’s main configuration parameters. These items are informational only, not password-protected, and can’t be changed (read only).

Figure 5.10



5.3.3 Submenu "Measuring Units"

Use the "Engineering Units and K-Factor Menu" to navigate to "Measuring Units" menu option. This option allows configuration of the flow meter/controller with the desired units of measurement. These are global settings and determine what appears on all process information screens and data log records. Units should be selected to meet your particular metering needs. A total of 47 different volumetric and mass-based engineering units are supported (See Table 5.1).

NOTE: Program the Measuring Units first because subsequent menus may be based on the units selected. Once Flow Unit of Measure is changed the Totalizer's Volume based Unit of Measure will be automatically changed.

5.3.4 "Submenu User-Defined Units"

In addition to conventional flow units user-defined flow engineering units may be selected. Use the "Engineering Units and K-Factor Menu" to navigate to the "User-defined Units" menu option. This option enables user-defined configuration of any engineering unit required for process measurement.

The following three parameters are available for this function:

a) UD Unit volume K-Factor (defined in Liters),
b) UD Unit time base (defined in Seconds),
c) UD Unit use density (units with or without density support).

Before using the User-defined Unit, be sure the proper conversion factor of the new unit with respect to one liter is set (the default entry is 1.00 Liter). Also, proper time base values for User-Defined Units must be set.

The following selections are available: 1 second, 60 seconds (1 minute), 3600 seconds (1 Hour), 86400 seconds (1 Day). The default entry is 60 seconds. If a mass-based User-defined Unit is desired, the "UD Unit Use Density" parameter must be set to "YES". The default entry is "NO" so the Fluid STD Density parameter is not used for flow rate calculation.

TABLE 5.1 SUPPORTED ENGINEERING UNITS LIST

NUMBER	FLOW RATE ENGINEERING UNITS	TOTALIZER ENGINEERING UNITS	DESCRIPTION
1	%FS	%s	Percent of full scale
2	ml/sec	ml	Milliliter per second
3	ml/min	ml	Milliliter per minute
4	ml/hr	ml	Milliliter per hour
5	ml/day	ml	Milliliter per day
6	litr/sec	litr	Liter per second
7	litr/ min	litr	Liter per minute
8	litr/hr	litr	Liter per hour
9	litr/day	litr	Liter per day
10	m^3/sec	m^3	Cubic meter per second
11	m^3/ min	m^3	Cubic meter per minute
12	m^3/hr	m^3	Cubic meter per hour
13	m^3/day	m^3	Cubic meter per day
14	f^3/sec	f^3	Cubic feet per second
15	f^3/min	f^3	Cubic feet per minute
16	f^3/hr	f^3	Cubic feet per hour
17	f^3/day	f^3	Cubic feet per day
18	gal/sec	gal	Gal per second
19	gal/min	gal	Gal per minute
20	gal/hr	gal	Gal per hour
21	gal/day	gal	Gal per day
22	gram/sec	gram	Grams per second
23	gram/min	gram	Grams per minute
24	gram/hr	gram	Grams per hour
25	gram/day	gram	Grams per day
26	kg/sec	kg	Kilograms per second
27	kg/min	kg	Kilograms per minute

NUMBER	FLOW RATE ENGINEERING UNITS	TOTALIZER ENGINEERING UNITS	DESCRIPTION
28	kg/hr	kg	Kilograms per hour
29	kg/day	kg	Kilograms per day
30	lb/sec	lb	Pounds per second
31	lb/min	lb	Pounds per minute
32	lb/hr	lb	Pounds per hour
33	lb/day	lb	Pounds per day
34	Mton/min	Mton	Metric Ton per minute
35	Mton/hr	Mton	Metric Ton per hour
36	Igal/sec	Igal	Imperial Gal per second
37	Igal/min	Igal	Imperial Gal per minute
38	Igal/hr	Igal	Imperial Gal per hour
39	Igal/day	Igal	Imperial Gal per day
40	MilL/min	MilL	Million Litr per minute
41	MilL/hr	MilL	Million Litr per hour
42	MilL/day	MilL	Million Litr per day
43	bbl/sec	bbl	Barrel per second
44	bbl /min	bbl	Barrel per minute
45	bbl /hr	bbl	Barrel per hour
46	bbl /day	bbl	Barrel per day
47	User	User	User-defined

5.3.5 Submenu “K-Factors Settings”

Conversion factors relative to Nitrogen are convenient to use when the flow meter/controller mated to the TIO is calibrated for Nitrogen and another gas is required to be measured/controlled.

Conversion factors relative to Nitrogen for up to 22 common gases are stored in the TIO (see APPENDIX II). In addition, provision is made for a **user-defined** conversion factor. Conversion factors may be applied to all units of measure (except %FS unit) via LCD/Keypad or digital communication interface.

The following three parameters are available for this function:

a) K-Factor Mode: Disable, Internal Index, user-defined (default Disabled)
b) Internal K Factor Index: 1 – 22 (from internal K-Factor table, see APPENDIX II)
c) User-defined K-Factor: 0.001 – 999.9 (default value is 1.000).

Note: The conversion factors will not be applied for the % F.S. engineering unit.

5.3.6 Submenu “Alarm Settings”

TIO provides the user with a flexible Alarm/warning system that monitors the Fluid Flow for conditions that fall outside configurable limits as well as visual feedback for the user via the LCD or via an optically-isolated output. The Flow Alarm has several attributes which may be configured by the user via LCD/Keypad or digital communication interface. These attributes control the conditions which cause the Alarm to occur and to specify actions to be taken when the flow rate is outside the specified conditions.

Depending on the TIO function configuration (flow meter or controller) there are two Alarm algorithms. If the TIO is configured as a flow meter, Flow Alarm conditions become true when the current flow reading is equal to or Higher/Lower than corresponding values of High and Low Flow Alarm levels. If TIO is configured as flow controller, Flow Alarm conditions become true when difference between Set Point value and current flow reading is equal or Higher/Lower than corresponding values of High and Low Flow Alarm levels.

Alarm action can be assigned with preset Delay Interval (0-3600 seconds) to activate the optically-isolated output (separate for High and Low Alarm). Latch Mode control feature allows each optical output to be latched on or follow the corresponding Alarm status.

Following settings are available for Flow Alarm (see Figure 5.7):

a) Flow Alarm Mode (Tabular entry)

This function determines whether the Flow Alarm is Enabled or Disabled. The following selections are available: Enabled or Disabled. The default entry is Disabled. Alarm Mode selections can be set with the **UP** and **DN** buttons and are accepted by pressing **ENT** button.

b) Low Flow Alarm (Numerical entry)

The limit of required Low Flow Alarm value can be entered in increments of 0.1% from 0 - 100%F.S.

If a Low Alarm occurs, and one of the two optical outputs is assigned to the Low Flow Alarm Event (see paragraph 5.3.10) the optically-isolated output will be activated:

- For Flow Meter function: when the flow is less than the Low Flow Alarm value.
- For Flow Controller function: when the absolute difference between Set Point value and actual flow reading is equal to or higher than the Low Flow Alarm value and Actual Flow value is less than Set Point value.

The Low Flow Alarm condition is also indicated on the corresponding Process Information Screen by displaying L character.

NOTE: For Flow Meter function the value of the Low Flow Alarm must be less than the value of the High Flow Alarm.

c) High Flow Alarm (Numerical entry)

The limit of required High Flow Alarm value can be entered in increments of 0.1% from 0 - 100% F.S. If a High Alarm occurs, and one of the two optical outputs is assigned to the High Flow Alarm Event (see paragraph 5.3.10) the optically-isolated output will be activated for:

- Flow Meter function: when the flow is more than the High Flow Alarm value.
- Flow Controller function: when absolute difference between Set Point value and Actual Flow reading is equal to or higher than the High Flow Alarm value and actual flow value is more than set point value.

The High Flow Alarm condition is also indicated on the corresponding Process Information Screen by displaying the H character.

NOTE: For Flow Meter function the value of the High Flow Alarm must be more than the value of the Low Flow Alarm.

d) Flow Alarm Action Delay (Numerical entry)

The Flow Alarm Action Delay is a time in seconds that the Flow Rate value remains above the High limit or below the Low limit before an Alarm condition is validated. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

e) Flow Alarm Action Latch (Tabular entry)

The Flow Alarm Action Latch settings control the Latch feature. If optically-isolated output is assigned to the Flow Alarm Event, in some cases, the Flow Alarm Latch feature may be desirable.

The following settings are available: Disable or Enabled. By default, the Flow Alarm is non-latching. That means the Alarm is indicated only while the monitored Flow Value exceeds the specified set conditions.

5.3.7 Submenu "Totalizer #1"

TIO provides the user with two independent Programmable Flow Totalizers. The total volume of the flowing fluid is calculated by integrating the actual instantaneous fluid flow rate with respect to time. Totalizer #1 (main Totalizer) value is stored in the EEPROM and saved every 1 second. In case of power interruption the last saved Totalizer value will be loaded on the next power on cycle, so the main Totalizer reading will not be lost. Use the "Totalizer Menu" to navigate to the "Totalizer #1" menu option.The following settings are available for Totalizer #1 (see Figure 5.7):

a) Totalizer #1 Mode (Tabular entry)

This option determines whether Totalizer #1 is Enabled or Disabled. The following selections are available: Enabled or Disabled. The default entry is Disabled. Totalizer #1 Mode selections can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

NOTE: Before enabling the Totalizer, ensure that all Totalizer settings are configured properly. Totalizer Start values must be entered in the currently active Volumetric or Mass flow engineering unit. The Totalizer will not totalize until the Process Flow Rate becomes equal to or more than the Totalizer Start value. Totalizer Event values must be entered in currently active volume or mass based engineering units. If the Totalizer Event at preset total volume feature is not required, set Totalizer Event value to zero (default settings).

b) Totalizer #1 Flow Start (Numerical entry)

This option allows the start of the Totalizer at a preset flow rate. Totalizer #1 will not totalize until the process flow rate becomes equal to or more than the Totalizer #1 Flow Start value. The limit of required Totalizer #1 Flow Start value can be entered in increments of 0.1% from 0 - 100%F.S.

c) Totalizer #1 Action Volume (Numerical entry)

This option allows the user to activate preset required action when the Totalizer reaches a preset volume. Totalizer #1 Action Volume value must be entered in currently active volume / mass-based engineering units. Totalizer #1 Action Event becomes true when Totalizer #1 reading is more or equal to preset "Totalizer #1 Action Volume". If the Totalizer#1 Action at preset total volume feature is not required, set "Totalizer #1 Action Volume" value to zero (default settings).

d) Totalizer #1 Power On Delay (Numerical entry)

Sometimes it is convenient to start the Totalizer only after specified power-up delay interval. Most of the mass flow meters and controllers require some warm-up time from the power-up event in order to stabilize the process variable output and get an accurate reading. "Totalizer #1 Power On Delay" option allows set specified a time interval which must elapse from the device power-up event before the Totalizer will be activated. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

e) Totalizer #1 Auto Reset (Tabular entry)

This option allows automatic reset of the Totalizer #1 when it reaches preset Action Volume value. This feature may be convenient for batch processing when predefined volume of the fluid must be repeatedly dispensed into the process. The following selections are available: Enabled or Disabled.

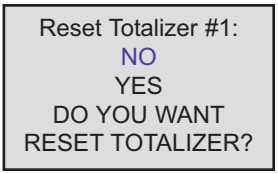
The default entry is Disabled. Totalizer #1 Auto Reset selections can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

f) Totalizer #1 Auto Reset Delay (Numerical entry)

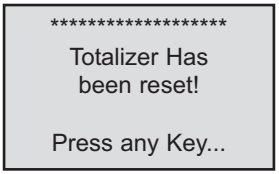
This option may be desirable when the "Totalizer #1 Auto Reset" feature is enabled. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

g) Reset Totalizer #1 (Numerical entry)

The Totalizers #1 reading can be reset by selecting the "Reset Totalizer #1" menu option. A typical display with Totalizer #1 Reset screen is shown below.



Once the "YES" option is selected, Totalizer #1 will be reset and the following conformation screen will appear:



5.3.8 Submenu "Totalizer #2"

The Totalizer #2 (pilot Totalizer) value is stored in the flow meter volatile memory (SRAM) and saved every 100 ms. In case of power interruption the Totalizer #2 volume will be lost (reset to zero). It is preferable to use Totalizer #2 for short term process flow calculation (for example: batch processing) Use the "Totalizer Menu" to navigate to "Totalizer #2" menu option. The following settings are available for Totalizer #2 (see Figure 5.7):

a) Totalizer #2 Mode (Tabular entry)

This option determines whether Totalizer #2 is Enabled or Disabled. The following selections are available: Enabled or Disabled. The default entry is Disabled. Totalizer #2 Mode selections can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

NOTE: Before enabling the Totalizer, ensure that all Totalizer settings are configured properly. Totalizer Start values must be entered in currently active Volumetric or Mass Flow engineering units. The Totalizer will not totalize until the process flow rate becomes equal to or more than the Totalizer Start value. Totalizer Event values must be entered in currently active volume or mass-based engineering units. If the Totalizer Event at preset total volume feature is not required, then set the Totalizer Event value to zero (default settings).

b) Totalizer #2 Configuration (Tabular entry)

Totalizer #2 can be configured to count up or down. When configured to count down, be sure "Totalizer #2 Action Volume" parameter is set to the desired value of more than zero. In this case Totalizer #2 Action Event will be activated when the Totalizer counts down to zero. The following selections are available: Count **UP** or Count **DN**. The default entry is Count **UP**. Totalizer #2 configuration selections can be set with the **UP** and **DN** buttons and are accepted by pressing **ENT** button.

c) Totalizer #2 Flow Start (Numerical entry)

This option allows the start of the Totalizer at a preset flow rate. Totalizer #2 will not totalize until the process flow rate becomes equal to or more than the Totalizer #2 Flow Start value. The limit of required Totalizer #2 Flow Start value can be entered in increments of 0.1% from 0 -100%F.S.

d) Totalizer #2 Action Volume (Numerical entry)

This option allows the user to activate the preset required action when:

- The totalizer reaches a preset volume if the totalizer is configured to count up.
  (or)
- The totalizer reaches zero value if the totalizer is configured to count down.

Totalizer #2 Action Volume value must be entered in currently active volume / mass-based engineering units. When set to count up, Totalizer #2 Action Event becomes true when Totalizer #2 reading is more or equal to preset "Totalizer #2 Action Volume". If the Totalizer#2 Action at preset total volume feature is not required, set "Totalizer #2 Action Volume" value to zero (default settings).

NOTE: When Totalizer #2 is configured to count down, be sure "Totalizer #2 Action Volume" value is set to any value higher than zero.

e) Totalizer #2 Power On Delay (Numerical entry)

Sometimes it is convenient to start the Totalizer only after a specified power-up delay interval. Most of the mass flow meters and controllers require some warm-up time from the power-up event in order to stabilize process variable output and to get accurate reading. “Totalizer #2 Power On Delay” option allows setting a specified time interval which must elapse from the device power-up event before the Totalizer will be activated. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

f) Totalizer #2 Auto Reload (Tabular entry)

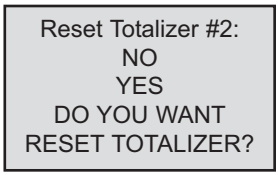
This option allows automatic reset/reload Totalizer #2 when it reaches preset Action Volume value (when configured to count **UP**) or zero value (when configured to count Down). This feature may be convenient for batch processing when predefined volume of the fluid must be repeatedly dispensed into the process. The following selections are available: Enabled or Disabled. The default entry is Disabled. Totalizer #2 Auto Reload selections can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

g) Totalizer #2 Auto Reset Delay (Numerical entry)

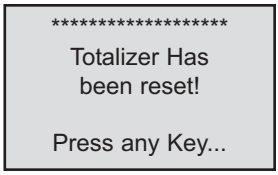
This option may be desirable when “Totalizer #2 Auto Reload” feature is enabled. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

h) Reset Totalizer #2 (Numerical entry)

Totalizers #2 reading can be reset by selecting “Reset Totalizer #2” menu option. A typical display with Totalizer #2 Reset screen is shown below.



Once the “YES” option is selected, Totalizer #2 will be reset and the following conformation screen will appear.



5.3.9 Submenu “Pulse Output”

The flow Pulse Output is operates independently from Totalizers and is based on configuration settings (see Figure 5.7) which can provide pulse frequency proportional to instantaneous fluid flow rate.

The LCD/keypad and digital communication interface commands are provided to:

- Enable/Disable Pulse Output
- Start Pulse Output at preset flow rate (0.0 – 100.0 %F.S.)
- Configure the Unit/Pulse value (in current engineering units)
- Configure Pulse Active On Time (10 - 6553 ms)

NOTE: The Pulse Output minimum Active On time is a 10 milliseconds (.01 second). The Optical Pulse Output cannot operate faster than one pulse every 100 millisecond (.1 second). A good rule to follow is to set the Unit/Pulse value equal to the maximum flow in the same units per second. This will limit the pulse rate to no faster than one pulse every second.

For example: Maximum flow rate = 1200 kg/min
(1200 kg/min = 20 kg/sec)
If unit per pulse is set to 1200 kg per pulse, the Optical Pulse Output will pulse once every minute.

If unit per pulse is set to 20 kg per pulse, the Optical Pulse Output will pulse once every second.

The Optically-isolated Pulse Output incorporates Pulse output queue, which accumulates pulses if the Pulse Output is accumulating process flow faster than the pulse output hardware can function. The queue will allow the pulses to “catch up” later if the flow rate decreases. A better practice is to slow down the Pulse Output by increasing the value in the Unit/Pulse setting in the Pulse Output menu (see Figure 5.7).

NOTE: If Pulse Output feature is required, one of the Digital Optically-Isolated outputs must be assigned to the “Pulse Output” function (see Paragraph 4.3.10). Pulse output signal will be accessible via corresponding Digital Optically-Isolated output on the screw terminal header J1 (see Paragraph 3.5 for proper wiring connections).

5.3.10 Submenu “Opt. Outputs Settings”

Two sets of optically-isolated digital outputs are provided to actuate user-supplied equipment. These are programmable via digital interface or LCD/Keypad such that the outputs can be made to switch when a specified event occurs (e.g. when a Low or High Flow Alarm limit is exceeded, when the Totalizer reaches a specified value), or it may be directly controlled by user.

The user can configure each optical output action from 9 different options:

- Disabled: No Action.
  (Output is not assigned to any events and is not energized).
- Low Flow Alarm.
- High Flow Alarm.
- Range between H&L Flow Alarm settings.
- Totalizer #1 reading exceed set limit.
- Totalizer #2 reading exceed set limit.
- Pulse Output function.
- Diagnostic: Output will be energized when any of the Diagnostic or System events are active.
- Manual On Control: Output will be energized until Disabled option is selected.

By default both optically-isolated outputs are disabled.

NOTE: Optically-isolated outputs are accessible via screw terminal header J1 and require application of external DC voltage across terminals. See Paragraph 4.5 for proper wiring connections.

5.3.11 Submenu “Display Settings”

Process Information screens can be configured to be static (manual control) or dynamic (automatic sequencing). In the static mode pressing the **UP** button allows the user to page through the PI screens in the forward direction. Pressing **DN** button, pages through the PI screens in the reverse direction. When the last PI screen is reached, the firmware “wraps around” and scrolls to the initial PI screen once again.

NOTE: PI screens which are masked in the Screen Mask Register (see below) will be skipped.

Use the “General Settings” menu to navigate to the “Display Settings” menu option (See Figure 5.7).

The following settings are available for LCD Display:

a) Display Mode (Tabular entry)

This option determines whether Display screens are in Static (manual control) or Dynamic (automatic sequencing) mode. The following selections are available: Static or Dynamic. The default entry is: Static (manual control). Display screens mode parameter can be set with the **UP** and **DN** buttons and are accepted by pressing the **ENT** button.

b) Screen Cycle Time (Numerical entry)

This menu selection defines the time interval in seconds for each PI screen to be displayed in the dynamic mode (automatic sequencing). Screen Cycle Time can be set to any value in the range between 1 to 3600 seconds (numerical entry).

c) Screen Mask (Tabular entry)

Using Screen Mask settings the user can enable (unmask) or disable (mask) up to 4 different process variable combinations (see Figure 5.4). By default the unit is shipped from the factory with all PI screens enabled. A typical display with Screen Mask selection is shown below.

Screen Masc:
Screen #1 [*]
Screen #2 [*]
Screen #3 [*]
Screen #4 [*]

In the example shown above, all PI screens are enabled. Each PI screen is assigned to a corresponding bit in the PI Screen Register. In order to change PI Screen mask settings the user should select the desired screen using **UP** and **DN** buttons and then press **RIGHT** button. The asterisk will appear/disappear on the right side of the corresponding screen. The asterisk signifies that the screen is enabled. In order to disable the screen, the corresponding asterisk must be removed. Use the **ENT** button to accept and save new PI Screen Mask settings in the device's nonvolatile memory.

NOTE: PI Screen #1 cannot be disabled (unmasked).

d) Display Back Light (Numerical entry)

Using Display Back Light settings the user can adjust the desired level of the LCD back light has 19 different levels. Use **UP** and **DN** buttons to adjust back light level and press the **ENT** button to accept and save back light level settings in the device's nonvolatile memory.

e) Display Contrast (Numerical entry)

Using Display Contrast settings the user can adjust the desired level of the LCD contrast which has 16 different levels. Use **UP** and **DN** buttons to adjust contrast levels and press **ENT** button to accept and save contrast level settings in the device's nonvolatile memory.

NOTE: By default the contrast level is set to 6 which is the optimal level for room temperature (20 °C or 70 °F).

5.3.12 Submenu "Device Function"

This menu selection allows the selection of TIO function according to the mated device type. If TIO is connected to flow meter then ***"Meter"*** function must be selected. If TIO is connected to flow controller then ***"Controller"*** function must be selected.

NOTE: Based on "Device Function" (device function as flow meter or flow controller) settings, different parameters may be displayed in the Process Information (PI) screen (See Figure 5.4) and different features of the TIO device may be enabled or disabled (set point control only enabled when TIO is configured as flow controller). Also some features (e.g. Flow Alarm) may have different behavior. Be sure the "Device Function" parameter is set according to the actual device being used.

5.3.13 Submenu "Communication Settings"

This menu selection allows the configuration of a digital communication interface speed (Baud rate) and device RS-485 bus address (only applicable for optional RS-485 interface)

The following settings are available for "Communication Settings" (see Figure 5.7):

a) Baud Rate Settings (Tabular entry)

This option determines device digital communication interface speed (Baud rate) and can be set to one of the following:
1200
2400
4800
9600
19200
38400
57600
115200

By default the device shipped from factory with baud rate set to 9600.

NOTE: The baud rate set on the TIO device should always follow the baud rate of the host PC or PLC it connected to.

b) RS-485 Bus Address (Numerical entry)

The standard TIO comes with an RS-232 interface. The optional RS-485 interface has two hexadecimal characters of the address which must be assigned. By default each flow meter is shipped with RS-485 address set to 11 hexadecimal. When more than one device is present on RS-485 bus, each device should have a unique address. The two characters of the address in the hexadecimal representation can be changed from 01 to FF.

NOTE: Address 00 is reserved for global addressing. Do not assign, the global address for any device. When command with global address is sent, all devices on the RS-485 bus execute the command but do not reply with an acknowledge message.

NOTE: Do not assign the same RS-485 address for two or more devices on the same RS-485 bus. If two or more devices with the same address are connected to the one RS-485 network, a communication collision will take place on the bus and communication errors will occur.

RS-485 address setting is not used for TIO's with RS-232 interface.

5.3.14 Submenu "Device Calibration"

The Calibration Menu contains the parameters, which must be set according to the flow meter / controller being used and according to required process conditions. These values should be changed only by properly trained personnel. Device Analog Output and Input calibration was performed in the factory and should not be initiated unless recommended by factory personnel. The following settings are available for "Device Calibration" menu selection:

a) Full Scale Range (Numerical entry)

The Full Scale Range value in Litr/min should be set equal to the full scale range (converted to Litr/min) of the device mated to TIO. The analog input and output will be scaled automatically to this value. For example, if Full Scale Range value set to 10.0 Litr/min and the device is configured for 0-5 Vdc analog input, when 5.0 Vdc is applied to TIO analog input the PI flow rate will indicate 100.0%FS (if %F.S. units of measure is selected).

NOTE: Failure to set Full Scale Range parameter in Litr/min equal to the full scale range (converted to Litr/min) of the device mated to TIO may cause an erroneous reading and unexpected device behavior.

b) Low Flow Cut-Off (Numerical entry)

The Low flow cut-off can be selected between 0.0 and 10.0 % of the full scale range. Flows less than the cut-off value are internally driven to zero and not totalized. Default value of the "Low flow Cut-Off" parameter is zero (disabled).

c) Flow Power Up Delay (Numerical entry)

Sometimes it is convenient to start the process input signals after the specified power-up delay interval. Most mass flow meters and controllers require some warm-up time from the power-up event in order to stabilize process variable output and get accurate reading. “Flow Power **UP** Delay” option allows a set specified time interval which must elapse from the device power-up event, before processing of the input signals will be activated. During the active faze of the Power Up Delay, the flow rate will be internally driven to zero and not totalized. Valid settings are in the range of 0 to 3600 seconds (default value is 0, no delay).

d) Fluid Std. Density (Numerical entry)

The density of the flowing fluid at standard temperature and pressure conditions must be entered in g/litr. This parameter is used only when mass-based engineering units are selected. Valid settings are in the range of 0.000001 to 10000.0 g/litr. Factory set default value is 1.25 g/litr (Nitrogen).

e) Analog Output Calibration

NOTE: The analog outputs available in the TIO were calibrated at the factory. There is no need to perform analog output calibration unless the DAC IC, output amplifier IC or passive components from analog output circuitries were replaced. Any alteration of the analog output scaling variables in the EEPROM table will VOID calibration warranty supplied with the instrument.

The TIO analog output calibration involves calculation and storing the off set and span variables in the EEPROM based on two calibration points (0 and 100% F.S.). The 0-5 (0-10)Vdc output has only scale variable and 4-20 mA output has offset and scale variables.

Power up the TIO instrument for at least 15 minutes prior to commencing the calibration procedure. Observe analog output jumper position (see Figure 4.2) and connect the corresponding type of measurement device to pins 5 (plus) and 8 (minus) of the 9-pin D-connector. Follow firmware prompts and adjust calibration point values according to measurement device reading. If calibration must be aborted, press **ESC** button. When calibration is completed firmware will display new offset and span values and ask the user to press the **ENT** button to save new calibration variables to EEPROM or **ESC** to abort calibration and exit without saving. In the end, the firmware will prompt with confirmation message.

f) Analog Input Calibration

NOTE: The analog inputs available for the TIO were calibrated at the factory. There is no need to perform analog input calibration unless the CPU IC, input amplifier IC or passive components from the analog input circuitries were replaced. Any alteration of the analog input scaling variables in the EEPROM table will VOID the calibration warranty supplied with instrument.

The TIO analog output calibration involves calculation and storing the offset and span variables in the EEPROM based on two calibration points (0 and 100% F.S.). The 0-5 (0-10)Vdc output has only scale variable and 4-20 mA output has offset and scale variables.

NOTE: Check the actual input jumpers' configuration before applying any input signal to TIO. Be sure your input signal does not exceed the maximum allowed level for corresponding input type (see Table 4.1). Do not apply voltages above 5.0 Vdc unless TIO input was specifically configured in the factory for 0-10 Vdc (check actual model number and specification). Exceeding maximum allowed input level may cause inadvertent damage to the device circuitry.

Power up the TIO instrument for at least 15 minutes prior to commencing the calibration procedure. Observe analog input jumper position (see Figure 4.2) and connect corresponding type of the calibration signal source device to pins 4 (plus) and 8 (minus) of the 9-pin D-connector. Follow firmware prompts and apply calibration point values according to on screen instructions. If calibration must be aborted, press **ESC** but ton. When calibration is completed firmware will display new offset and span values and ask press **ENT** button to save new calibration variables to EEPROM or **ESC** to abort calibration and exit without saving. In the end, the firmware will prompt with a confirmation message.

g) Pilot Calibration Timer

The Pilot Calibration timer accumulates operational hours since the last time the unit was calibrated. The smallest increment value is 0.1 Hour (6 minutes). The value of the timer may be reset by the user by pressing **RIGHT** button. Once **RIGHT** button is pressed the confirmation screen will appear with the "Yes" or "No" menu. Selecting "Yes" will reset the pilot calibration timer back to zero.

5.3.15 Submenu "Signal Conditioner"

A noise reduction filter algorithm (Running Average or Noise Reduction Filter) is available in the flow meter when pulsating flow or especially noisy signals are encountered. The Flow Linearizer algorithm is also available when flow linearity must be improved.

There are three parameters which make up **Running Average Filter:**

- Number of Samples
- Time Interval
- Error Limit

They are described individually below.

The following settings are available for the "Signal Conditioner" (see Figure 5.7):

a) Signal Conditioner Mode (Tabular Entry)

This option determines whether the Noise Reduction feature is enabled and the type of noise reduction algorithm. The following selections are available:

- Disabled
- NRF (Noise Reduction Filter)
- Running Average

Factory default value is NRF.

b) NRF Number of Samples (Numerical Entry)

The sample number value between 1 and 32 can be selected. The number of samples value represents the number of previous individual inputs used to calculate the average value. Eventually the number of samples in the running average also affects the response time. The more samples are used, the more inertial flow output readings will be to the actual flow change. A suggested nominal number of 12 samples (default value) is a good starting point for most applications.

c) NRF Time Interval (Numerical Entry)

Time Interval can be selected between 0 and 199 ms. The value represents the response time of the NRF flow rate change. The higher the Time Interval values the longer the response time of the filter. If noise reduction filter is not desired, it may be disabled by setting the Time Interval parameter to zero. By default units are shipped from the factory with the Time Interval value set to 50.

d) NRF Error Limit (Numerical Entry)

The Error Limit value can be selected between 0.0 and 10.0 % F.S. (for consistency) . The value represents the difference of the signal sample from previous measured value. The Error Limit is configured to reject noise spikes within the flow range while allowing normal variation of the flow signal. The factory default setting 2.0% of full scale optimizes noise rejection in most applications.

e) Average Filter Damping (Numerical Entry)

The Average Filter Damping parameter is only applicable for Running Average mode of the Signal Conditioner and its value can be selected between 0 and 500 ms.The value represents the response time for a 0 - 66 % step flow rate change. When the damping value set to 0, it is disabled. Factory default value is 200.

f) Flow Linearizer Mode (Tabular Entry)

The Flow Linearization algorithm may be used to improve linearity of the flow measurement. The default Flow Linearization Table, stored in the device EEPROM, is linear and does not change input signal. By default the unit is shipped from the factory with disabled Flow Linearizer.

The flow linearization table calibration can be done using only the supplied “TIO Configuration Utility” software via digital (RS-232 or RS-485) interface. It involves building a table of the actual flow values (EEPROM indexes 98, 100, 102, 104, 106, 108, 110, 112, 114, 116, 118) and corresponding sensor readings (EEPROM indexes 99, 101, 103, 105, 107, 109, 111, 113, 115, 117, 119). Actual flow and sensor reading values are entered in normalized fraction format: 100.000 %F.S. corre sponds to 1.000000 flow value 0.000 % F.S. corresponds to 0.000000 flow value. The valid range for flow values is from 0.000000 to 1.000000 (note: TIO will accept up to 6 digits after decimal point). There are 11 elements in the table so the data should be obtained at an increment of 10.0 % of F.S. (0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0 and 100.0 % F.S.).

Note: Do not alter memory index 98 and 99 (must be 0.0). These numbers represent zero flow calibration points and SHOULD NOT BE CHANGED.

Note: It is recommended to use Aalborg® supplied calibration and maintenance software for linearization table calibration. This software includes an automated calibration procedure which may radically simplify reading and writing for the EEPROM linearization table.

5.3.16 Submenu "Program Set Point"

The Program Set Point Control allows execution of custom, user-preset programs of up to sixteen steps. During execution of the program, the user can activate or deactivate the LOOP mode and pause program execution. Various flow configurations may be preprogrammed: ramping, pulsing, linearized increasing and/or decreasing of the flow. Before executing, the program should be entered in the program table in the format: SETPOINT [% F.S.] - TIME [sec.]. TIME means: time it takes for the value of the set point signal for the flow controller, to linearly approach the SETPOINT value (ramping).

Note: Program Set Point feature will work only if "Device Function" parameter is set to Controller.

Following settings are available for "Program Set Point" (see Figure 5.7):

a) Program Set Point Mode (Tabular Entry)

This function determines whether the Program Set Point is Enabled or Disabled. The following selections are available: Enabled or Disabled. The default entry is Disabled. Program Set Point Mode selections can be set with the **UP** and **DN** buttons and are accepted by pressing **ENT** button.

b) Program Set Point Loop Mode (Tabular Entry)

This function determines whether the Program Set Point Loop is Enabled or Disabled. If Loop is enabled as the program reaches the last step it wraps around and again starts execution from the first enabled step. The following selections are available: Enabled or Disabled. The default entry is Disabled. Program Set Point Loop Mode selections can be set with the **UP** and **DN** buttons and are accepted by pressing **ENT** button.

c) PSP Steps Mask (Tabular Entry)

Using PSP Steps Mask settings the user can enable (unmask) or disable (mask) any step in the program. If the step is masked, the program will skip it and move to the next enabled step. By default the unit is shipped from the factory with all program steps enabled (unmasked). A typical display with PSP Steps Mask selection is shown below.

PSP Steps Masc:			
S01	0.0%	0s	[*]
S02	0.0%	10s	[*]
S03	25.0%	25s	[*]
S04	25.0%	10s	[*]
S05	50.0%	25s	[*]

In the example shown above, all PSP Steps are enabled. Each PSP Step assigned to a corresponding bit in the PSP Steps Register. In order to change PSP Step mask settings user should select desired Step using **UP** and **DN** buttons and then press **RIGHT** button. The asterisk will appear/ disappear on the right side of the corresponding Step. The asterisk represents that Step is enabled. In order to disable Step, the corresponding asterisk must be removed. Use **ENT** button to accept and save new PSP Steps mask settings in device non volatile memory.

d) PSP Steps Settings (Numerical Entry)

By using PSP Steps Settings menu selection the user can assign required set point and time values for each step in the program. A typical display with PSP Steps Settings selection is shown below.

PSP Steps Settings:			
S01	0.0%	0s	[*]
S02	0.0%	10s	[*]
S03	25.0%	25s	[*]
S04	25.0%	10s	[*]
S05	50.0%	25s	[*]

In the example shown above, Step 01 is selected. For each step there are two parameters: set point value in %F.S. and time interval in seconds. In order to change PSP Step settings user should select desired step using **UP** and **DN** buttons and then press the **ENT** button. The cursor in the selected (highlighted) parameter will start flashing. Use **UP**, **DN**, **LEFT**, **RIGHT** buttons to adjust desired value. Then press **ENT** button to accept and save the new PSP Step settings in the device's nonvolatile memory.

5.3.17 Submenu "Event Register Menu"

TIO is equipped with a self-diagnostic Alarm Event Register which is available via the digital interface and on the screen LCD indication. Use the "Diagnostic Menu" to navigate to "Event Register Menu" option.

The following Diagnostic Events are supported:

Table 5.2

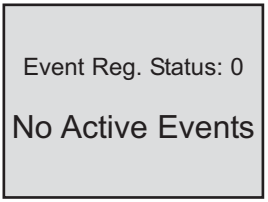
EVENT NUMBER	DIAGNOSTIC AND ALARM EVENTS DESCRIPTION	LCD BIT CODE
1	CPU Temperature Too High	0
2	High Flow Alarm	1
3	Low Flow Alarm	2
4	Range Between High and Low	3
5	Totalizer#1 Exceed Set Event Volume Limit	4
6	Totalizer#2 Exceed Set Event Volume Limit	5
7	Optical Pulse Output Queue overflow	6
8	Flow Rate above Limit	7
9	Vcc Power Voltage Out of Range	8
10	Serial Communication Error	9
11	EEPROM Error	A
12	Power On Event (power on delay timer > 0)	B
13	Password Event	C
14	Fatal Error (unrecoverable error)	D

NOTE: Any Alarm or Diagnostic Events that may have occurred (Event 0 to Event D) are stored in the internal status register. All detected events (if corresponding bit in the latch register is not masked) remain stored until the register is manually reset (by key-pad or by means of the digital communication interface). If event corresponding bit in the latch register is masked (disabled), the event will be indicated as long as it is active (no latching). The status Alarm Event Register is mapped to the SRAM (volatile memory). In case of power interruption the status Event Register will be automatically reset.

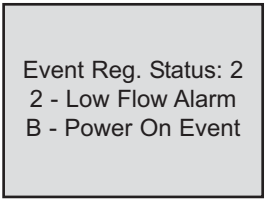
The following settings are available for “Event Register Menu” (see Figure 5.7):

a) Event Register Status (Read Only)

Each active Alarm Event will be indicated on the LCD screen. In addidtion the total number of currently active events will be displayed on the first line (header). A typical display without active diagnostic and Alarm Events is shown below.



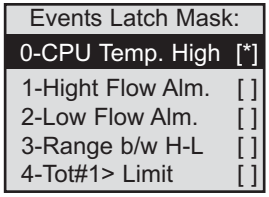
A typical display with two active events is shown below.



If more than 7 events are displayed, the user can use **UP** and **DN** buttons to scroll and see all indicated events. If the event is not latched in the Event Latch Mask Register it may appear and disappear from the status screen and will be indicated as long as actual event is taking place.

b) Event Latch Mask (Tabular entry)

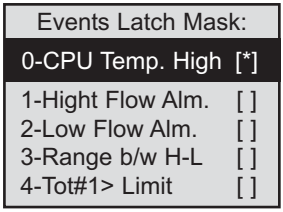
Using Event Latch Mask settings the user can enable (unmask) or disable (mask) the latch feature individually for each event. The event is enabled if an asterisk sign [*] is set to the right across from the corresponding event. If the event is not latched (no aste.risk across from the corresponding event) it may appear and disappear from the status screen. It will be indicated as long as the actual event is taking place. By default the unit is shipped from the factory with only one event active: 0 – CPU Temperature Too High. For all other events the latch feature is disabled. A typical display with Event Latch Mask selection is shown below.



In the example shown above, latch features for all events are disabled, except event #0. In order to change Event Latch mask settings, the user should select the desired event using **UP** and **DN** buttons and then press the **RIGHT** button. The asterisk will appear/disappear on the right side of the corresponding event. The asterisk represents that the latch feature is enabled. In order to disable latch feature, the corresponding asterisk must be removed. Use **ENT** button to accept and save new Event Latch mask settings in the device's non-volatile memory.

c) Event Register Mask (Tabular entry)

Using the Event Register Mask settings, the user can individually enable (unmask) or disable (mask) each event. The event is enabled if the asterisk sign [*] is set to the right across from corresponding event. If the event is disabled, it will not be processed and indicated in the Events status Register even actual conditions for the event have occurred. By default the unit is shipped from the factory with only one event active: "0 – CPU Temperature Too High". All other events are disabled. A typical display with Event Register Mask selection is shown below.



In the example shown above, all events are disabled, except event #0. In order to change Event Register mask settings user should select the desired event using **UP** and **DN** buttons and then press the **RIGHT** button. The asterisk will appear/disappear on the right side of the corresponding event. The asterisk represents that the event is enabled. In order to disable event, the corresponding asterisk must be removed. Use the **ENT** button to accept and save the new Event Register mask settings in the device's nonvolatile memory.

d) Reset Event Register (Tabular entry)

The Event Register can be reset by selecting "Reset Event Register" menu option. A typical display with Reset Event Register screen is shown below.

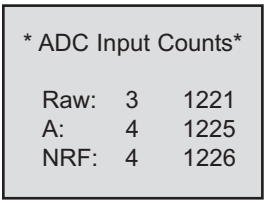
Once the "YES" option is selected, the Event Register will be reset and the following conformation screen will appear.

5.3.18 Submenu "Diagnostic Menu"

The Diagnostics Menu can be used for troubleshooting purposes and provides information about the device's internal variables. These items (except Events Register submenu described above) are only informational and cannot be changed (read only).

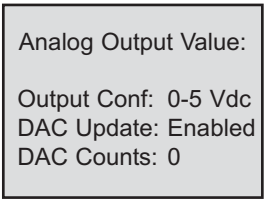
a) ADC Input Counts (Read Only)

This menu selection provides raw, average, and filtered values of the ADC counts for analog input circuitry (read only). A typical display with ADC Input Counts screen is shown below.



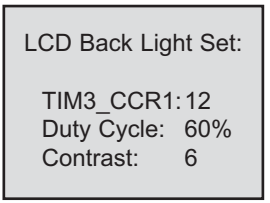
b) Analog Output Values (Read Only)

This menu selection provides information about currently selected analog output configuration, and DAC counts for analog output circuitry (read only). A typical display with DAC Output Values screen is shown below.



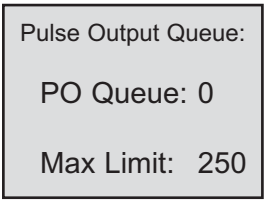
c) LCD Back Light Settings (Read Only)

This menu selection provides information about LCD back light level, PWM duty cycle and contrast (read only). A typical display with LCD Back Light Settings screen is shown below.



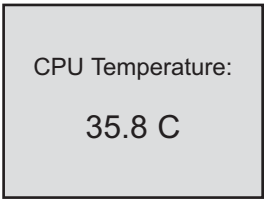
d) Pulse Output Queue (Read Only)

This menu selection provides information about Pulse output queue. A typical display with Pulse Output Queue screen is shown below.



e) CPU Temperature (Read Only)

This menu selection provides the current value of the PCB and CPU temperature in °C (read only). A typical display with CPU Temperature reading is shown below.



6. INSTALLATION

6.1 General Directions

- Mounting, electrical installations, parameters configuration, start up, and maintenance of this instrument may only be performed by trained personnel. Personnel must read and understand this operating manual before performing any installation or configuration steps.

- The TIO device should only be operated by trained personnel. All instructions in this manual are to be observed.

- Ensure that power and all input / output signals are correctly wired according to the wiring diagram provided in this manual. The housing of the device should only be opened by trained personnel.

6.2 Hardware Installation

NOTE: Electrostatic discharge may cause permanent damage to the electronic circuitry. Before installing or connecting any wires, the installer must discharge himself by touching the building protective earth ground.

The TIO Totalizer Input / Output Flow monitor / Controller can be attached (mounted) to the Aalborg® GFM series flow meters, GFC series controllers or used stand alone (panel mounted or table top installation).

6.2.1 Connecting TIO to GFM series Flow Meter

a) Mounting

Use GFM mounting kit (See Table 5.1) to attach TIO to the GFM Flow Meter (see Figure 6.1).

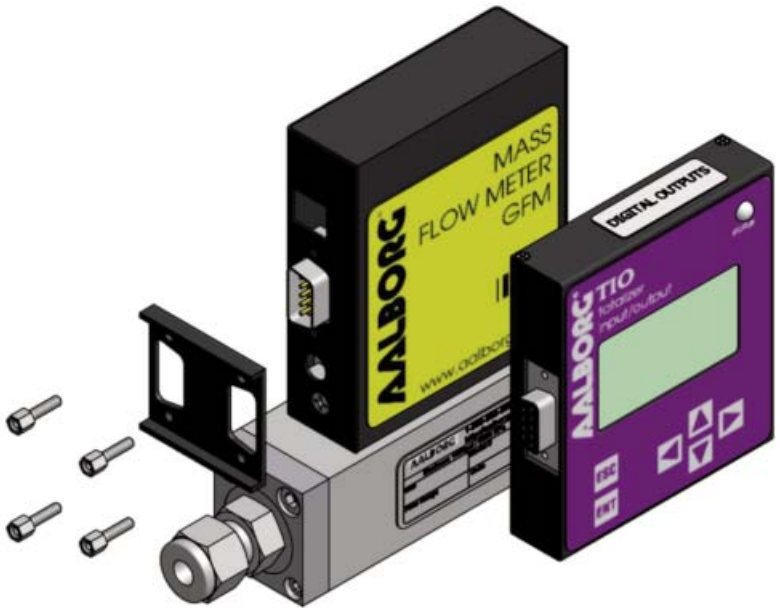


Figure 6.1 Mounting TIO to the GFM Flow Meter

b) Electrical Connection

GFM Flow Meters have three different output interfaces (0-5, 5-10 Vdc, 4-20 mA) which can be used to provide flow input signal to TIO.

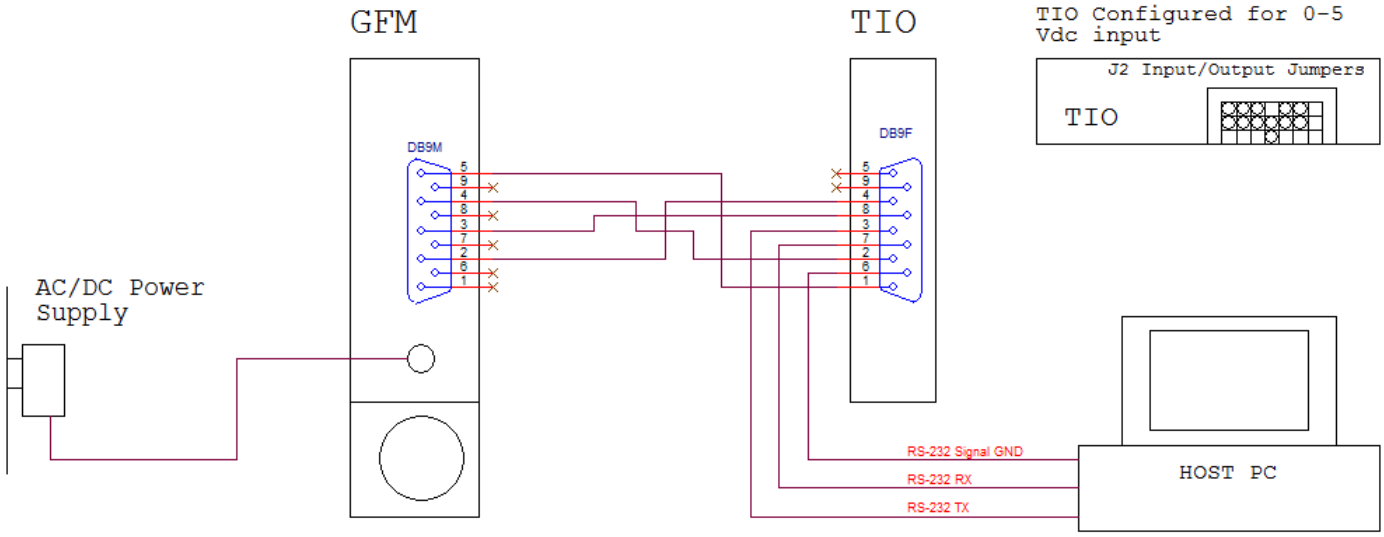


Figure 6.2 Connecting TIO to the GFM using 0-5 Vdc output from DB9 connector.

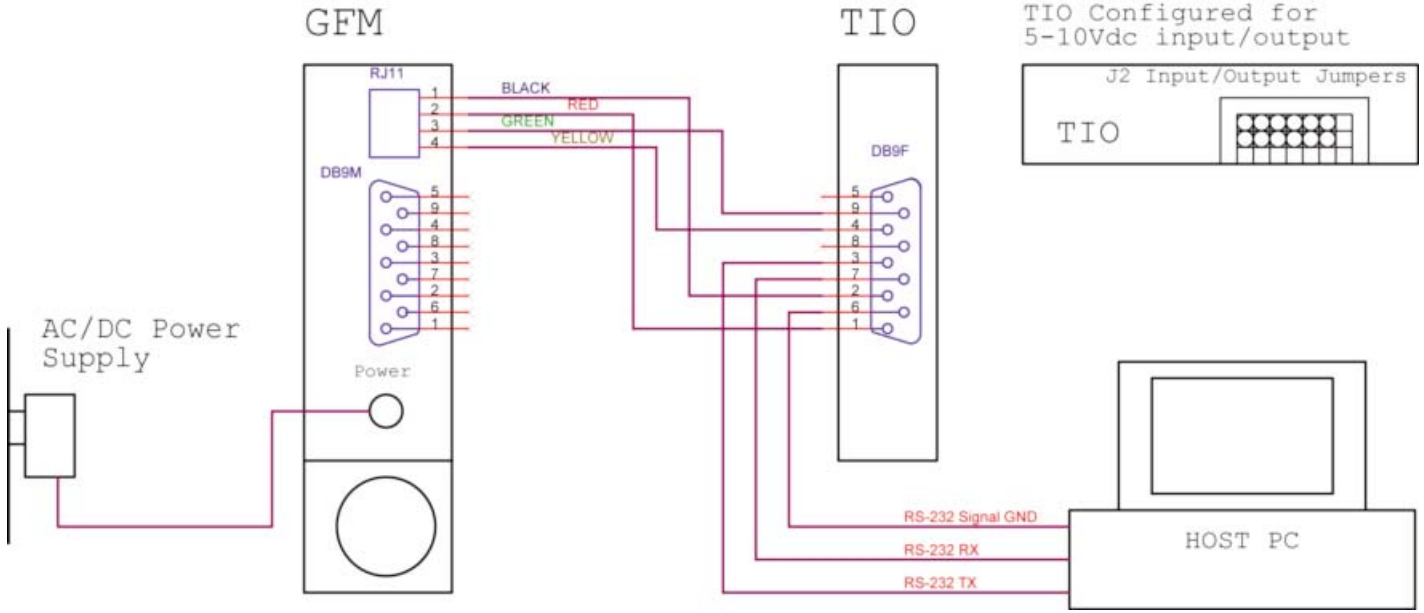


Figure 6.3 Connecting TIO to the GFM using 5-10 Vdc output from RJ11 connector.

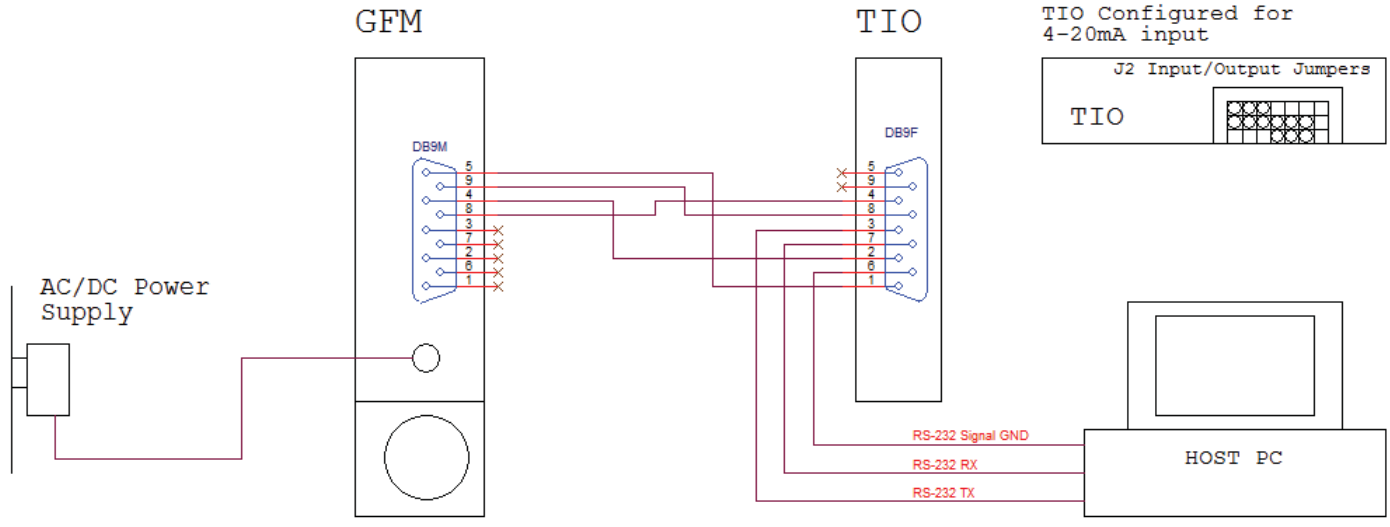


Figure 6.4 Connecting TIO to the GFM using 4-20 mA output from DB9 connector.

Based on interface being used, Optional Cables Kit Assemblies are available for order. See Table 6.1 for optional GFM cables kit assemblies.

TABLE 6.1 OPTIONAL GFM CABLES AND MOUNTING KIT ASSEMBLIES

Kit Part Number	DESCRIPTION	TIO Input	Communication Interface Cable	GFM Power Supply Option
KIT-TM-DD	Shielded cable with two 9 pins D-connectors for process signals and 6 feet communication branch	0-5 Vdc	YES	12 and 24 Vdc
KIT-TM-RD	4 wires cable between GFM RJ11 and TIO 9 pin D-connector	5-10 Vdc	NO	12 Vdc only
KIT-TM-FD	Flat 4 wires cable between GFM and TIO 9 pin D-connectors	0-5 Vdc	NO	12 and 24 Vdc
KIT-TM	GFM flow meter mounting kit, no cables	N/A	N/A	N/A

NOTE: For all GFM Kits (except KIT-TM) it is assumed that the power supplied is connected to the GFM power DC jack connector and the TIO receiving the power from the GFM.

c) Input/Output Jumper Configuration

NOTE: Your TIO device input / output jumpers were configured at the factory according to your order. There is no need to change input / output jumpers' configuration unless a different input is being used. Before applying power and process signals, make sure the input /output jumpers are installed in the correct position (See Table 6.2).

TABLE 6.2 J2 INPUT / OUTPUT JUMPER CONFIGURATION OPTIONS FOR GFM SERIES FLOW METERS								
PV INPUT TYPE (TIO INPUT)	J2 JUMPER CONFIGURATION						GFM CABLE KIT	NOTE
	J2A	J2B	J2C	J2D	J2E	J2F		
0 - 5 Vdc	2 - 3	5 - 6	8 - 9	10-11	14-15	17-18	KIT-TM-DD KIT-TM-FD	
5 - 10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	KIT-TM-RD	+5Vdc reference signal must be used
0 - 10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	NOT SUPPORTED FOR GFM	Special Order option! (PCB hardware must be changed)
4 – 20 mA	2 - 3	5 - 6	8 - 9	10-11	13-14	16-17	N/A (user custom cable assembly)	(249 Ohm passive, not isolated current input)

d) Parameters Configuration

Following parameters must be configured:

- **Device Function** (See 4.3.12 Submenu “Device Function”). “Meter” function must be selected.
- **Full Scale Range** (See 4.3.14 Submenu “Device Calibration”). Full Scale Range parameter must be set equal to the GFM full scale flow rate in Litr/min.
- **Fluid Std. Density** (See 4.3.14 Submenu “Device Calibration”). This parameter is required only when mass-based engineering units are selected.

NOTE: If “Full Scale Range”, “Device Function” and “Fluid Std. Density” parameters are not set properly the device may have erroneous reading and unpredictable behavior.

User may configure other parameters (see Paragraph 5.3) according to individual preferences and application requirements.

6.2.2 Connecting TIO to GFC series flow controller

a) Mounting

Use GFC Mounting Kit (See Table 6.3) to attach TIO to the GFC flow controller (see Figure 5.5).

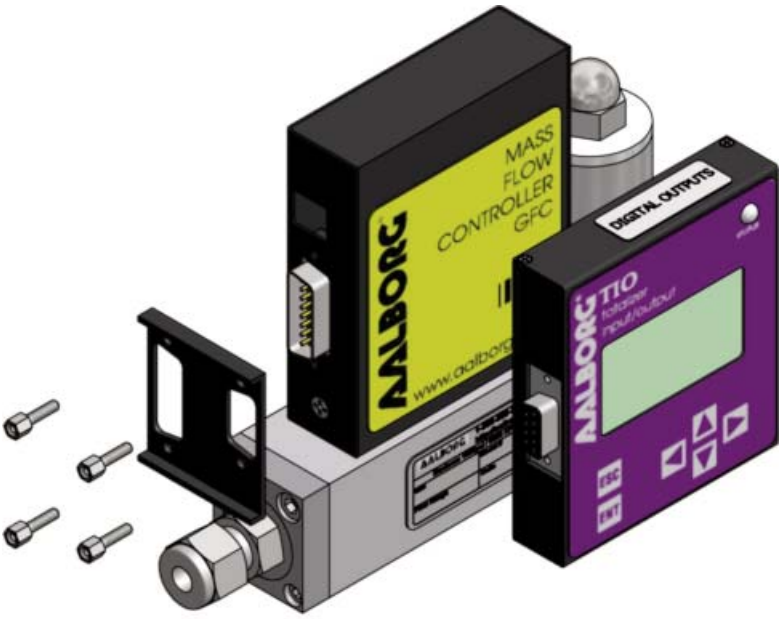


Figure 6.5 Mounting TIO to the GFC Flow Controller

b) Electrical Connection

GFC flow controllers have two output interfaces: 0-5 Vdc and 4-20 mA which can be used to provide flow input signal to TIO. They also support two analog input signals: 0-5Vdc and 4-20 mA (jumper-selectable on the GFC PC board).

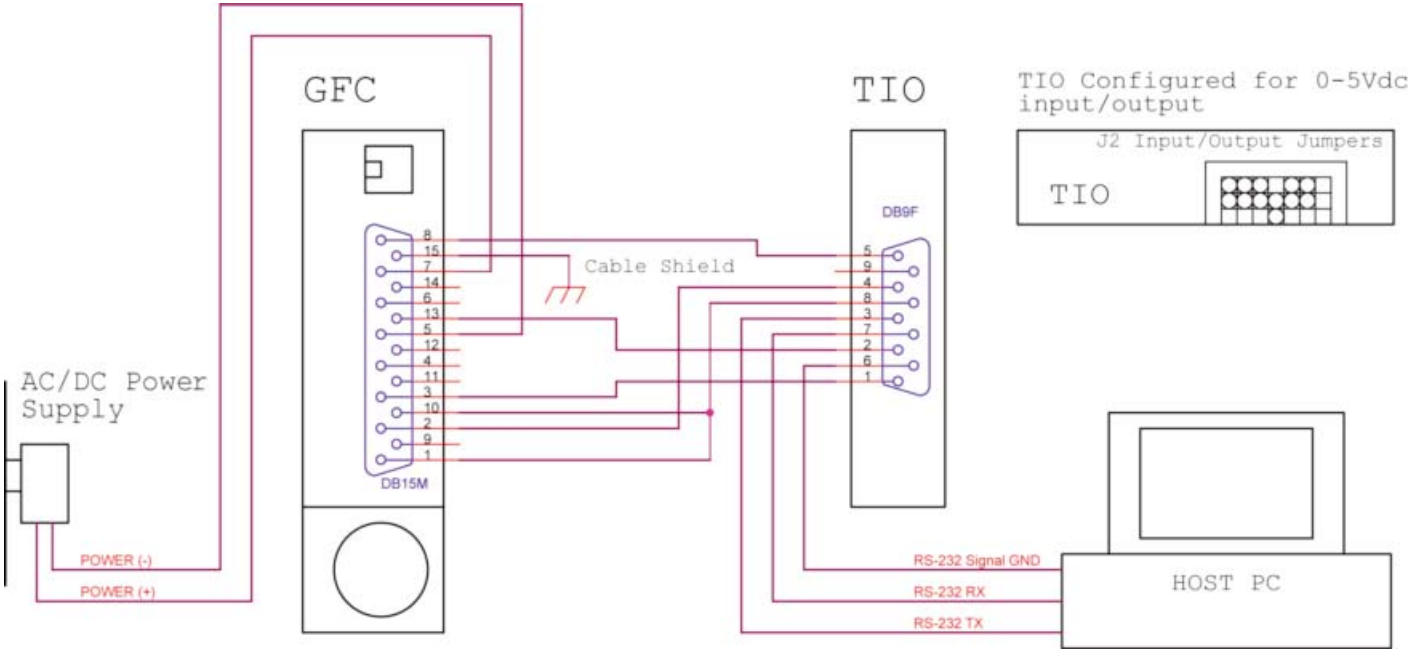


Figure 6.6 Connecting TIO to the GFC Using 0-5Vdc Input / Output from DB15 Connector.

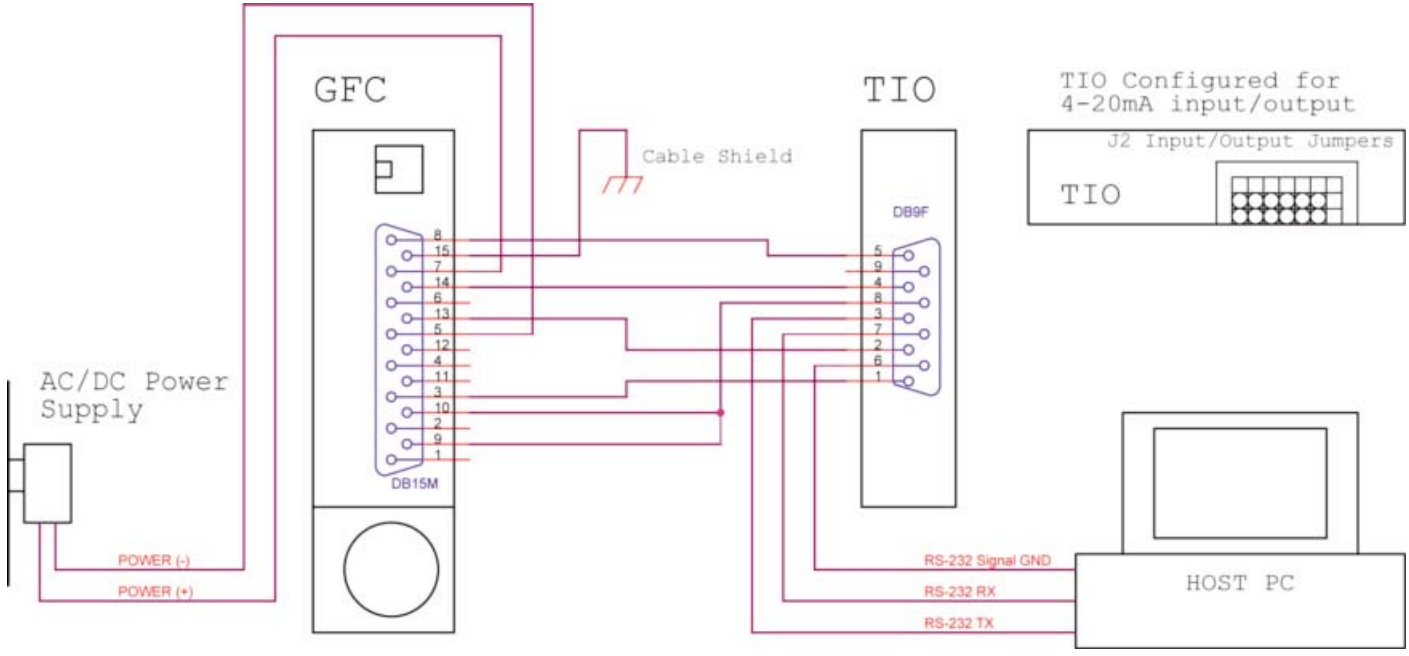


Figure 6.7 Connecting TIO to the GFC Using 4-20mA Input / Output from DB15 Connector.

Based on interface being used and power supply option, optional Cables Kit Assemblies are available for order. See Table 6.3 for optional GFC Cables Kit Assemblies.

TABLE 6.3 OPTIONAL GFC POWER SUPPLY / CABLES AND MOUNTING KIT ASSEMBLIES

Kit Part Number	Description	TIO Input/Output	Communication Interface Cable	GFC Power Supply Option
KIT-TC-110NA-2C	Shielded cable with North America plug 110 Vac to 12 Vdc power supply, communication branch	0-5 Vdc	YES	12 Vdc only
KIT-TC-110NA-2N	Shielded cable with North America plug 110 Vac to 12 Vdc power supply	0-5 Vdc	NO	12 Vdc only
KIT-TC-110NA-4C	Shielded cable with North America plug 110 Vac to 24 Vdc power supply, communication branch	0-5 Vdc	YES	24 Vdc only
KIT-TC-110NA-4N	Shielded cable with North America plug 110 Vac to 24 Vdc power supply	0-5 Vdc	NO	24 Vdc only
KIT-TC-230EU-2C	Shielded cable with EUROPE plug 230 Vac to 12 Vdc power supply, communication branch	0-5 Vdc	YES	12 Vdc only
KIT-TC-230EU -2N	Shielded cable with EUROPE plug 230 Vac to 12 Vdc power supply, communication branch	0-5 Vdc	NO	12 Vdc only
KIT-TC-230EU-4C	Shielded cable with EUROPE plug 230 Vac to 24 Vdc power supply, communication branch	0-5 Vdc	YES	24 Vdc only
KIT-TC-230EU-4N	Shielded cable with EUROPE plug 230 Vac to 24 Vdc power supply, communication branch	0-5 Vdc	NO	24 Vdc only
KIT-TC-240AU-2C	Shielded cable with AUSTRALIA plug 240 Vac to 12 Vdc power supply, communication branch	0-5 Vdc	YES	12 Vdc only

Kit Part Number	Description	TIO Input/Output	Communication Interface Cable	GFC Power Supply Option
KIT-TC-240AU-2N	Shielded cable with AUSTRALIA plug 240 Vac to 12 Vdc power supply	0-5 Vdc	NO	12 Vdc only
KIT-TC-240AU-4C	Shielded cable with AUSTRALIA plug 240 Vac to 24 Vdc power supply, communication branch	0-5 Vdc	YES	24 Vdc only
KIT-TC-240AU-4N	Shielded cable with AUSTRALIA plug 240 Vac to 24 Vdc power supply	0-5 Vdc	NO	24 Vdc only
KIT-TC-240UK-2C	Shielded cable with UK plug 240 Vac to 12 Vdc power supply, communication branch	0-5 Vdc	YES	12 Vdc only
KIT-TC-240UK -2N	Shielded cable with UK plug 240 Vac to 12 Vdc power supply	0-5 Vdc	NO	12 Vdc only
KIT-TC-240UK -4C	Shielded cable with UK plug 240 Vac to 24 Vdc power supply, communication branch	0-5 Vdc	YES	24 Vdc only
KIT-TC-240UK-4N	Shielded cable with UK plug 240 Vac to 24 Vdc power supply	0-5 Vdc	NO	24 Vdc only
KIT-TC	GFC flow controller mounting kit, no cables, no power supply	N/A	N/A	N/A

NOTE: All GFC Kits (except KIT-TC) have power supply for GFC flow controller and TIO receiving the power from GFC.

c) Input/Output Jumper Configuration

NOTE: Your TIO device input / output jumpers were configured at the factory according to your order. There is no need to change the input / output jumper's configuration unless different input is being used. Before applying power and process signals make sure the input / output jumpers are installed in the correct position (See Table 6.4).

TABLE 6.4 J2 INPUT / OUTPUT JUMPER CONFIGURATION OPTIONS FOR GFC SERIES FLOW CONTROLLERS

TIO PV TYPE		J2 JUMPER CONFIGURATION						GFC CABLE KIT	NOTE
OUTPUT	INPUT	J2A	J2B	J2C	J2D	J2E	J2F		
0-5Vdc	0-5Vdc	2 - 3	5 - 6	8 - 9	10-11	14-15	17-18	KIT-TC-XXXXX-XX	Supported by all GFC Kits, except KIT-TC
0-5Vdc	4-20 mA	2 - 3	5 - 6	8 - 9	10-11	13-14	16-17	N/A (user custom cable assembly only)	Not supported by GFC Cable Kits
4 – 20 mA	0-5Vdc	1 - 2	4 - 5	7 - 8	10-11	14-15	17-18	N/A (user custom cable assembly only)	Not supported by GFC Cable Kits
4 – 20 mA	4 – 20 mA	1 - 2	4 - 5	7 - 8	10-11	13-14	16-17	N/A (user custom cable assembly only)	Not supported by GFC Cable Kits
0 - 10 Vdc	0 - 10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	NOT SUPPORTED BY GFC	Special Order option! (PCB hardware must be changed)

d) Parameters configuration

The following parameters must be configured:

- **Device Function** (See 5.3.12 Submenu “Device Function”). ***“Controller”*** function must be selected.
- **Full Scale Range** (See 5.3.14 Submenu “Device Calibration”). Full Scale Range parameter must be set equal to the GFC full scale flow rate in Litr/min.
- **Fluid Std. Density** (See 5.3.14 Submenu “Device Calibration”). This parameter is required only when mass-based engineering units are selected.

NOTE: If “Full Scale Range”, “Device Function” and “Fluid Std. Density” parameters are not set properly, the device may have erroneous reading and unpredictable behavior.

User may configure other parameters (see Paragraph 5.3) according to his preferences and application requirements.

6.2.3 Connecting TIO to flow meters/controllers from other manufactures (stand alone)

a) Mounting

When TIO is connected to flow meters / controllers from other manufactures, it can be used as stand-alone table top or panel-mounted (see Figure 6.8). On the back side of the TIO enclosure there are 4 tapped holes which are designated to be used for the panel-mounted option.

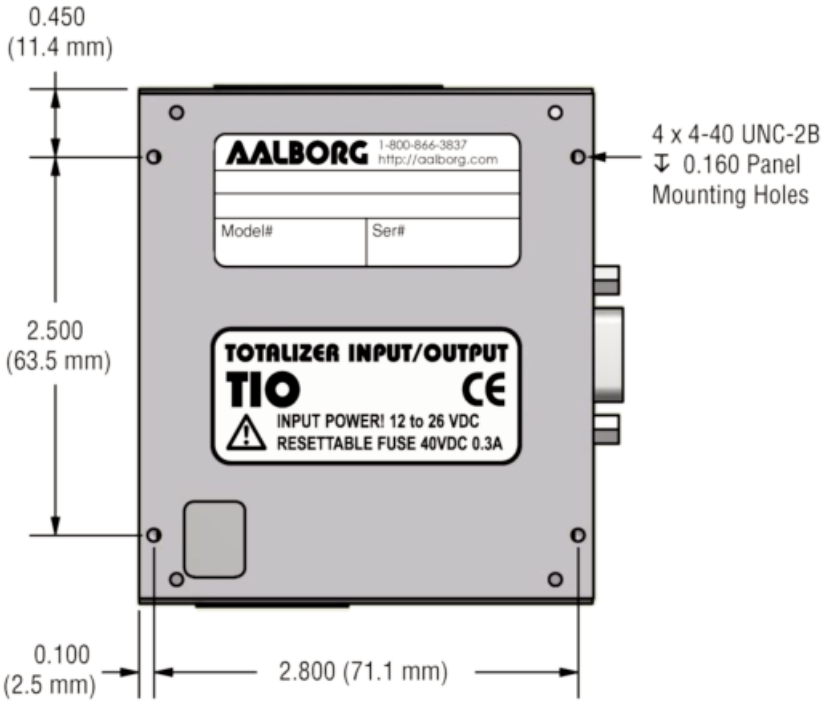


Figure 6.8 Dimensions for Panel Mounted Installation

b) Electrical Connection

TIO can be used with any generic flow meter / controller which supports 0-5 Vdc and / or 4-20 mA input / output interfaces. It also can be ordered for 0-10 Vdc input / output interface (special order not supported by generic models).

NOTE: Do not connect TIO input / output circuitry to voltages above 5.5Vdc unless TIO was specifically ordered for 0-10 Vdc input / output interface. Check device part number or contact Aalborg® customer service for device input / output type verification.

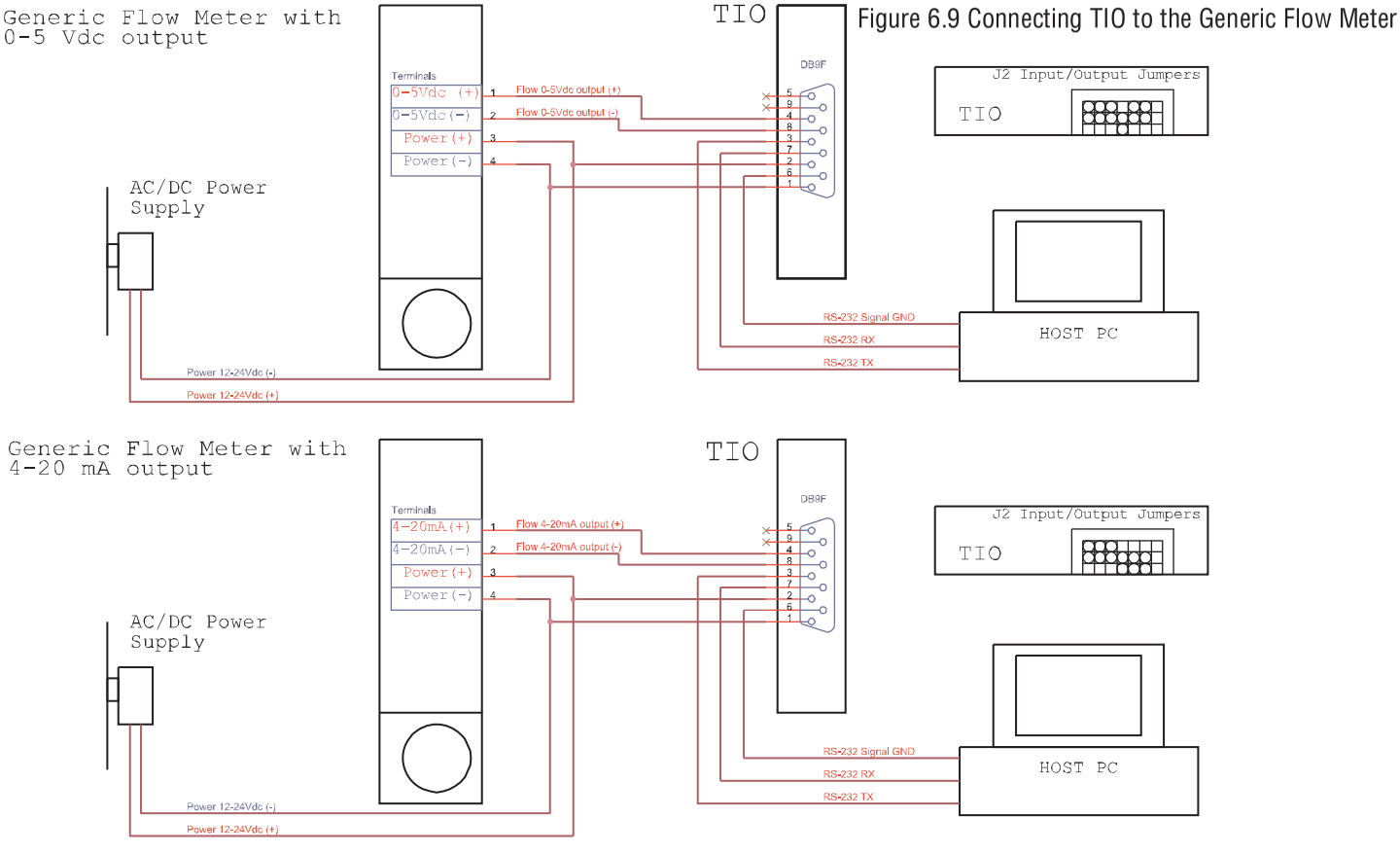
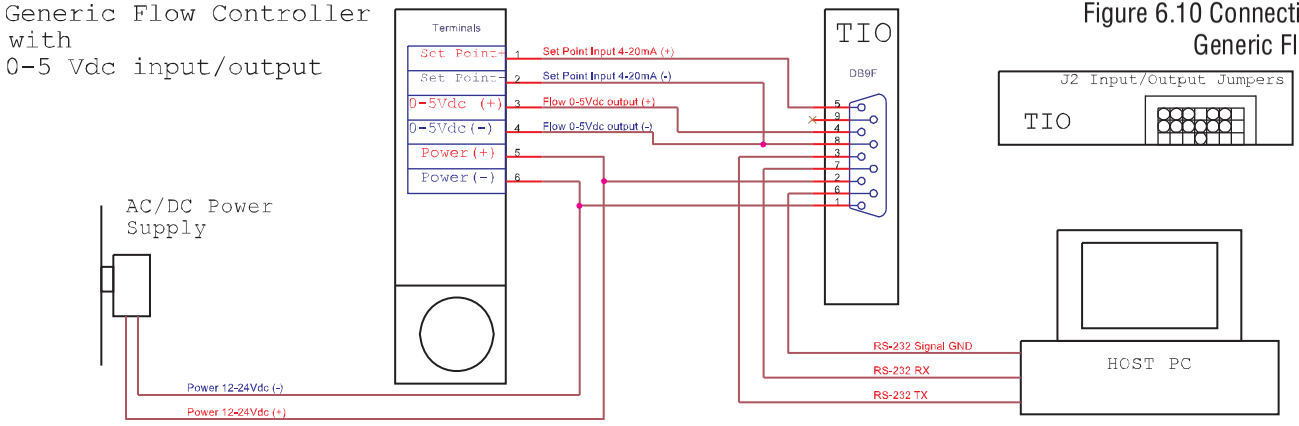
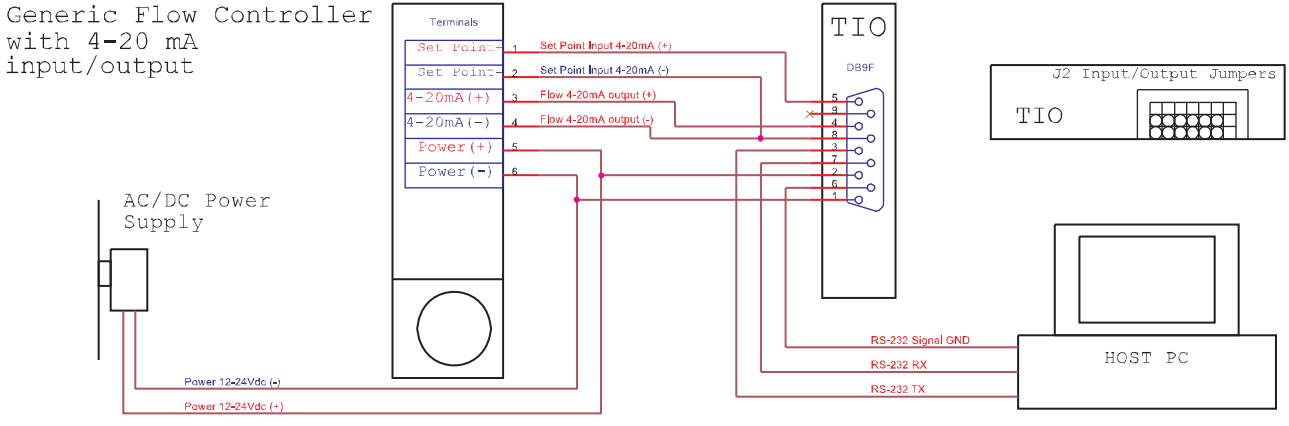


Figure 6.9 Connecting TIO to the Generic Flow Meter

Figure 6.10 Connecting TIO to the Generic Flow Controller





c) Input/Output Jumper Configuration

NOTE: Your TIO device input / output jumpers were configured at the factory according to your order. There is no need to change input / output jumper's configuration unless different input is being used. Before applying power and process signals, make sure the input /out put jumpers are installed in the correct position (See Table 6.5).

TABLE 6.5 J2 INPUT / OUTPUT JUMPER CONFIGURATION OPTIONS FOR GENERIC FLOW METERS AND CONTROLLERS

TIO PV TYPE		J2 JUMPER CONFIGURATION						NOTE
Output	Input	J2A	J2B	J2C	J2D	J2E	J2F	
0-5Vdc	0-5Vdc	2 - 3	5 - 6	8 - 9	10-11	14-15	17-18	
0-5Vdc	4-20 mA	2 - 3	5 - 6	8 - 9	10-11	13-14	16-17	
4 – 20 mA	0-5Vdc	1 - 2	4 - 5	7 - 8	10-11	14-15	17-18	
4 – 20 mA	4 – 20 mA	1 - 2	4 - 5	7 - 8	10-11	13-14	16-17	
N/A	5-10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	External +5Vdc reference signal must be connected to pin 9
0 - 10 Vdc	0 - 10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	Special Order option! (PCB hardware must be changed)
0 - 10 Vdc	4 – 20 mA	2 - 3	5 - 6	8 - 9	10-11	13-14	16-17	Special Order option! (PCB hardware must be changed)
4 – 20 mA	0 - 10 Vdc	1 - 2	4 - 5	7 - 8	11-12	14-15	17-18	Special Order option! (PCB hardware must be changed)
0-5Vdc	0 - 10 Vdc	2 - 3	5 - 6	8 - 9	11-12	14-15	17-18	Special Order option! (PCB hardware must be changed)
0 - 10 Vd	0-5Vdc	2 - 3	5 - 6	8 - 9	10-11	14-15	17-18	Special Order option! (PCB hardware must be changed)

NOTE: When TIO is connected to flow meter, output circuitry is not used. Jumpers J2A, J2B, J2C configuration is not applicable in this case and they should not be changed. In order to disable analog output, jumper J2B must be removed.

d) Parameters configuration

Following parameters must be configured:

- **Device Function** (See 5.3.12 Submenu "Device Function"). If TIO is connected to flow controller, then ***"Controller"*** function must be selected. If TIO is connected to flow meter, then ***"Meter"*** function must be selected.

- **Full Scale Range** (See 5.3.14 Submenu "Device Calibration"). Full Scale Range parameter must be set equal to the mated device full scale flow rate in Litr/min.

- **Fluid Std. Density** (See 5.3.14 Submenu "Device Calibration"). This parameter is required only when mass-based engineering units are selected.

NOTE: If "Full Scale Range", "Device Function" and "Fluid Std. Density" parameters not set properly, device may have erroneous reading and unpredictable behavior.

User may configure other parameters (see Paragraph 5.3) according to individual preferences and application requirements.

7. TROUBLESHOOTING

7.1 Common Conditions

Your TIO Totalizer Input/Output Flow Monitor/Controller was thoroughly checked at numerous quality control points during and after manufacturing and assembly operations. It was calibrated according to your input and output configuration. It was carefully packed to prevent damage during shipment. Should you feel that the instrument is not functioning properly, please first check for the following common conditions:

- Are all cables connected correctly?
- Are the connector pin outs matched properly?
- Are J2 input / output jumpers configured correctly?
- Is the power supply correctly selected according to requirements?

When several devices are used a power supply with appropriate current rating should be selected. When interchanging with other manufacturers' equipment, cables and connectors must be carefully wired for correct pin configuration.

7.2 Troubleshooting Guide

NO.	INDICATION	LIKELY REASON	SOLUTION
1	LCD Display remains blank when unit is powered up. Status LED is OFF	Power supply is bad or polarity is reversed.	Measure voltage on pins 2 and 1 of the DB9 interface terminal connector. If voltage is out of specified range, then replace power supply with a new one. If polarity is reversed (reading is negative) make correct connection.
		PC board is defective.	Return device to factory for repair.
2	LCD Displays flow reading, but 4-20 mA set point output signal does not change	Wrong configuration of J2 Input/Output Jumpers	Check J2 jumper configuration (see Table 6.4)
		External loop is open or load resistance more than 600 Ohm.	Check external connections to pins 5 and 6 of the DB9 interface terminal connector. Make sure the loop resistance is less than 400 Ohm for 12Vdc power supply option and 900 Ohm for 24Vdc power supply option.
		4-20 mA circuitry is burned out or damaged.	Using Key Pad, navigate to Submenu " Device Diagnostic" and select submenu "Analog Output Value". Record the DAC counts values and consult the factory with findings.
3	Fluid flows through the flow meter / controller, but LCD Display and /or Totalizer reading do not respond to the flow.	The fluid flow rate is below set Low flow cut-off value.	Check settings for Low Flow Cut-Off value and make required adjustment (see paragraph 5.3.14 submenu "Low Flow Cut Off").
		Wrong configuration of J2 Input/Output Jumpers	Check J2 input jumper configuration (see Table 6.4) If necessary contact factory for additional help.
		PC board is defective.	Using ESD precautions, measure voltage on pins 4 and 6 of the DB9 interface terminal connector. If voltage correlates with flow meter / controller output signal, check ADC counts: using Key Pad, navigate to Submenu "Device Diagnostic" and select submenu "ADC Input Counts". Record the ADC counts values and consult the factory with findings.
4	Fluid flows through the flow meter / controller, LCD Display Flow Rate reading responds to flow, but Totalizer reading is not changing.	The fluid flow rate is below set "Totalizer #1 Flow Start" parameter value.	Check settings for "Totalizer #1 Flow Start" value and make required adjustment (see paragraph 5.3.7.b submenu "Totalizer #1 Flow Start").
		Totalizer mode is disabled	Check settings for "Totalizer #1 Mode" parameter. Make sure Totalizer Mode set to "Enabled" (see paragraph 5.3.7.a submenu "Totalizer #1 Mode").
		Totalizer Power On Delay parameter is set to high value and Totalizer is disabled by firmware.	Check settings for "Totalizer Power On Delay" (see paragraph 5.3.7.e submenu "Totalizer #1 Power On Delay"). If settings are too high, make required adjustment.

NO.	INDICATION	LIKELY REASON	SOLUTION
5	Erratic Flow rate Reading	Wrong configuration of J2 Input/Output Jumpers	Check J2 input jumper configuration (see Table 6.4) If necessary contact factory for additional help.
		TIO “Full Scale Flow” parameter value (in litr/min) is not equal to the mated device full scale range	Check settings for “Full Scale Range (See Paragraph 5.3.14 Submenu “Device Calibration”). Full Scale Range parameter must be set equal to the mated device full scale flow rate in Litr/min.
		TIO “Fluid Std. Density” parameter is not set according to fluid being used and mass-based engineering units are selected.	Check settings for “Fluid Std. Density” (See Paragraph 5.3.14 Submenu “Device Calibration”). This parameter is required only when mass-based engineering units are selected.
6	Totalizer reading is wrong	Wrong configuration of J2 Input/Output Jumpers	Check J2 input jumper configuration (see Table 6.4) If necessary contact factory for additional help.
		TIO “Full Scale Flow” parameter value (in litr/min) is not equal to the mated device full scale range	Check settings for “Full Scale Range (See Paragraph 5.3.14 Submenu “Device Calibration”). Full Scale Range parameter must be set equal to the mated device full scale flow rate in litr/min.
7	LCD Displays flow reading, but communication interface does not work.	Wrong host PC interface, or wiring connection.	Make sure interface type (RS-232 or RS-485) on the host PC is the same as on TIO device. If required, use RS-232 to RS-485 converter. Check communication wiring connection according to Paragraph 4.4
		TIO has RS-485 interface, butt device address does not match to address used by host PC.	Change TIO RS-485 address to be matched to host PC software settings (see Paragraph 5.3.13 b).
8	The Device Diagnostic Alarm Event with code 0 – “CPU Temp. High” is active.	MCU / PCB temperature is too high (overload).	Disconnect power from the TIO. Make sure the ambient temperature is within specified range (below 70 °C). Let the device cool down for at least 15 minutes. Apply power to the device and check Diagnostic Alarm Event. If overload condition will be indicated again the unit must be returned to the factory for repair.
9	The Device System Event with code D - “Fatal Error” is active.	Fatal Error (EEPROM or SRAM corrupted)	Cycle the power on the TIO. If System Event with code D indication again the unit must be returned to the factory for repair.

APPENDIX A

TIO Totalizer Input/Output Flow Monitor/Controller EEPROM Variables
Rev.A001 [08/10/2011]

INDEX	NAME	DATA TYPE	NOTES
0	BlankEEPROM[10]	char[10]	Do not modify. Table Revision [PROTECTED]
1	SerialNumber[20]	char[20]	Serial Number [PROTECTED]
2	ModelNumber[20]	char[20]	Model Number [PROTECTED]
3	SoftwareVer[10]	char[10]	Firmware Version [PROTECTED]
4	ManufReservedF1	float	Manufacture Specific float data [PROTECTED]
5	ManufReservedF2	float	Manufacture Specific float data [PROTECTED]
6	ManufReservedF7	float	Manufacture Specific float data [PROTECTED]
7	ManufReservedF8	float	Manufacture Specific float data [PROTECTED]
8	ReservedText[12]	char[12]	Reserved for Manufacture Specific Text Info [PROTECTED]
9	ManufReservedF3	float	Manufacture Specific float data [PROTECTED]
10	ManufReservedF4	float	Manufacture Specific float data [PROTECTED]
11	ManufReservedF5	float	Manufacture Specific float data [PROTECTED]
12	ManufReservedF6	float	Manufacture Specific float data [PROTECTED]
13	ManufReservedUI1	uint	Manufacture Specific uint data [PROTECTED]
14	ManufReservedUI2	uint	Manufacture Specific uint data [PROTECTED]
15	ManufReservedUI3	uint	Manufacture Specific uint data [PROTECTED]
16	ManufReservedUI4	uint	Manufacture Specific uint data [PROTECTED]
17	ManufReservedSI1	int	Manufacture Specific int data [PROTECTED]
18	ManufReservedSI2	int	Manufacture Specific int data [PROTECTED]
19	ManufReservedSI3	int	Manufacture Specific int data [PROTECTED]
20	TimeSinceCalHr	float	Time elapsed since last calibration in hours
21	ProtectionCode	uint	Program Parameters Protection Code [0-255]
22	DeviceFunction	uint	Device Function:0-FlowMeter,1-FlowController
23	BaudRate	uint	Comm. Interface Baude Rate Index [0-7]
24	Address485	char[4]	Two hexadecimal characters address for RS485 only [01-FF]
25	FlowUnits	int	Current Units of Measure [0-46]
26	UDUnitKfactor	float	Current Units of Measure [0-46]
27	UDUnitTimeBase	int	User-Defined Unit Time base index:[0-3]
28	UDUnitDensity	uint	User-Defined Unit use density flag 1-'Y', 0-'N'
29	KfactorMode	uint	0-Disabled, 1-Internal, 2-User-Defined
30	KfactorIndex	uint	Internal K-Factor Index [0-21]
31	UserDefKfactor	float	User-defined K-Factor
32	DiagEventMask	uint	Mask for Diagnostic Events: Clear bit-> mask
33	PSP_Mode	uint	Mode for Program SP: 0-disabled, 1-enabled

INDEX	NAME	DATA TYPE	NOTES
34	SetPointPFS	float	Set Point value in %FS fraction notation [0.0 - 1.1]
35	DiagEventLatchMask	uint	Diagnostic Events Latch Mask register: Clear bit-> mask
36	Reserved3	float	Device General Reserved Settings
37	Reserved4	float	Device General Reserved Settings
38	OptOut1_Config	uint	Optical Output #1 Configuration (function)
39	OptOut2_Config	uint	Optical Output #2 Configuration (function)
40	GLCD_Mode	uint	Main Process screen mode: 0-Static,1-Dynamic
41	GLCD_Static_Mode	uint	Type of the static LCD screen: [0-3]
42	GLCD_AUTO_Mode_Mask	uint	Type of the AUTO LCD screen: keeps mask for each variable
43	Cycle_Time	uint	Time in seconds for each screen to be displayed in Dynamic mode
44	GLCD_Contrast	uint	GLCD Contrast settings [1 - 16]
45	GLCD_Reserved	uint	GLCD reserved settings
46	GLCD_LED_PWM	uint	GLCD LED backlight PWM Duty cycle [1-19]
47	PSP_StepMasc	uint	Mask Register for Program SP steps [0x0000 - 0xFFFF]
48	PSP_LoopMode	uint	Program SP Loop mode: 0-disabled, 1-enabled
49	Out_Scale_mA	float	Analog 4-20 mA Out Scale
50	Out_Offset_mA	float	Analog 4-20 mA Out Offset
51	In_mA_Mode	uint	Reserved input parameter
52	In_mA_Reserved	uint	Reserved input parameter
53	In_Scale_mA	float	Analog 4-20 mA Input Scale
54	In_ Offset _mA	float	Analog 4-20 mA Input Offset
55	OutScaleV	float	Flow Analog 0-5/0-10 Vdc Out Scale
56	OutOffsetV	float	Flow Analog 0-5/0-10 Vdc Out Offset
57	InScaleV	float	Flow Analog 0-5/0-10 Vdc Input Scale
58	InOffsetV	float	Flow Analog 0-5/0-10 Vdc Input Offset
59	F_AlarmMode	uint	Flow Alarm Mode (0=Disabled, 1=Enabled)
60	F_LowAlarmPFS	float	Low Flow Alarm in PFS [0-1.0 fraction notation %F.S.]
61	F_HiAlarmPFS	float	High Flow Alarm in PFS [0-1.0 fraction notation %F.S.]
62	F_AlmDelay	uint	Delay in seconds 0-3600 for Flow Alarm action
63	F_AlarmLatch	uint	Flow Alarm Latch
64	F_AlarmSpare	uint	Flow Alarm Spare settings
65	Total1_Mode	uint	Totalizer#1 mode (0-Disabled, 1-Enabled)
66	Total1_Config	uint	Totalizer#1 configuration (0-Count Up)
67	Total1_FlowStart	float	Start tot. at flow [0-1.0 fraction notation %F.S.]
68	Total1_VolStop	float	Limit volume in %s, 0 = disable
69	Total1_PowOnDelay	uint	Totalizer#1 power on delay in second [0-3600]
70	Total1_ValueLock	uint	Lock Totalizer#1 value (0-can be reset, 1-can not be reset)

INDEX	NAME	DATA TYPE	NOTES
71	Total1_Volume_BkUp	float	Totalizer#1 backup volume in %s (saved every 6 minutes)
72	Total1_AutoReset	uint	Reset Total. Volume value when Totalizer value equals Limit volume 0 - No, 1 - Yes
73	Total1_AtoResetDelay	uint	Delay in seconds before AutoReset will reset Totalizer#1 volume reading to zero [0-3600]
74	Total1_Reserved	uint	Totalizer#1 reserved
75	Total2_Mode	uint	Totalizer#2 mode: (0-Disabled, 1-Enabled)
76	Total2_Config	uint	Totalizer#2 configuration (0-Count Up, 1-Count Down)
77	Total2_FlowStart	float	Start tot. at flow [0-1.0 fraction notation %F.S.]
78	Total2_VolStop	float	Limit volume in %s, 0 = disable
79	Total2_PowOnDelay	uint	Totalizer#2 power on delay in second [0-3600]
80	Total2_Volume_BkUp	float	Totalizer#2 backup volume in %s (saved every 6 minutes)
81	Total2_ReloadVolStop	uint	Reload VolStop value when Totalizer reading counts down to zero 0 - No, 1 - Yes
82	Total2_ReloadDelay	uint	Delay in seconds before Reload VolStop value when Totalizer reading counts down to zero [0-3600]
83	Total2_10SecBackUp	uint	Enable or Disable every 10 seconds EEPROM backup (reserved for future version release)
84	Total2_Reserved	uint	Totalizer#2 reserved
85	Flow_Pulse_Mode	uint	Flow Pulse Output Mode (0=Dis'd, 1=En'd)
86	PulseFlowStart	float	Start pulse output at flow [0-1.0 fraction notation %F.S.]
87	Units_Per_Pulse	float	Units per pulse scaling
88	Active_Low_Time	uint	Number of ms output will be activated when pulse is developed
89	Flow_Pulse_Reserved	uint	Pulse Output Reserved
90	FlowCondMode	uint	0 - No conditioning, 1 - NRF, 2 - Running Average
91	Flow_NRF_NSample	uint	Flow NRF Number of Samples [1 - 32]
92	Flow_NRF_ErrLimit	float	Flow NRF Error Value [0.05 10.0] %F.S. (FN)
93	Flow_NRF_TimeLimit	uint	Flow NRF Time Interval [0-199], 0 - disabled
94	Flow_Damping	uint	Reading Damping 0-500 ms
95	Flow_Window	uint	Flow running average window [0-32] 0-disable
96	FlowLinearizer	uint	Flow Linearizer: On (1), Off (0)
97	Flow_SC_Reserved	uint	Flow Signal Conditioner reserved
98	FlowTbl[0].FlowPFSIn	float	Flow Linearizer Index 0 PFS In (must be 0.0)
99	FlowTbl[0]. FlowPFSOut	float	Flow Linearizer Index 0 PFS Out (must be 0.0)
100	FlowTbl[1]. FlowPFSIn	float	Flow Linearizer Index 1 PFS In [0.0 – 1.0]
101	FlowTbl[1]. FlowPFSOut	float	Flow Linearizer Index 1 PFS Out [0.0 – 1.0]
102	FlowTbl[2]. FlowPFSIn	float	Flow Linearizer Index 2 PFS In [0.0 – 1.0]
103	FlowTbl[2]. FlowPFSOut	float	Flow Linearizer Index 2 PFS Out [0.0 – 1.0]
104	FlowTbl[3]. FlowPFSIn	float	Flow Linearizer Index 3 PFS In [0.0 – 1.0]

INDEX	NAME	DATA TYPE	NOTES
105	FlowTbl[3]. FlowPFSOut	float	Flow Linearizer Index 3 PFS Out [0.0 – 1.0]
106	FlowTbl[4]. FlowPFSIn	float	Flow Linearizer Index 4 PFS In [0.0 – 1.0]
107	FlowTbl[4]. FlowPFSOut	float	Flow Linearizer Index 4 PFS Out [0.0 – 1.0]
108	FlowTbl[5]. FlowPFSIn	float	Flow Linearizer Index 5 PFS [0.0 – 1.0]
109	FlowTbl[5]. FlowPFSOut	float	Flow Linearizer Index 5 PFS Out [0.0 – 1.0]
110	FlowTbl[6]. FlowPFSIn	float	Flow Linearizer Index 6 PFS In [0.0 – 1.0]
111	FlowTbl[6]. FlowPFSOut	float	Flow Linearizer Index 6 PFS Out [0.0 – 1.0]
112	FlowTbl[7]. FlowPFSIn	float	Flow Linearizer Index 7 PFS In [0.0 – 1.0]
113	FlowTbl[7]. FlowPFSOut	float	Flow Linearizer Index 7 PFS Out [0.0 – 1.0]
114	FlowTbl[8]. FlowPFSIn	float	Flow Linearizer Index 8 PFS In [0.0 – 1.0]
115	FlowTbl[8]. FlowPFSOut	float	Flow Linearizer Index 8 PFS Out [0.0 – 1.0]
116	FlowTbl[9]. FlowPFSIn	float	Flow Linearizer Index 9 PFS In [0.0 – 1.0]
117	FlowTbl[9]. FlowPFSOut	float	Flow Linearizer Index 9 PFS Out [0.0 – 1.0]
118	FlowTbl[10]. FlowPFSIn	float	Flow Linearizer Index 10 PFS In [0.0 – 1.0]
119	FlowTbl[10]. FlowPFSOut	float	Flow Linearizer Index 10 PFS Out [0.0 – 1.0]
120	MDSerialNumber	char[20]	Serial Number for Mated Device
121	MeterFSRange	float	Device F.S. range in Std Litr/min
122	LowFlowCutOff	float	Must be between [0 and 0.1] fraction %F.S. notation [0-1.0]
123	FlowPowerUpDelay	uint	Flow Power Up delay [0-1200] sec.
124	Density	float	Fluid Density g/litr
125	FluidName[20]	char[20]	Name of the Fluid used for Calibration
126	CalibratedBy[20]	char[20]	Name of person, meter was calibrated by
127	CalibratedAt[20]	char[20]	Name of the Calibration Lab
128	DateCalibrated[12]	char[12]	Calibration date
129	DateCalibrationDue[12]	char[12]	Date calibration due
130	UserTagName	char[20]	User-Defined Device Tag Name or Number
131	PSPTbl[0].PFS	float	PSP Table Index 0 Set Point PFS (0.0-1.0)
132	PSPTbl[0].Time	float	PSP Table Index 0 Time (sec)
133	PSPTbl[1].PFS	float	PSP Table Index 1 Set Point PFS (0.0-1.0)
134	PSPTbl[1].Time	float	PSP Table Index 1 Time (sec)
135	PSPTbl[2].PFS	float	PSP Table Index 2 Set Point PFS (0.0-1.0)
136	PSPTbl[2].Time	float	PSP Table Index 2 Time (sec)
137	PSPTbl[3].PFS	float	PSP Table Index 3 Set Point PFS (0.0-1.0)
138	PSPTbl[3].Time	float	PSP Table Index 3 Time (sec)
139	PSPTbl[4].PFS	float	PSP Table Index 4 Set Point PFS (0.0-1.0)
140	PSPTbl[4].Time	float	PSP Table Index 4 Time (sec)
141	PSPTbl[5].PFS	float	PSP Table Index 5 Set Point PFS (0.0-1.0)

INDEX	NAME	DATA TYPE	NOTES
142	PSPTbl[5].Time	float	PSP Table Index 5 Time (sec)
143	PSPTbl[6].PFS	float	PSP Table Index 6 Set Point PFS (0.0-1.0)
144	PSPTbl[6].Time	float	PSP Table Index 6 Time (sec)
145	PSPTbl[7].PFS	float	PSP Table Index 7 Set Point PFS (0.0-1.0)
146	PSPTbl[7].Time	float	PSP Table Index 7 Time (sec)
147	PSPTbl[8].PFS	float	PSP Table Index 8 Set Point PFS (0.0-1.0)
148	PSPTbl[8].Time	float	PSP Table Index 8 Time (sec)
149	PSPTbl[9].PFS	float	PSP Table Index 9 Set Point PFS (0.0-1.0)
150	PSPTbl[9].Time	float	PSP Table Index 9 Time (sec)
151	PSPTbl[10].PFS	float	PSP Table Index 10 Set Point PFS (0.0-1.0)
152	PSPTbl[10].Time	float	PSP Table Index 10 Time (sec)
153	PSPTbl[11].PFS	float	PSP Table Index 11 Set Point PFS (0.0-1.0)
154	PSPTbl[11].Time	float	PSP Table Index 11 Time (sec)
155	PSPTbl[12].PFS	float	PSP Table Index 12 Set Point PFS (0.0-1.0)
156	PSPTbl[12].Time	float	PSP Table Index 12 Time (sec)
157	PSPTbl[13].PFS	float	PSP Table Index 13 Set Point PFS (0.0-1.0)
158	PSPTbl[13].Time	float	PSP Table Index 13 Time (sec)
159	PSPTbl[14].PFS	float	PSP Table Index 14 Set Point PFS (0.0-1.0)
160	PSPTbl[14].Time	float	PSP Table Index 14 Time (sec)
161	PSPTbl[15].PFS	float	PSP Table Index 15 Set Point PFS (0.0-1.0)
162	PSPTbl[15].Time	float	PSP Table Index 15 Time (sec)
163	EEMagicNumber	uint	Number used to verify EEPROM integrity

APPENDIX B

Internal K-Factors Table

INDEX	ACTUAL GAS	K Factor Relative to N_2	Cp [Cal/g]	DENSITY [g/l]
1	Argon Ar	1.4573	.1244	1.782
2	Arsine AsH3	0.6735	0.1167	3.478
3	Boron Triflouride BF3	0.5082	0.1778	3.025
4	Bromine Br2	0.8083	0.0539	7.130
5	Acetylene C2H2	0.5829	0.4036	1.162
6	Cyanogen C2N2	0.61	0.2613	3.322
7	Methane CH4	0.7175	0.5328	0.715
8	Chlorine Cl_2	0.86	0.114	3.163
9	Carbon Dioxide CO_2	.7382	.2016	1.964
10	Carbonyl Fluoride COF2	0.5428	0.1710	2.945
11	Carbonyl Sulfide COS	0.6606	0.1651	2.680
12	Carbon Disulfide CS_2	0.6026	0.1428	3.397
13	Fluorine F2	0.9784	0.1873	1.695
14	Hydrogen H_2	1.0106	3.419	.0899
15	Helium He	1.454	1.241	.1786
16	Nitrous Oxide	0.7128	0.2088	1.964
17	Ammonia NH3	0.7310	0.492	0.760
18	Neon NE	1.46	0.246	0.9
19	Nitric Oxide NO	0.99	0.2328	1.339
20	Oxygen O2	0.9926	0.2193	1.427
21	Sulfur Dioxide SO2	0.69	0.1488	2.858
22	Xenon Xe	1.44	0.0378	5.858

APPENDIX C

Totalizer-IO ASCII Commands Set

RS232/RS485 **Rev. A1 07/18/2011**

The standard Totalizer-IO comes with an RS232 interface. The protocol described below allows communication with the unit using either a custom software program or a "dumb" terminal. All values are sent as printable ASCII characters. For RS-232 interface, the start character and two characters of address must be omitted. For the RS485 interface the start character is always '!' and two characters of the address follow. The command string is terminated with a carriage return (line feeds are automatically stripped out by the Totalizer-IO:

RS-485: !<Addr>,<Cmd>,Arg1,Arg2,Arg3,Arg4<CR> Example: !12,F<CR>

RS-232: Cmd,Arg1,Arg2,Arg3,Arg4<CR> Example: F<CR>

Where: ! Start character **
Addr RS485 device address in the ASCII representation of hexidecimal (00 through FF are valid).**
Cmd The one or two character command from the table below.
Arg1 to Arg4 The command arguments from the table below. Multiple arguments are comma delimited.
CR Carriage return character.

****Default address for all units is set to 11 hex. Do not submit start character and device address for RS-232 option.**

Several examples of commands follow. All assume that the Totalizer-IO has been configured for address 18 (12 hex) on the RS485 bus:

1. To get a flow reading: !12,F<CR>

   The device will reply: !12,50.0<CR> (Assuming the flow is at 50.0% FS)

2. To get current Flow Alarm status: !12,A,S<CR>

   The device will reply: !12,AS:N<CR> > (Assuming no Alarm conditions)

3. To get Totalizer#1 reading: !12,T,1,R<CR>

   The device will reply: !12,T1R:93.5<CR>
   (Assuming the Totalizer#1 reading is 93.5)

4. Set the flow High and Low Alarm limit to 90% and 10% of full scale flow rate:
   !12,A,C,90.0,10.0<CR>

   The device will reply: !12, AC:90.0,10.0<CR>

AALBORG® TOTALIZER-IO ASCII SOFTWARE INTERFACE COMMANDS

NOTE: AN "*" INDICATES POWER UP DEFAULT SETTINGS.
AN "**"INDICATES OPTIONAL FEATURE NOT AVAILABLE ON ALL MODELS.

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Flow	Requests the current flow reading in current EU	1	F					<Value> (Actual flow in current engineering units)
Set Point	Set point value in current EU (Read, Write) With Argument #2 = 'S' set point value will be saved in the EEPROM	2	S	NO ARGUMENT (read status)				S:<Value> (Set Point in current engineering units) Example: S:20.5
				<Value> (write, not saved in EEP-ROM memory)				S:<Value> (Set Point in current engineering units) Example: S:20.5
				<Value>(write, saved in EEPROM memory)	S			S:<Value> ,S (Set Point in current engineering units) Example: S:20.5,S
Density	Read / Set Fluid Density for standard conditions in g/litr [0.000001-10000.0] g/litr	3	D	NO ARGUMENT (read current value)				D:<Value> (Actual density in g/litr) Example: D:1.25
				<Value> (write and save new value)				D:<Value> (Actual density in g/litr) Example: D:1.56
Diagnostic Events Register	Read/Reset current status of Diagnostic Events Register See list of the Diagnostic Events below.	4	DE	NO ARGUMENT (read status)				DE:0x10 0x10 – diagnostic word (16 bits wide)
				R (reset Event Log register to 0x0000)				DE:0x0

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Diagnostic Events Mask	Display/Set Diagnostic Events Mask Register See list of the Diagnostic Events below.	5	DM	NO ARGUMENT (read current Diagnostic Events Mask Register)				DM:0x9FFF 0x9FFF – diagnostic mask (16 bits wide). Set bit - Enable Clear bit - Disable
				<Value> 0x0000 - 0xFFFF Set new value NOTE: all 6 characters are required				DM:0x9FFF
Diagnostic Events Latch Mask	Display/Set Diagnostic Events Latch Mask register See list of the Diagnostic Events below.	6	DL	NO ARGUMENT (read current Diagnostic Events Latch Mask register)				DL:0x100F 0x100F – diagnostic latch mask (16 bits wide). Set bit - Enable Clear bit - Disable
				<Value> 0x0000 - 0xFFFF Set new value to Diagnostic Events Latch Mask register. NOTE: all 6 characters are required				DL:0x100F 0x100F – diagnostic latch mask (16 bits wide). Set bit - Enable Clear bit - Disable
Device Info	Read device configuration info: - full scale range (L/min) - device function (M/C) - input settings (V,C) - output settings (V,C) - low flow cut off (%F.S.) - power up delay (sec.)	7	DI					DI: 100.0,M,V,V,2.0,2 100.0 – full scale L/min M – device function (meter) V – input (0-5 Vdc) V – output (0-5 Vdc) 2.0 – Low flow cut off (%F.S.) 2 – flow power on delay (sec.)

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Flow Alarms	Sets / reads the parameters of the Flow Alarms. Note: If device function is set to "Meter" the High Alarm value must be more than Low Alarm value. Meter Alarm conditions: Flow ≥ High Limit = H Flow ≤ Low Limit = L Low < Flow < High = N Controller Alarm conditions: Flow-SP High Limit = H SP-Flow Low Limit = L Low > SP-Flow < High = N	8	A	C (set Alarm configuration)	<Value> (high limit, %F.S.)	<Value> (low limit, %F.S.)		AC:40.1,20.5
				A (action delay in sec.)	<Value> [0-3600]			AA:<Value (sec)>
				E (enable Alarm)				A:E
				D (disable Alarm)*				A:D
				R (read current status)				AR:N (no Alarm) AR:H (High Alarm) AR:L (Low Alarm)
				S (Read current settings)				AS:M,H,L,D,B where: M – mode (E/D) H – High settings value L – Low settings value D – Action Delay (sec) B – Latch mode (0-1) Example: AS:E,40.0,20.0,2,0
				L (Latch mode)	<Value> (0-disabled*) (1-enabl'd)			AL:<Value> where: Value = 0 – 1 Example: AL:0

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Optical Outputs	Assigns action of the two optical outputs. The optical outputs can be assigned to: D – No Action (disabled*) AL – Low Flow Alarm AH – High Flow Alarm AR – Range between High & Low Alarms T1 – Tot#1 Reading > limit T2 – Tot#2 Reading > limit PO – Pulse Output DE – Diagnostic Events M – Manual On (enabled)	9	O	1 (Output #1) 2 (Output #2)	D*			O1:D or O2:D
					AL			O1:AL or O2:AL
					AH			O1:AH or O2:AH
					AR			O1:AR or O2:AR
					T1			O1:T1 or O2:T1
					T2			O1:T2 or O2:T2
					PO			O1:PO or O2:PO
					DE			O1:DE or O2:DE
					M			O1:M or O2:M
					S (read current settings)			O1:D or O2:PO
Device Function	Sets / Reads Device Function Device Function: M – Flow Meter C – Flow Controller	10	DF	<Value> M – Flow Meter C – Flow Controller				DF:<Value> Example: DF:M DF:<Value> Example: DF:M
				No Argument (Returns Current Device Function)				

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Totalizers	Sets and controls action of the flow Totalizers. NOTE: Start Totalizer at Flow value must be entered for in %FS (0.0 – 100.0). Limit volume must be entered in currently selected EU. If Totalizer hit limit event is not required, set "Limit Volume" value (argument 4) to zero. Totalizer#1 can be configured to Count Up only (argument M is not supported). Totalizer#2 can be configured to Count Up or Count Down mode. When configured to Count Down mode, limit volume must be more than zero. Totalizer#1 reading is stored in EEPROM (non-volatile) memory. Power cycle will not affect Totalizer#1 reading.Totalizer#2 reading is backed up in EEPROM with 6 minutes interval. Power cycle may affect Totalizer#2 reading. Totalizer#1 cannot be reset if ResetLock (EE index 70) value set to 1.	11	T	1 (Totalizer #1) 2 (Totalizer #2)	Z (Reset to zero)			T1Z or T2Z
					C Start flow and Event Condition	<value> (start Totalizer at flow) %FS [0.0 – 100.0]	<value> (Limit volume In current volume based EU)	T1C:2.5, 0.0 or T2C:2.0,20580.5
					P Power On Delay	<value> (0-3600 sec.)		T1P:10 or T2P:20
					D (disable Totalizer)*			T1:D or T2:D
					E (enable Totalizer)			T1:E or T2:E
					R (read current Totalizer volume)			T1R:<value> or T2R:<value> (in current EU)
					S (read current settings status)			T1S:Mode,Direction,Start Flow,LimitVolume, PowOnDelay,AutoResetMode, AutoResetDelay Example: T1S:E,0,0.5, 2045.2,10,0,5
					A Set Auto Reset/Reload mode	<value> [0-1] 0 – Disable 1 – Enable		T1A:0 - disabled Or T2A:1 - enabled
					I Set Auto Reset/Reload Interval delay	<value> [0-3600 sec.]		T1I:2 Or T2I:0
					B Restore Totalizer#1 value from EE backup			T1B Not supported by Totalizer #2.
					M Totalizer#2 counting direction configuration	<value> [0-1] 0- Count Up 1-Count Down		T1M:0 Not supported by Totalizer #1.

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Pulse Output	Sets and controls action of the programmable Pulse Output circuitry. NOTE: Unit/Pulse value must be entered in currently selected EU. EU must not be time based. It is recommended to set the unit/pulse value equal to the maximum flow in the same units per second. This will limit the pulse to be no faster than one pulse every second. Example: Maximum flow rate: 600 liter/min (600 liter/min = 10 liters per second) If Unit/Pulse is set to 10 liters per pulse, the output will pulse once every second (F=1 Hz). Pulse active time in ms must be at least twice less than pulse period (1/F).	12	P	U Set Units Per Pulse Parameter.	<Value> (Unit/Pulse) In current E.U. (example: 10 litr/pulse)			PU:<value> Example: PU:10
				T Set Pulse active Time in ms	<value> [10 -6553 ms]			PT:<value> Example: PT:100
				D (disable pulse output)*				P:D
				E (enable pulse output)				P:E
				Q (read current pulse output Queue value)				PQ:<value> (number of pulses in Queue)
				F Set Flow Start value	<value> (0.0–100.0%FS)			PF:1.0
				S (read setting status)				PS:Mode,FlowStart, Unit/Pulse,PulseTime Interval Example: PS:E,1.0,1.666,100

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Units of measure	Set units of measure for flow rate and Totalizer reading. Note: The units of the Totalizer output are not per unit time. For User-defined units: k-Factor value represents conversion value from L/min. Time base argument: S – seconds M – minutes H – hours D – days Density Argument: Y – use density N – do not use density Igal – Imperial Gal MilL – million liters Mton – Ton (metric) Bbl – Barrels	13	U	%FS*				U:%
				ml/sec				U: ml/sec
				ml/min				U: ml/min
				ml/hr				U: ml/hr
				ml/day				U: litr/day
				litr/sec				U: litr/sec
				litr/min				U: litr/min
				litr/hr				U: litr/hr
				litr/day				U: litr/day
				m^3/sec				U: m^3/sec
				m^3/min				U: m^3/min
				m^3/hr				U: m^3/hr
				m^3/day				U: m^3/day
				f^3/sec				U:f^3/sec
				f^3/min				U:f^3/min
				f^3/hr				U:f^3/hr
				f^3/day				U:f^3/day
				gal/sec				U: gal/sec
				gal/min				U: gal/min
				gal/hr				U: gal/hr
				gal/day				U: gal/day
				gram/sec				U: gram/sec
				gram/min				U: gram/min
				gram/hr				U: gram/hr
				gram/day				U: gram/day
				kg/sec				U: kg/sec
				kg/min				U: kg/min
				kg/hr				U: kg/hr
				kg/day				U: kg/day
				lb/sec				U: lb/sec
				lb/min				U: lb/min
				lb/hr				U: lb/hr
				lb/day				U: lb/day

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
				Mton/min				U: Mton/min
				Mton/hr				U: Mton/hr
				lgal/sec				U: lgal/sec
				lgal /min				U: lgal/min
				lgal /hr				U: lgal/hr
				lgal/day				U: lgal/day
				MilL/min				U: MilL/min
				MilL/hr				U: MilL/hr
				MilL/day				U: MilL/day
				bbl/sec				U: bbl/sec
				bbl/min				U: bbl/min
				bbl/hr				U: bbl/hr
				bbl/day				U: bbl/day
				USER (User-defined)	<k-factor value> [>0.0]	<Time Base> S-second M-Minute H-Hour D-Day	<Use Density> [Y or N]	U:user,K-Factor, TimeBase,UseDensity Example: U:USER,1.5,M,N
				No Argument (status)				U:<EU name> Example: U:litr/min

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
K-Factor	Read and set K-Factor relative to N2 Mode: D – Disabled (K-Factor = 1.0) I – Internal U – User-Defined	14	K	S (read current settings) Returns current mode, index and UD value				KS:Mode,Index, UDvalue Example: KS:U,1,0.91200
				D (Set Mode: Disabled)				KD
				I (Set Mode: Internal Index)	<Index> [1-22]			KI:Index,GasName Example: KI:1,Ar
				U (Set Mode: User-Defined Value)	<Value> [0.00001-999.9]			KU:Value Example: KU:0.91200
Calibration Settings	Sets/Reads Calibration related variables. Argument 1 = T Hours since last time unit was calibrated. NOTE: must be reset to zero after calibration.	15	C	P Flow Power Up Delay [seconds]	<Value> [seconds]			CP:<value> Example: CP:3
					No Argument (Returns Current Power Up Delay)			CP:<value> Example: CP:3
				F Device Full Scale Range in liter/min	<Value> [liter/min]			CF:<value> Example CF:1000.0
					No Argument (Returns Current Meter FS Range)			CF:<value> Example: CF:1000.0
				L Device Low Flow Cut Off in % of full scale	<Value> (%FS)			CL:<value> Example: CL:5.0
					No Argument (Returns Current value)			CL:<value> Example: CL:5.0
				T Read/Reset Calibration/ Maintenance Timer	No Argument (read timer)			CT:<value> Example: CT:1024.2
				Z Set Cal. Timer to Zero				CT:Z

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Signal Conditioner Settings	Sets/Reads Signal Conditioner Parameters Argument1 = F: Display/Change NR Filter Parameters: NRF Sample Number [1-32] NRF Time Limit [0-199] NRF Error Limit [0.0-10.0%]	16	SC	M Read/Change Device Signal Conditioner Mode N – No Conditioning F – NRF Filter A – Running Average	<New Mode> [N, F, A]			SCM:<value> Example: SCM:F
					No Argument (Returns Current Mode)			SCM:<value> Example: SCM:F
				D Flow Running Average Damping [0-500 ms] 0 - Disabled	<new value> in ms [0-500]			SCD:<value> Example: SCD:50
					No Argument (Returns Current set.)			PWD:<value> Example: SCD:50
				F NR Filter Settings: NRF Sample Numb. NRF Time Limit NRF Error Limit	<new value> Sample# [1-32]	<new val.> Time Limit [0-199]	<new val.> Error Limit [0.0-10%]	Example: PWF:4,8,0.0
					No Argument (Returns Current set.)			Example: PWF:4,8,0.0
				L Device Flow Linearizer E- Enable D- Disable	<New Value> E or D			SCL:<value> Example: SCL:E
					No Argument (Ret. Current settings)			SCL:<value> Example: SCL:E

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
LCD and Process Screens Settings	Sets/Reads LCD related parameters. Argument 1 = S Process Screens Mask register: 0x00FF – screen mask (8 bits wide). Set bit – Enable Clear bit – Disable See list of the Process Screens below: 0x01 – Flow/Set Point, Tot#1 0x02 – Flow, Tot#2 0x04 – Flow,Tot#1, Tot#2	17	L	M LCD Process Screen Mode: S – Static D – Dynamic	<New Value> S or D			LM:<value> Example: LM:S
					No Argument (Ret. Current settings)			LM:<value> Example: LM:S
				C LCD Contrast Level: [0-16]	<new value> [1-16]			LC:<value> Example: LC:6
					No Argument (Ret. Current settings)			LC:<value> Example: LC:6
				B LCD Back Light Level: [0-19]	<new value> [1-19]			LB:<value> Example: LB:16
					No Argument (Ret. Current settings)			LB:<value> Example: LB:16
				T Process Screen Time Interval in sec. (for dynamic mode)	<New Value> [1-3600]			LT:<value> ExampleLT:5
					No Argument (Ret. Current settings)			LT:<value> ExampleLT:5
				S Process Screens Mask register	No Argument (read current Screen Mask register)			LS:0x03 0x00FF – screen mask (8 bits wide). Set bit – Enable Clear bit – Disable
					<Value> 0x0000 - 0x00FF Set new value NOTE: all 6 characters are required			LS:0x03

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Process Information	Read Process Information Returns: Flow Rate (in current EU) Totalizer #1 (in current EU) Totalizer #2 (in current EU) Flow Alarm Status (D,N,L,H) Diagnostic Events Register	18	PI	No Argument				F,T1,T2,FA,DE Example: 24.5,1254.2,12.0,N,0x0
Program Set Point	Sets/Reads Program Set Point parameters	19	PS	M Read/Change Device PSP Mode	<New Value> E or D			PSM:<value> Example: PSM:D
					No Argument (Ret. Current settings)			PSM:<value> Example: PSM:D
				L Read/Change Device PSP Loop Mode	<New Value> E or D			PSL:<value> Example: PSL:D
					No Argument (Ret. Current settings)			PSL:<value> Example: PSL:D
				P Read/Change Device PSP Step Parameters Read: only one argument is required. Change: all 3 arguments are required.	<Step Number> [1-16]	No Argument (Ret. Current settings)		PSP<step>:<SP>,<Time> Example: PSP02: 50.0,25
					<Step Number> [1-16]	<Set Point> [0-100%FS]	<Time> [0-86400 s.]	PSP<step>:<SP>,<Time> Example: PSP02: 50.0,25
				A Read/Change Device PSP Mask Register	No Argument (read current PSP Mask register)			PSA:0xFFFF 0x00FF – screen mask (8 bits wide). Set bit – Step Enabled Clear bit – Step Disabled
					<Value> 0x0000 - 0xFFFF Set new value NOTE: all 6 characters are required			PSA:0xFFFE

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
				C Read/Change Device PSP Run/Stop Control Program Set Point Control can be set to: R – Run S – Stop	No Argument (Ret. Current settings)			PSC:<Value> Example: PSC:S
					<Settings> R – Run S - Stop			PSC:<Value> Example: PSC:R
Read EEPROM Memory	Reads the value in the specified memory location.	20	MR	0 to 163 (Memory Table Index)				<memory value>
Write EEPROM Memory	Writes the specified value to the specified memory location. **Use Carefully, Can cause unit to malfunction.** (Note: Some addresses are write protected!)	21	MW	20 to 163 (Memory Table Index)	<Value>			MW,XXX,<Value> where: XXX=Table Index Example: MW,105,101.3

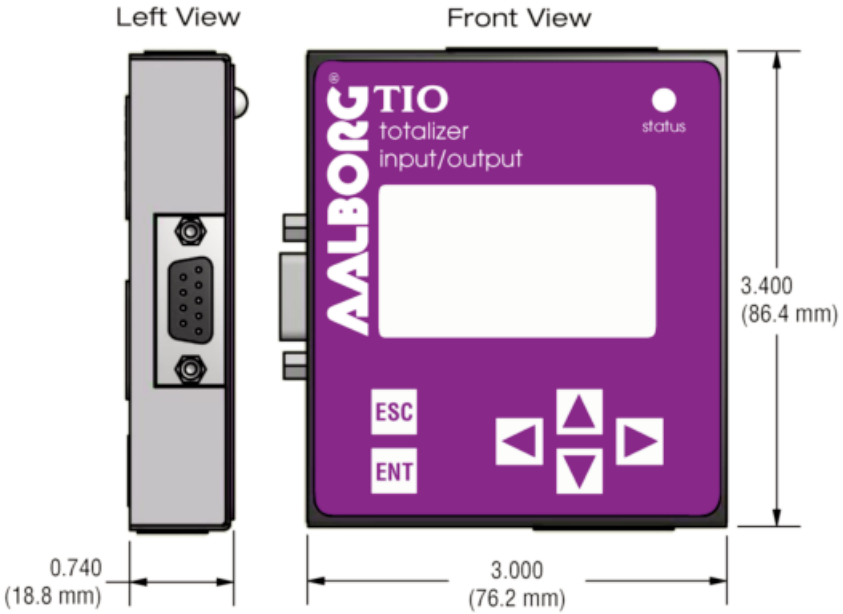
UART ERROR CODES	
1	Not Supported Command or Back Door is not enabled.
2	Wrong # of Arguments.
3	Address is Out of Range (MR or MW commands).
4	Wrong # of the characters in the Argument.
5	Attempt to Alter Write Protected Area in the EEPROM.
6	Proper Command or Argument is not found.
7	Wrong value of the Argument.
8	Reserved.
9	Manufacture specific info EE KEY (wrong key or key is disabled).

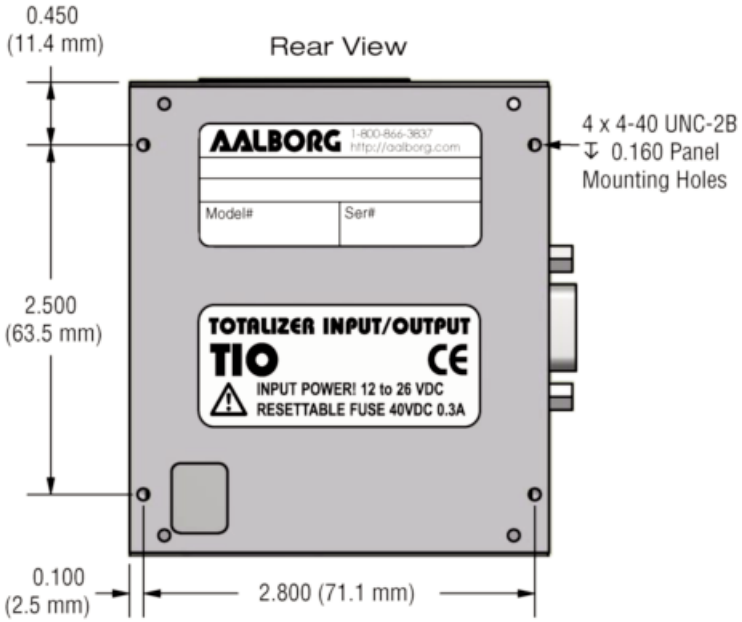
DIAGNOSTIC AND SYSTEM EVENTS CODES AND BIT POSITION		
Code	**Event Description**	**Bit position**
0	CPU Temp. High	0x0001
1	High Flow Alarm	0x0002
2	Low Flow Alarm	0x0004
3	Range between H-L	0x0008
4	Tot#1 > Limit	0x0010
5	Tot#2 > Limit	0x0020
6	OptPulse Queue	0x0040
7	Flow OverLimit	0x0080
8	Vcc OutOfRange	0x0100
9	SerComm. ERROR	0x0200
A	EEPROM ERROR	0x0400
B	Power on Event	0x0800
C	Password Event	0x1000
D	Fatal Error	0x2000

INTERNAL K-FACTOR TABLE LIST		
Index	**Gas**	**K-Factor**
1	Ar	1.4573
2	AsH3	0.6735
3	BF3	0.5082
4	Br2	0.8083
5	C2H2	0.5829
6	C2N2	0.6100
7	CH4	0.7175
8	Cl2	0.8600
9	CO2	0.7382
10	COF2	0.5428
11	COS	0.6606
12	CS2	0.6026
13	F2	0.9784
14	H2	1.0106
15	He	1.4540
16	N2O	0.7128
17	NH3	0.7310
18	NE	1.4600
19	NO	0.9900
20	O2	0.9926
21	SO2	0.6900
22	Xe	1.4400

APPENDIX D

Mechanical Drawings

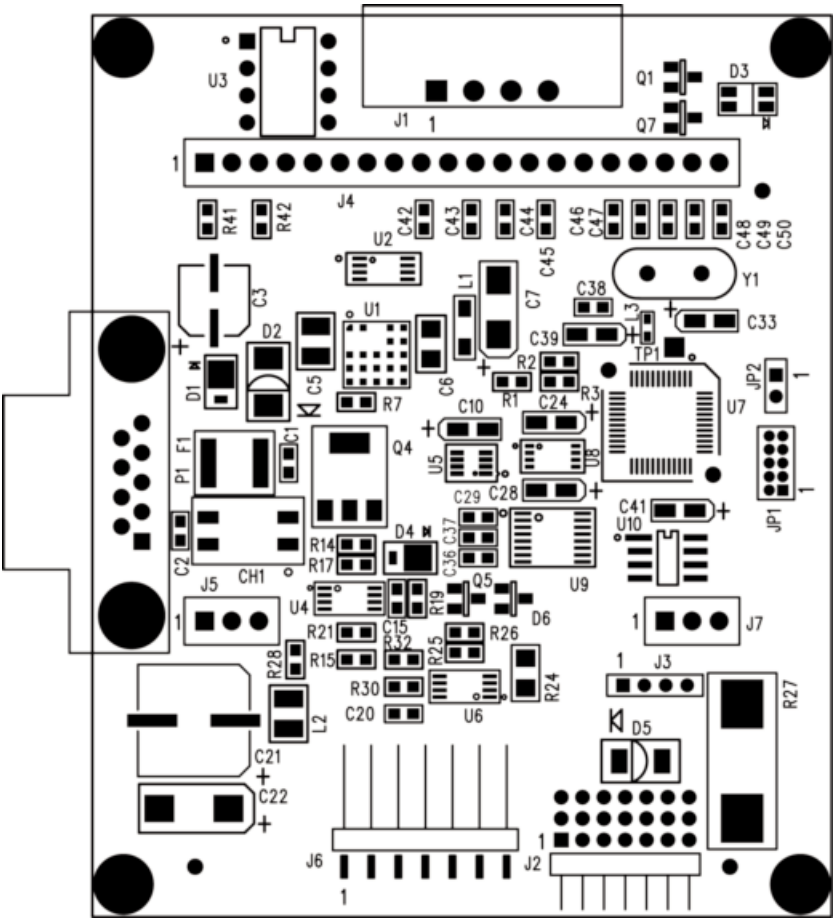




APPENDIX E

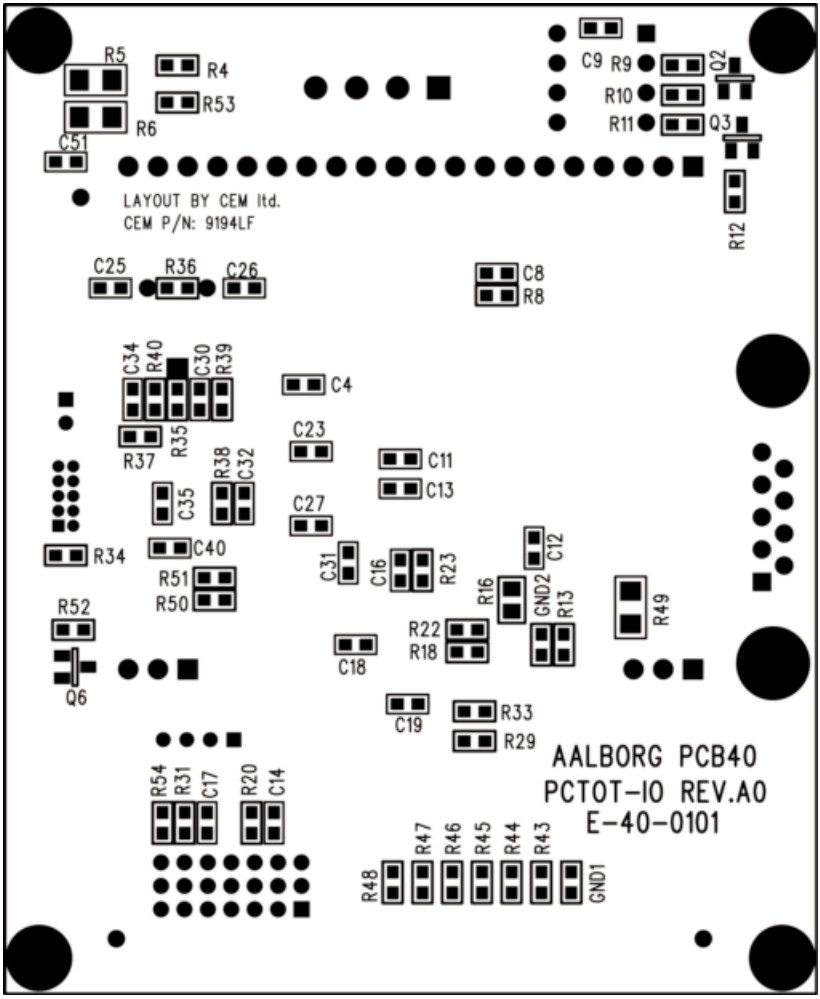
Circuit Layout Diagrams

Circuit Layout Top



Circuit Layout Bottom

Mirror



APPENDIX F

Warranty

Aalborg® TIO Totalizer Input/Output Flow Monitor/Controller is warranted against parts and workmanship for a period of one year from the date of purchase. It is assumed that equipment selected by the customer is constructed of materials compatible with the environment in which the TIO is being used. Proper selection is the responsibility of the customer. It is understood that power supply voltage and external signals should not exceed allowable limits provided in this manual, and it is deemed the responsibility of the customer that only operators with basic knowledge of the equipment and its limitations are permitted to control and operate the equipment covered by this warranty. Anything to the contrary will automatically void Aalborg's liability and the provisions of this warranty. Defective products will be repaired or replaced at no charge solely at the discretion of Aalborg®. Shipping charges are borne by the customer. This warranty is void if the equipment is damaged by accident or misuse or has been repaired or modified by anyone other than Aalborg® or factory authorized service facility. This warranty defines the obligation of Aalborg® and no other warranties expressed or implied are recognized.

⚠ CAUTION:

This product is not intended to be used in life support applications!