FMC INVALCO

Liquid Flow Computer
Model 715
Installation/Operation Manual

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Table of Contents

Introduction....2
Specifications....2
Model Number Designation....3
Operation....3
Dual Inputs....4
Calculation of Rate and Total....4
Filtering....4
Total Conversion....4
Non-Linearity Correction (Linearization)....4
Output Pulse and Flow Alarm....5
Temperature Compensation....5
Volume Correction for General Liquids....6
Compensation for Petroleum Liquids....6
Compensation for LPG....7
Density Meter Input....7
General Installation....7
Options....8
Calibration....9
Programming the Setup Parameters....9
Programming Options....11
Checking the Input Signal....12
Input Circuits....12
Temperature or Density Input....12
Trouble Shooting....13
Dimensions....14

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Introduction

The INVALCO Model 715 Microprocessor-Based Liquid Flow Computer is designed to interface with all INVALCO Turbine Meters and a wide range of flow measurement devices produced by other manufacturers.

Specifications

Display

Six digit LCD, 0.7" high digits.

Keyboard

Sealed membrane keyboard with four keys.

Transducer Supply

8-24 VDC field adjustable, 50mA maximum (2-3V less than minimum input voltage).

Power Requirements

11.5 to 28.0 VDC, 140mA typical (no options), or AC.AC Mains: Set internally to 95-135 VAC or 190-260 VAC.

Operating Temperature

32°F to 130°F (0°C to 55°C).

Facia

Watertight to NEMA 3S or IP65.

Dimensions

5.7" (144mm) wide x 2.8" (72 mm) high x 7.4" (188 mm) deep

Panel Cutout

5.5" (139 mm) x 2.6" (67 mm)

Frequency Input

Frequency Range:

Minimum - 0.25 Hz on rate. 0 Hz on total.

Maximum - 10 kHz.

Input Circuits:

Accept most sine, logic, and proximity switch inputs.

K-Factor Range:

0.1000 to 50,000

Non-Linear Correction:

Up to ten correction points.

Approvals

Canadian Standards Association (CSA) Approved. CE compliant.

4-20mA Input Option (715 LA)

Input:

For density or temperature.

Input Impedance:

250 ohms.

Accuracy:

0.05%.

Circuit:

The 250 ohm resistors are connected to a common signal ground (current sinking).

RTD Input Option (715 LR)

Temperature Measurement Range:

-148°F to 392°F (-100°C to 200°C). Note: A wider temperature range can be handled via a 4-20mA input.

Accuracy:

0.1°C.

RTD Type:

Platinum PT100, two, three, or four-wire.

Linearity:

The non-linearity of the RTD is compensated for internally.

Scaled Pulse Output:

Pulse Width:

10mSec (negative going pulse).

Duty Cycle:

Maximum of 49 pulses per second.

Output:

An open-collector transistor will sink 100mA maximum. The pulse output is suitable for driving remote counter or PLC's.

RS232/485 Option

Type:

RS232, four wire RS422 and two wire RS485 are provided. When using the RS422/485, multipoint communication can be implemented with up to 32 instruments connected to a common bus.

Function:

Printer and computer protocols are fully programmable.

Printer:

A print is initiated on each reset or at a programmable time interval. Protocols are provided for roll and column printers.

Computer:

An ASCII-based protocol enables all displayed parameters to be read and the totals to be reset.

Baud Rate:

300 to 9,600.

Data Bits:

Seven or eight.

Parity:

None, odd, or even.

Time:

A real-time clock is provided to give time and date on each output.

4-20mA Output Option

Function:

Via 4mA and 20mA, fully scaled and programmable.

Resolution:

Ten bits.

Accuracy:

Better than 0.1%.

Maximum Load:

Voltage Burden: 5V

500 ohms internally powered.

950 ohms from external 24 Vdc.

Isolation:

Output is isolated.

High Low Alarm Output:

Function:

Two form C relays are provided for programmable high or low setpoints.

Maximum Switching Power:

1250 VA.

Maximum Switching Voltage:

250 Vac, 30 Vdc.

Maximum Switching Current:

5 Amps.

Model Number Designation

General Description	
715-D	Base Display Unit - No Input options w/Rate, Total, Accumulated Total, and Scaled Pulse Output
715-LA	Temp/Density Compensating Flow Computer w/Analog Temperature/Density Input
715-LR	Temp/Density Compensating Flow Computer w/RTD Temperature Input
Enclosure Options	
- 1xxx	Panel Mount (Nema 4 Facia) (includes mounting hardware)
- 2xxx	Weather-proof to Nema 4X Definition (IP66)
- 3xxx	Explosion-proof to Nema 7 Definition
Output Options	
- x0xx	No Output Options Required
- x1xx	4-20mA Output of Rate
- x2xx	RS-232/422/485 Serial Communication
- x3xx	Hi/Lo Alarm Relay's
- x4xx	4-20mA Output of Rate and High/Low Alarm Output
- x5xx	RS-232/422/485 Serial Communication and High/Low Alarms
Power Supply Options	
- xxAx	12/28 Vdc or 110/120 Vac, Selectable (Standard Selection)
- xxEx	220/240 Vac Input
- xxDx	12/28 Vdc Only (Typical for Truck Applications)
Other/Special Options	
- xxxB	Backlit Display
- xxxC	Conformal Coating of PC Boards
- xxxH	50 Watt Heater (only when enclosure is used)
Blank	No Requirements

Operation

The Model 715 Flow Computer for liquid flow measurement allows all operating parameters and calculation constants to be user programmed.

The display will normally show the rate or resettable total, as selected by the rate or total keys on the front panel. An LED will light to indicate which function is currently displayed.

All parameters and constants are stored in a non-volatile memory which retains data without battery backup for a minimum of 10 years.

A DIP switch on the rear panel enables the frequency input circuit to be set to interface with a wide range of flowmeters.

Front Panel Operation

The display will normally show the Rate or resettable Total. An LED will light to indicate which function is currently displayed.

The DISPLAY button can be used to display the following additional information:

Accumulated Total:

On the first press of the DISPLAY button, the display shows ACCTOT for one second followed by the actual total. The Accumulated Total continuously totalizes the flow and is not resettable from the front panel.

Temperature:

If temperature compensation is selected, the second press of the DISPLAY button will show the product temperature.

If a Density Meter input is selected rather than temperature, the density will be displayed. The display will read "DENS" for one second followed by the actual density value.

Gross Total:

If temperature compensation is selected, the third press of the DISPLAY button will show GROSS for one second followed by the actual gross total.

In any display function, if the DISPLAY button has not been pressed for 5 seconds, the display will automatically go back to the Rate or Total display.

The display functions are defined as follows:

Rate

Rate of flow in engineering units with temperature compensation (if selected).

Total

The net resettable total. The Net Total is temperature compensated (if selected).

Accumulated

The Accumulated Total is a Net Total (i.e. temperature compensated), but it is not resettable via the front RESET button.

Gross Total

The Gross Total is the total without temperature compensation. The Gross Total will reset each time the RESET button is pressed.

Temperature

The instantaneous temperature of the fluid in °F or °C depending on which units are selected during programming.

On reaching the maximum displayed total, all totals will roll over to zero and continue totalizing. If, at any time, power is lost or the instrument is switched off, the totals will be stored in the non-volatile memory. When power is switched back on to the instrument, the stored totals will be recalled from memory and the totals will be incremented from the last values.

Dual Inputs

In many custody transfer applications, it is a requirement that the flowmeter have two outputs so that the integrity of the signal can be assured. This usually requires a turbine meter to have two coils, or a positive displacement meter to have two pulse units.

The Model 715 can interface to flowmeters fitted with two sensors.

The dual input feature, referred to as a quadrature input, has two functions:

1. To detect a difference in the number of pulses from each input during delivery.

The instrument will alarm if the pulse difference (since reset) exceeds 1 in 1000 pulses. When an alarm condition exists, the totals will cease counting and will freeze at the last total prior to the alarm.

On detection of the alarm condition, the alarm output on Terminal 7 will go low (energize) and the display will cease counting. The output can be used to shut off the flow or to warn the operator. The display will also periodically flash the error message, ERR 13.

The alarm condition is reset by pressing the DISPLAY button.

2. Bi-directional Flow

The 715 has the ability to detect forward and reverse flow. The inputs must be connected with Channel 1 being the 90° flow signal and Channel 2 being the 0° signal. For forward/reverse detection to function correctly, there must be clear definition of the input signals.

Calculation of Rate and Total

The flow rate, R, is calculated as follows:

$$R = \frac{f \times H}{S}$$

where:

f is the input frequency in Hz

H is the timebase of rate

S is the Scaling Factor
(pulses per unit of volume)

The user programs the Scaling Factor and selects the timebase during the Calibration procedure as detailed later in this manual.

When non-linearity correction is programmed, up to 10 scaling factors are programmed to cover different frequency ranges. The instrument will then automatically select the correct scaling factor to be applied at the measured frequency.

Filtering

Frequency fluctuations caused by pulsating flow through a flowmeter often make the Rate impossible to read with any precision. The Flow Computer has a digital filter which will average out these fluctuations and enable the Rate to be read to four digit accuracy. When the Rate is retransmitted via the 4-20mA output, the filtering will also average out any fluctuations on the output.

As a guideline to the degree of filtering to be used, the following table shows the response to a step change in input. The value, A, is the filter constant which is programmed during the Calibration routine. The times for the display value to reach 90% and 99% of full swing are given in seconds, for different values of A.

A	90%	99%
1	0	0
2	1	2
4	2	4
6	3	6
10	5	11
15	8	17
20	11	22
25	14	28
35	20	40
45	25	51
60	34	69
75	43	86
90	52	103
99	57	113

Table 1. Response to a Step Input (in seconds).
Note: *If A is set to 1 there is no filtering of the input signal.*

Total Conversion

The Total Conversion feature enables the rate to be displayed in one engineering unit (i.e. gallons/minute) and the totals to be displayed in another engineering unit (i.e. barrels).

The Scaling Factor is always programmed in the unit relating to Rate and the Total Conversion constant is a division factor which can be used to convert the totals to the different unit. The Total Conversion factor affects the net, accumulated and gross totals, and is limited between 0.01 and 2000.

For Example:

If the Rate is required in gallons per minute:

1. The Scaling Factor would be programmed as pulses per gallon.
2. The timebase would be programmed as minutes.

   If the Totals are required in barrels:

3. The Total Conversion factor is programmed as 42 (there are 42 gallons per barrel). All totals will now totalize in barrels.

Non-Linearity Correction (Linearization)

Up to 10 frequencies and scaling factors can be programmed to correct for known non-linearities in the flow meter. Data on the flow meter's linearity is supplied by INVALCO in the form of a Calibration Certificate.

INVALCO'S standard certificate lists 5 flow rates and frequencies with the measured K-Factor (i.e. pulses per gallon) at each flow rate.

Figure 1 illustrates the change in scaling factor with frequency for hypothetical flow meter. The heavy black line represents the actual scaling factor of the flow meter, while the light black line is the approximation used in the instrument.

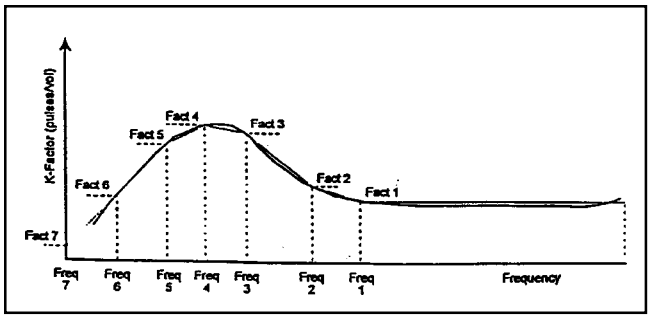


Figure 1. Non-Linearity Correction

Linear Interpolation is used between points on the curve, except for Factor 1 which maintains a constant value between Frequency 1 and the maximum input frequency.

During Calibration, the program requires the user to input a frequency and the Scaling Factor (K-Factor of the flow meter) at up to 10 points on the curve. Generally these points will correspond to those shown on the Certificate.

If any frequency is set to 0Hz (Frequency 7 in the preceding example), then the program will require no further correction points to be programmed. Hence, the user can program any number of correction points up to a maximum of 10. Note that if all 10 correction points are required, then Frequency 10 will automatically be assigned the value of 0Hz.

Output Pulse and Flow Alarm

An OUTPUT PULSE is available on Terminal 10 for driving remote counters and produces a pulse each time the Accumulated Total increments by one digit. For example, if the Accumulated Total has a resolution of 0.01 gallons, a pulse is produced each 0.01 gallons.

The pulse is a current sinking pulse of approximately 10mSec produced by an open collector transistor and can sink up to 100mA. The maximum pulse rate is limited to 49 pulses per second and the resolution on the accumulated total must be set so that the accumulated total increments at less than 49 counts per second.

Note: *Due to the uneven pulse output spacing on this output, the pulse output cannot be used to drive rate indicators.*

The FLOW ALARM uses an identical circuit to the Output Pulse, and is on Terminal 7.

The Flow Alarm is used by the Dual Pulse Input, if selected, and will output and error signal if there is a difference between the input pulses as described under Dual Inputs.

The Flow Alarm output will switch "on" (i.e. the signal goes low) whenever an alarm condition exists. The alarm will switch "off" (i.e. the signal goes high) when the alarm is reset by pressing the DISPLAY button.

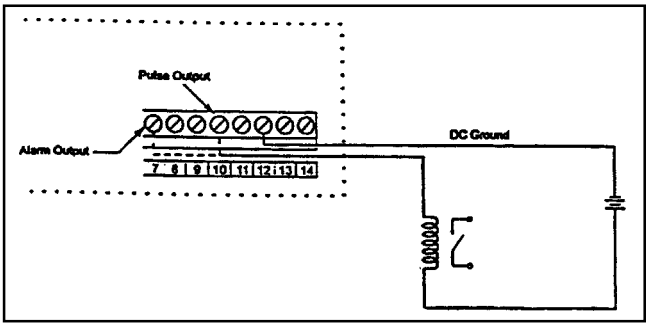


Figure 2. Driving an External Relay or Impulse Counter

Temperature Compensation

Temperature compensation corrects for any change in measured liquid volume due to a change in temperature. There are four methods of compensation which can be selected:

1. Density correction for general liquids with known temperature vs. density characteristics. A five point temperature vs. density curve can be programmed and the MASS flow calculated.
2. Volume correction for general liquids using a thermal coefficient of expansion. This method is useful for correction to a base volume over relatively small changes in temperature.
3. Correction for Petroleum Liquids to US and International standards to a base temperature of 60°F and 15°C.
4. Correction for LPG to US and International standards, to a base temperature of 60°F and 15°C.

In addition, the Model 715 will also accept a 4-20mA signal from a Density Meter (in place of a temperature input) and use this input to calculate MASS flow.

Temperature Input

The Model 715 is available with either a 4-20mA input or a PT100 Platinum RTD input for temperature. The input option must be specified at the time of ordering.

The temperature inputs are continually checked to ensure that they are within the specified limits and an Input Error will be displayed as "ERR12" if the 4-20mA input drops below 3.5mA or if the RTD resistance is outside the valid resistance ranges.

4-20mA Input (Model 715A)

With a 4-20mA input, a linear relationship is assumed over the span of the transmitter. The temperatures or densities at 4mA and 20mA are programmable during the Calibration routine.

RTD Input (Model 715R)

A four wire temperature measurement is used to give high accuracy and, internally, the software will compensate for the non-linearity of the RTD.

During calibration, a "temperature adjust facility" enables the temperature reading to be adjusted. This allows for manufacturing tolerances on the RTD to be corrected.

Volume Correction for General Liquids

For general Liquids, a linear correction factor can be applied to give volumetric flow at base conditions. The flow equations is

$$\text{Net Flow} = \frac{\text{Volumetric Flow}}{1 + (T_f - T_b) \times a}$$

where:

Tf is the flow termperature (°F or °C)

Tb is the base temperature (°F or °C)

a is the thermal coefficient of expansion per °F or °C.

The Thermal Coefficient of Expansion, "a", for a liquid can be determined empirically or can be found in chemical engineering texts.

Density Correction for General Liquids

If density correction for general liquids is selected, a five point temperature vs. density table can be programmed. The instrument uses this table to develop a curve to determine the density of the product after measuring the temperature of the fluid. (see Figure 3).

The instrument will also allow a constant density value to be programmed by selecting only one correction point. In this case, the temperature input is ignored.

This feature is useful if the temperature sensor is removed for maintenance.

The flow equation is:

Mass Flow = R x Density

Where R is the volumetric flow rate

When programming the temperature-density table, the density can be programmed in any units, but the units must be consistent with the flow rate R, and the required units for MASS flow. For example, if R is in gallons and the mass is required in pounds, then the density must be programmed as lb/gal.

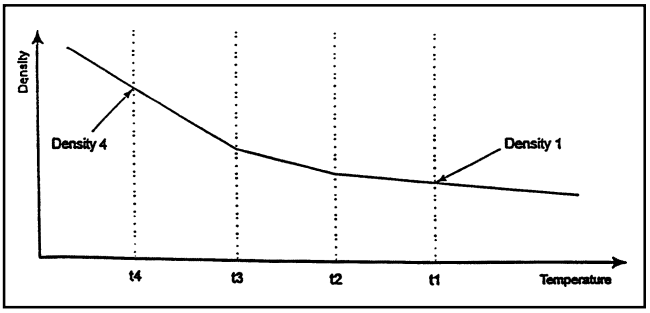


Figure 3. Temperature Density Curve for 4 point table.

The above figure shows the temperature-density curve for a 4 point table. Above t4, the curve has the same slope as between t3 and t4, and below t1, the curve has the same slope as between t1 and t2.

Compensation for Petroleum Liquids

The petroleum correction program uses equations described in API Standard 2540. For US units, the equations from Table 24A, 24B and 24D are used and, for metric units, equations from Table 54A, 54B, and 54D are used.

Based on the programmed density and the measured temperature, the software derives a volume correction factor (VCF). The gross (uncompensated) rate is multiplied by the VCF to give the net compensated total.

For US units, the Specific Gravity is programmed and the volume is referenced to 60°F. For Metric units, the Density is programmed in kg/m3 and the volume is referenced to 15°C.

Five product groups are defined by the equations and, during Calibration, the relevant product group must be selected. The product groups and the relevant densities which can be programmed are as follows:

Product Group	Specific Gravity	Density (kg/m^3)
Crude Oil	0.751 - 1.000	750 - 1000
Jet Fuels, Kerosene and Solvent	0.751 - 0.850	750 - 850
Gasoline	0.641 - 0.800	640 - 800
Lube Oil	0.851 - 0.960	850 - 960
Diesel, Heating and Fuel Oils	0.801 - 1.100	800 - 1100

When programming the density, the values must be entered within these specified limits otherwise and error message will be displayed, prompting the operator to check the parameters.

Compensation for LPG

The LPG correction program uses API Table 34 to correct to US units and API Table 54 to correct to Metric units. For US units, the Specific Gravity is programmed and the volume is referenced to 60°F. For Metric units, the Density is programmed in kg/m3 and the volume is referenced to 15°C.

When programming the density, the values must be within the following limits otherwise an error message will be displayed.

US units	0.501 - 0.600
Metric units	0.500 - 0.600 kg/liter

The temperature compensation is performed over a temperature range of -49°F to 140°F (-45°C to 60°C).

Density Meter Input

Density correction is available on the Model 715A where a density meter is connected across the temperature inputs (Terminal 5) in place of a termperature transmitter. The densitometer must have a 4-20mA output.

During Calibration, the density at 4mA and 20mA can be programmed and the mass flow is calculated as:

Mass Flow = R x Density

where R is the volumetric flow rate.

If the input falls below 3.5mA, an error status, “Err 12” is displayed.

General Installation

Earth Ground is provided via a terminal lug on the side of the case. Note that this grounding point is for the case only and there is complete electrical isolation between this point and all electronic circuits. When high voltages are applied to the relay contacts the case must be suitably grounded. All relay outputs are total isolated from the case and from the internal circuitry.

A Supply Output Voltage is provided to power sensors. This output will provide a regulated voltage of 8 to 24 volts and the voltage is adjustable by means of the potentiometer on the rear panel. Maximum current is 50mA and the instrument comes with the voltage factory set at 24 volts. When the instrument is powered from a DC power source, the maximum output voltage on the Supply Output is the DC Input Voltage less 3.5 volts.

The instrument will operate from either 12-28 volts DC or from AC voltage. The VAC is factory set to either 110 VAC nominal or 220 VAC nominal. An internal transformer provides full isolation between the VAC and the electronic circuits.

The DC Ground terminal provides a common ground for the 12-28 volt power input, the 8-24 volt output and for grounding signal shields.

When connecting to a Flow Computer which is some distance from the flow meter, it is good practice to use shielded cable. The shield should be connected to Ground terminal. The other end of the shield, at the flow meter, should not be connected.

RC Networks for Interference Suppression

When driving highly inductive loads with the relay outputs, it is recommended that RC suppression networks (“Snubbers”) are used for two reasons:

1. To limit the amount of electrical noise caused by arcing across the contacts which may, in extreme cases, cause the microprocessor to act erratically.
2. To protect the relay contacts against premature wear through pitting.

RC suppression networks consist of a capacitor and series resistor and are commonly available in the electrical industry. The values of R and C are dependant entirely on the load. However, if the user is unsure of the type of “snubber” to use, values of 0.25uF and 100 ohms will usually suffice.

The basic principle of operation is that the capacitor prevents a series of sparks arcing across the contact as the contact breaks. The series resistor limits the current through the contact when the contact closes.

Wiring Designations for the Model 715

Terminal	Model 715A	Model 715R
1	Calibration Link	Calibration Link
2	Switch Common	Switch Common
3	Flow Pulse Input (Ch. 2)	Flow Pulse Input (Ch. 2)
4	Not to be used	PT100 I (+)
5	Temp. Input (4-20mA)	PT100 Signal (+)
6	Not to be used	PT100 Signal (-)
7	Flow Alarm	Flow Alarm
8	Flow Common (-)	Flow Common (-)
9	Flow Pulse Input (Ch. 1)	Flow Pulse Input (Ch. 1)
10	Pulse Out	Pulse Out
11	DC Power Out (8-24 VDC)	DC Power Out (8-24 VDC)
12	DC Ground	DC Ground
13	DC Power Input	DC Power Input
14	Flow Input (4-20mA)	PT100 I (-)

Terminal	Analog Flow Output	RS232/422
20	Not to be used	RS232 Signal Ground
21	0 Volts	RS232 Data In
22	0-10 Volts	RS232 Data Out
23	-12 Volts	RS422 (-) Data Out
24	I (-)	RS422 (+) Data Out
25	I (+)	RS422 (-) Data In
26	+15 Volts	RS422 (+) Data In
27	Not to be used	RS232 CTS

Terminal	Relay	Option
31	Relay 2	Normally Open
32	Relay 2	Normally Closed
33	Relay 2	Common
34	Relay 1	Normally Open
35	Relay 1	Normally Closed
36	Relay 1	Common

Options

The 4-20mA Output Option

The 4-20mA output is electrically isolated from the instrument power supply and signal inputs to ensure minimum interference. The 4-20ma is directly proportional to the displayed rate.

Either 2 wire current transmission is available with the loop powered internally, or 3 wire transmission from an external loop supply.

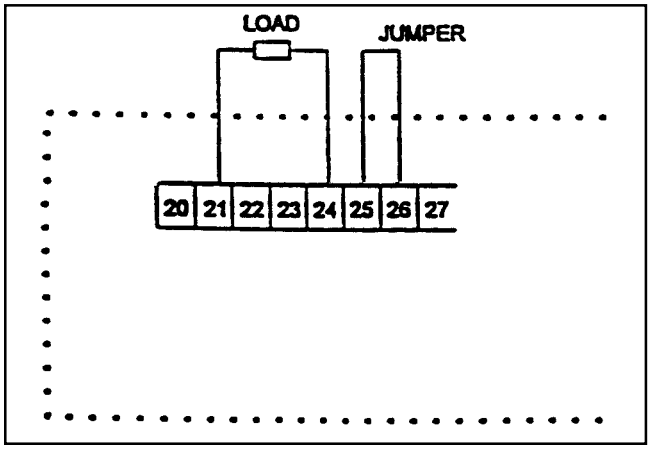


Figure 4. Two Wire Transmission (Internal Supply)

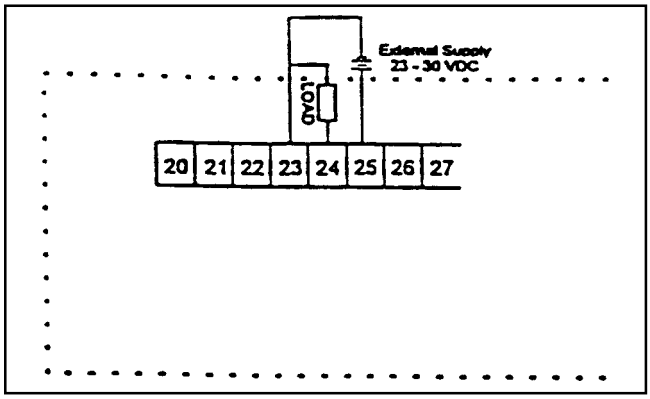


Figure 5. Three Wire Transmission (External Supply)

Load Specification

Maximum load which the output can drive:

Internally powered loop: 500 ohms

Externally powered: R = (V-5)/.02

where :

V is the external loop voltage.

R is the maximum load in ohms.

Calculation

The computer's 4-20mA output range can be set independently of the flow meter's range to effectively amplify the input signal. In driving chart recorders, for example, this enables the output to zoom in on a particular operating area, instead of having to display the full operating range of the flow meter.

For example, 4mA may be set as 0 gpm and 20mA as 100 gpm or the user could set 4mA as 100 gpm and 20mA as 120 gpm.

For rates or displayed values above and below the maximum and minimum values the output will remain at its 20mA or 4mA level respectively.

It should be noted that the output will be updated every 0.25 seconds in unison with the display and, between updates, the output value is constant.

The RS232/422 Interface Option

With this option installed, the circuits for both the RS232 and RS422 are provided as standard. They can be used to interface to both printers and computers, and a number of standard protocols are built into the instrument.

Hardware

Both interfaces are available on the rear terminal strips and the user can select either one by making the appropriate connections.

The RS232 interface is primarily used with printers or for simple communication with computer over a short distance. The RS422 is used for communication over a long distance or in applications requiring multipoint communication.

Multipoint Communication

Multipoint Communication is a system whereby a number of instruments can be address over a dual twisted pair interface. Up to 32 instruments can be connected to a common bus using the RS422 (RS485) interface.

Each instrument can be programmed with a unique address which is used by the Master Controller (i.e. IBM/PC) to identify each instrument. The Controller will send the address down the line and will alert the relevant instrument. Subsequent software protocol will control the flow of data between the Controller and the Instrument.

Communication Protocol

The RS232/422 option has a real time clock and enables the time and date to be set and printed on tickets. The date format can be USA (months/days/hours) or European (days/months/years), while the time is on a 24 hour clock.

Note: *The clock will only retain its time for 3 days minimum if there is no power connected to the instrument. After this period, the clock may need to be reset.*

The baud rate, parity and work length can be programmed during calibration and the user must ensure that these correspond to the setting on the printer or computer with which the Model 715 is communicating.

Printer

A ticket is printed each time the RESET button is pressed. The instrument prints the ticket before resetting the resettable total. Protocols are provided to drive the following printers:

1. Standard Computer Printer (Note that the printer must have an RS232 Serial Interface).

2. EPSON CTM290 Slip Printer.

The tickets can also be printed with a number of different units. The units are selectable from a pre-programmed list.

A CTS input is provided, and will prevent the instrument from transmitting an further characters to a printer if the printer buffer is full. The CTS input is usually connected to the "Data Buffer Full" output from the printer.

If the printer buffer is large enough to handle the message output from the instrument, then this input need not be used and should be left unconnected.

Computer

The instrument receives and transmits messages in ASCII with all command strings and replies terminated by a carriage return.

Xoff/Xon protocol is also supported. The instrument will automatically determine if the message sent by the host computer is preceded by an Xoff character. If it does recognize an Xoff as the first character of a command string, the instrument will automatically switch to Xoff/Xon protocol. It will begin and end all messages with Xoff and Xon characters respectively.

During Calibration, the instrument can be programmed to operate in a full duplex or half duplex transmission mode. If full duplex mode, all commands sent to the instrument will be echoed back to the host computer. In half duplex, the commands are not echoed.

The Relay Output Option

The Relay Output Option consists of two Form C relays which can be preset during calibration to energize when the rate or displayed value exceeds or drops below the preset values.

The "low" relay is energized whenever the rate is below the preset value. The "high" relay is energized whenever the rate exceeds the preset value. The preset values are programmed during calibration as described in the following section.

Calibration

The calibration routine enables the Setup Parameters to be programmed and the input signals to be checked.

The calibration routine can be entered in two ways:

1. By connecting a jumper (or switch) to the rear terminal strip across Terminals 1 and 2.
2. By pressing the TOTAL button and, while holding, pressing the RESET button. Both buttons must then be held for approximately 6 seconds.

Note: *This second method of access can be disabled during the calibration so that it is only possible to enter the calibration routine using Method 1 above.*

The buttons function as follows:

Button	Function
RATE	Changes a flashing digit to the next digit.
TOTAL	Increments a flashing digit or changes a parameter selection.
RESET	Resets a flashing digit to zero.
DISPLAY (Program)	Steps through the program sequences.

Note: *The arrows in the RATE and TOTAL buttons indicate that these buttons can be used to change and increment digits respectively.*

In stepping through the program sequence, the abbreviated Parameter Description is always displayed first, followed by the actual value or parameter. When a value or parameter can be changed it is always shown as flashing, and the LED's are lit to indicate which button can be used to change the value.

On first entering the calibration routine, the display will show the Model Number followed by:

CAL	Setup Program Parameters.
Options	Options (if installed).
Test	Check Input Signals.
End	Exit to Normal Operation.

Pressing the TOTAL button will scroll through these modes and pressing the DISPLAY button will select the appropriate mode.

To exit calibration, step through the Setup or Test Program until the end, press the DISPLAY button when END is displayed. Ensure that the calibration link is removed.

Programming the Setup Parameters

Step	Display	Explanation
1	CAL	To setup the program parameters, select the CAL Mode by pressing the DISPLAY Button
2	RESTOT	Reset all totals to zero.
	xxxxxx	To clear all totals (net, gross and accumulated). Press the reset key.
3	FL INP	Select either a single frequency input or a dual input (two pulses from a single flow meter).
	single	Single Input
	quad	Dual Input
	analog	Analog Input (Model 715A) If you are using an analog flow transmitter ie DP cell) consult factory for details.
4	CORRCT	Select either a linear input or non-linear correction for the flow meter input.
	Linear	Linear Input (no correction required).
	Nonlin	Correction of non-linear input.
	Sq rt	Square Root Input (only if analog input). Not discussed in this manual.
5	SCALE	**Linear Selected**
	Fact	Enter the Scaling Factor (K-Factor) of the flow meter. The program then skips to Step 8. The digits before the decimal point (whole numbers) are programmed first, followed by the decimals. The scaling factor can be programmed in the range of 0.1000 to 50,000.

Step	Display	Explanation
5	SCALE	**Non-Linearity Correction Selected.** Up to 10 Frequencies and Scaling Factors can be entered. INVALCO Turbine Meters are provided with a 5 point calibration.
	Freq 1	The first frequency point in the range of 0-9999Hz
	Fact 1	This is the K-Factor of the flow meter (pulses per gal, etc.) at Freq. 1. The digits before the decimal point (whole numbers) are programmed first, followed by the decimals.
	Freq 2	The second frequency point. If any Freq is set to 0, no further correction points can be programmed The non-linearity correction is limited to the number of programmed frequency points.
	Fact 2 to Fact 10	Scaling Factor 2 Scaling Factor 10. Note: Freq 10 is not displayed since it must always be zero. *Skip to Step 7*
	Fact	This is the Signal Span (Analog Flow devices only).
6	CUTOFF	This is displayed only if an analog input for flow rate (FL INP) is selected. Not discussed in this manual.
7	F dPt	Number of decimal points used to display Rate. Between 0 to 0.00000.
8	t.base	The Timebase is used to calculate the Rate and entered as:
	60 secs	units/min
	hours	units/hour
	days	units/day
	secs	units/second
9	FILTER	The Filter Constant for filtering the rate display and the 4-20mA output
	1 to 99	No Filtering Very heavy filtering
10	TOTCON	A Division Factor to convert the totals to different units from those used for rate (gallons/min and barrels etc.).
	1	Rate and Totals have the same engineering units.
	x.xxxx	Other factors can be programmed between 0.01 and 2000.
11	t.dPt	Number of decimal points between 0 and 0.000 displayed in the Net (resettable) Total.
12	A.dPt	Number of decimal points displayed by the Accumulated (non-resettable) Total between 0 and 0.000.

Programming the Setup Parameters (con't)

Step	Display	Explanation
13	t.c	The type of Temperature Compensation can be selected as follows:
	none	No Temperature Compensation
	genliq	Volume Correction for General Liquids
	gendns	Density Correction for General Liquids
	petrol	Compensation for Petroleum Products
	LPG	Compensation for Liquid Petroleum Gas
	dens	Density Meter Input (Model 715A only)
		Note: *If none is selected the program will go to Step 20 (Access). If a Density Meter Input is selected, the following Steps are displayed.*
14	d4	The density at 4mA input is programmed.
15	d20	The density at 20mA input is programmed.
		Note: *All other Selections at Step 13 will display the following steps.*
14	t.	Select either US units or Metric units as the basis of the Temperature Compensation.
	F	US Units
	C	Metric Units
		Note: *If the instrument has a 4-20mA temperature input (Model 715A), the 4mA and 20mA temperature points must be entered.*
15	IP4	Enter the temperature that corresponds to 4mA in either °F or °C depending on units selected in Step 14.
16	IP20	Enter the temperature that corresponds to 20mA.
		Note: *If the instrument has a direct RTD input (Model 715R) the temperature can be adjusted (offset) to correct for the RTD intolerance.*
15	ADJt	Adjust the temperature displayed during test.
	xx.xx	Input the offset. (The first digit is 0 for positive or - for negative.)
		Note: *Steps 18 to 20 depend on which option for temperature compensation was selected in Step 13.*
		Volume Correction for General Liquids
17	REF °F	Program the base temperature for the (°C) compensation. Enter the temperature in °F or °C depending on the units selected in Step 14.
18	COEF A	Enter the thermal coefficient of change "a" as a %. For example, if the coefficient of expansion is 0.0029/°C enter the & change as 0.2900 (0.0029 x 100).
		Note: *The program will now go to Step 20.*

Programming the Setup Parameters (con't)

Step	Display	Explanation
		Density Correction for General Liquids
17	NotPx	Number of temperature-density correction points up to five. If x is set to 1, a fixed density can be programmed. (The density is not dependant on the temperature.)
18	tp1	Temperature point 1.
19	dens1	Density 1.
		Note: *Up to 5 correction points can be entered.*
		Petroleums
17		Select the petroleum type.
	CRUDE	Crude oils as per tables 24A & 54A.
	LUBE	Lube oils as per tables 24D & 54C.
	OILS	Fuel and Heating Oils, and diesel as per Tables 24B & 54 B.
	JET	Jet Fuels, kerosenes, and solvents as per Tables 24B & 54 B.
	GAS	Gasolines and naphthenes as per Tables 24B & 54B.
18	dn 60°F or dn 15°C	If US units are selected the Specific Gravity is programmed. If Metric units are selected the Density at 15°C in kg/m3 is programmed.
		Note: *The program will now go to Step 20.*
		Liquid Petroleum Gas
17	dn 60°F	If US units are selected the Specific Gravity is programmed. If Metric units are selected the Density in kg/liter is entered.
20	ACCESS	Enable access to calibration routine via front panel.
	Front	Enable access via front panel.
	No Acc	Disable access via front panel.

Programming Options

Step	Display	Explanation
1	OPTIONS	Options (if installed).
		4-20mA Output Option Installed
2	OUTPUT	Select either 4-20mA or 0-10 volt.
	4-20	4-20mA (also 2-10 volts)
	0-10	0-10 V (also 0-20mA)
3	OP4	Flow rate at 4mA or 0 volts.
	xxxx	Enter flow rate.
4	OP20	Flow rate at 20mA or 10 volts.
	xxxx	Enter flow rate.

Programming Options (con't)

Step	Display	Explanation
		RS232/422 Option Installed
5	DF	Date Format
	Eur	European (days/months/years)
	USA	USA (months/days/years)
6	Date	Enter date as:
	xx:xx:xx	Years:Months:Days
7	TC	Enter time as 24 hour clock
	xx:xx	Hours:Minutes
8	BAUD	Baud Rate
	xxx	300, 600, 1200, 2400, 4800, and 9600
9	DATA	Word Length
	7	7 bits
	8	8 bits
10	PARITY	Parity
	NP	No Parity
	OP	Odd Parity
	EP	Even Parity
11	SIGNAL	Signal Type
	rs232	RS232
	rs422	RS422
12	ID NO	Unit Identification Number
	0	None
	1-255	ID Number
13	PTYPE xx	Printer/Computer Type
	00	Standard Computer Printer
	01	EPSON CTM 290 Slip Printer
	20	Computer
		Note: *If a printer protocol is selected, the following message is displayed.*
13	UNIT xx	Units of measurement printed.
	00	None
	01	Liters (Ltrs)
	02	Gallons (Gals)
	03	Barrels (bbls)
		Note: *If a computer protocol is selected, the following message is displayed.*
13	ECHO	ECHO Command
	On	Echo (Full Duplex)
	Off	No Echo (Half Duplex)
		Note: *If the Relay Option is installed, the following will be displayed.*
14	AL:Hi xxxxx	High Alarm switching point. The high relay will energize if the flow rate exceeds this value.
15	AL:Lo xxxxx	Low Alarm switching point. The low relay will energize if the flow rate falls below this value.

Checking the Input Signal

Step	Display	Explanation
1	TEST	Check the Input Signals.
		Model 715A - If temperature or density correction is selected, display will show:
2	T4-20 or D4-20	Displayed for 1 second to indicate input the 4-20mA temperature or density input.
	xx.xx	The input current is then displayed.
		Model 715R - If temperature correction is selected, display will show:
	RTD	Displayed for 1 second to indicate the RTD.
	xxx.xx	The measured temperature is displayed.
3		Press DISPLAY to step to the Flow Input.
		Single Frequency Input
	Freq	Displayed for 1 second followed by the actual frequency.
	xxxx.xx	Frequency in Hz.
		Quadrature (Dual) Frequency Input
	Freq	Displayed for 1 second followed by the actual frequency.
	xxxx.xx	Frequency in Hz. If flow is reversing a "-" will appear.
		RS232/422 Option Installed
4	CLOC	Clock
	xx:xx:xx	Time in Hours:Min:Sec

Input Circuits

Flow Inputs

The Model 715 has two pulse input circuits:

- Channel 1 is used with both single and quadrature input singles.
- Channel 2 is used only when a quadrature input is selected, and becomes the 0° input while Channel 1 becomes the 90° input.

The frequency input circuits for the Model 715 can be configured by the user to interface with most flowmeters. A small 8 pole DIP switch on the rear of the instrument is used to set up the input circuit to operate with different types of signals.

Switch settings are factory set to interface with any INVALCO Turbine Meter. Refer to the table below for factory settings. Consult the factory for switch settings to interface with other sensor types:

Input Signal Type	Input Terminals		Switch Settings							
	CH1									
	+	-	1	2	3	4	5	6	7	8
Logic Signal, CMOS Pulse	9	8	off	off	off	off	on	off	off	off
Coil (20mV P-P minimum)	9	8	off	on	off	off	off	off	off	off
Coil (low impedance) 22mV P-P minimum	9	8	on	on	off	off	off	off	off	off

Powering a Sensor or Amplifier

The Model 715 has a regulated DC output which can be used to power sensors. A trimpot on the rear of the instrument allows the voltage to be adjusted in the range of 8-24 volts and the output can supply a maximum of 50mA.

Temperature or Density Input

The Model 715 Flow Computer can be supplied as:

- Model 715A - 4-20mA input which can be used for temperature or density
- Model 715R - Direct 4 wire Platinum RTD (PT100)

4-20mA

This input can function as either a temperature or density input. The 4mA and the 20mA points are both programmed. Unlike the direct RTD measurement, no correction is made for the non-linearity of the temperature or density sensor.

RTD

Four wire RTD measurement is the most accurate form of measurement and can be used with the RTD mounted up to 100 meters from the Flow Computer. The use of shielded cable is recommended.

Two or three wire RTD's can be used in place of 4 wire RTD. However, 4 wires must be run to the RTD and the signal and current wires joined as close to the RTD as possible.

The program automatically corrects for the non-linearity in the RTD.

Trouble Shooting

The instrument has extensive self test facilities and will display an error code if it detects an invalid condition. If the instrument displays an error code other than those listed below, please contact the factory.

Error codes are displayed as “Err 12” and a list of commonly encountered codes appears below:

Input Errors

Code	Explanation
6	Invalid calibration parameter specified.
11	Invalid input configuration programmed.
13	Quadrature (dual) input error detected.
14	Communications input error. (RS232/422 Interface)

Output Errors

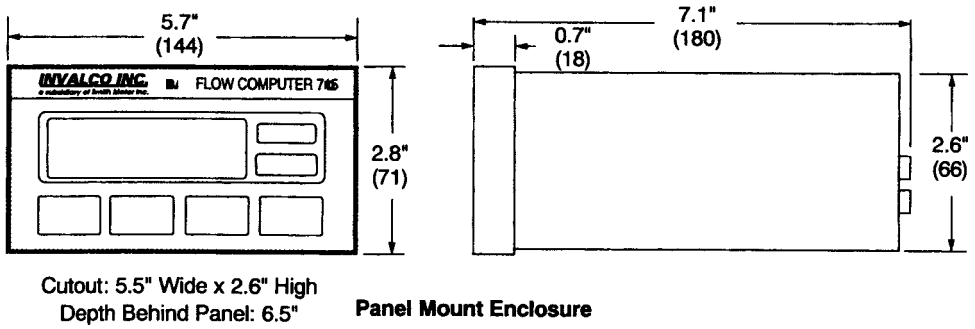
Code	Explanation
21	Invalid output configuration.
22	Communications error - Baud rate not set.
23	Communications error - Printer fault.

Calibration Errors

Code	Explanation
30	Zero value not allowed.
31	Outside allowable temperature range.
32	Outside allowable density range.
33	Invalid printer type.
34	Invalid volume units selected.

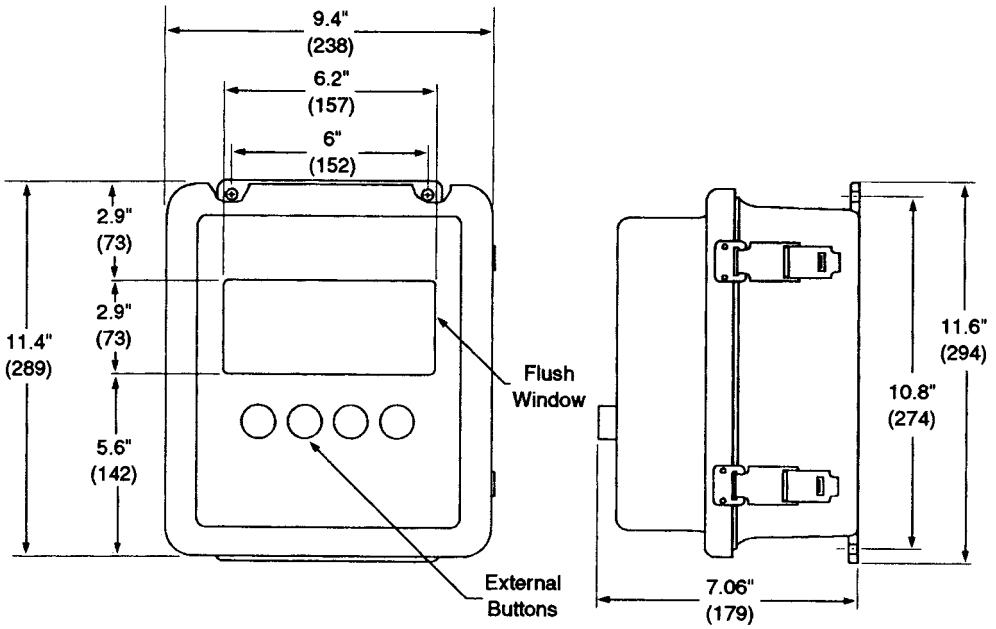
Dimensions

Inches (mm)

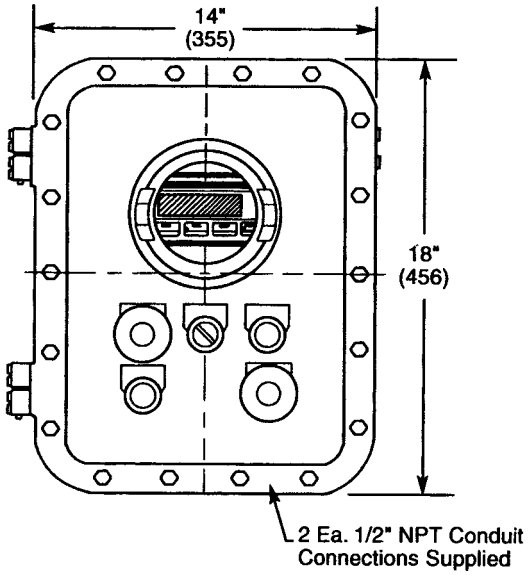


Cutout: 5.5" Wide x 2.6" High
Depth Behind Panel: 6.5"

Panel Mount Enclosure



Weather Proof Enclosure (NEMA 4X)
(Conduit Holes Not Provided)



Explosion Proof Enclosure (NEMA 7)

Note: *Dimensions - Inches to the nearest tenth (millimeters to the nearest whole mm), each independently dimensioned from respective engineering drawings.*

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