

**BATCH CONTROLLER
MODEL 414L**



March 1996

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1. INTRODUCTION

The Model 414L Batch Controller uses temperature correction to calculate the volumetric flow for liquids at standard reference conditions and to batch liquids using one or two stage valve control.

Mass flow can also be calculated from the temperature input and the volumetric flow input. Therefore, the Model 414L Batch Controller will enable relatively low cost mass flow measurement and control using positive displacement or turbine flowmeters and an RTD.

The Model 414L is ideally suited to custody transfer applications and includes the API/ASTM equations covering general petroleum products and LPG. Quadrature signal inputs are provided, where it is required to ensure the integrity of the flow signal, or to measure bi-directional flow.

Two versions of the instrument are available; the Model 414LR with direct RTD input and the Model 414LA with a 4-20mA temperature input. Both have two relay outputs capable of handling up to 5 Amps.

The Model 414L offers the following temperature compensation:

1. Density Correction

A five point temperature-density curve can be programmed and the MASS flow calculated.

2. Volume Correction for General Liquids

The thermal Coefficient of Expansion of the liquid can be programmed and a reference temperature defined for volume correction to that reference.

3. Petroleums

Volumetric correction to 15°C or 60°F for Crude, Oils, Jet Fuel and Gasoline as determined by API/ASTM Table 54A, 54B and 54D for metric units and Tables 24A, 24B and 24D for US units.

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4. Liquid Petroleum Gas

Volumetric correction to 15°C or 60°C for LPG as determined by Tables 54 and 34 of the API/ASTM standards.

In addition, the Model 414LA will accept a 4-20mA signal from a Density Meter and use this input to calculate mass flow.

As well as pulse inputs, the Model 414LA will also accept a 4-20mA from volumetric flowmeters such as vortex, magnetic or turbine flowmeters with a frequency to current converter on the output. The instrument will also operate with differential pressure devices used to measure flow, but the compensation is limited to density correction using a temperature input, or to a direct input from a density meter. Volume correction is not possible with a differential pressure device.

This instrument conforms to the EMC-Directive of the Council of European Communities 89/336/EEC and the following standards:

Generic Emission Standard EN 50081-1 Residential, Commercial & Light Industry Environment.

Generic Emission Standard EN 50081-2 Industrial Environment.

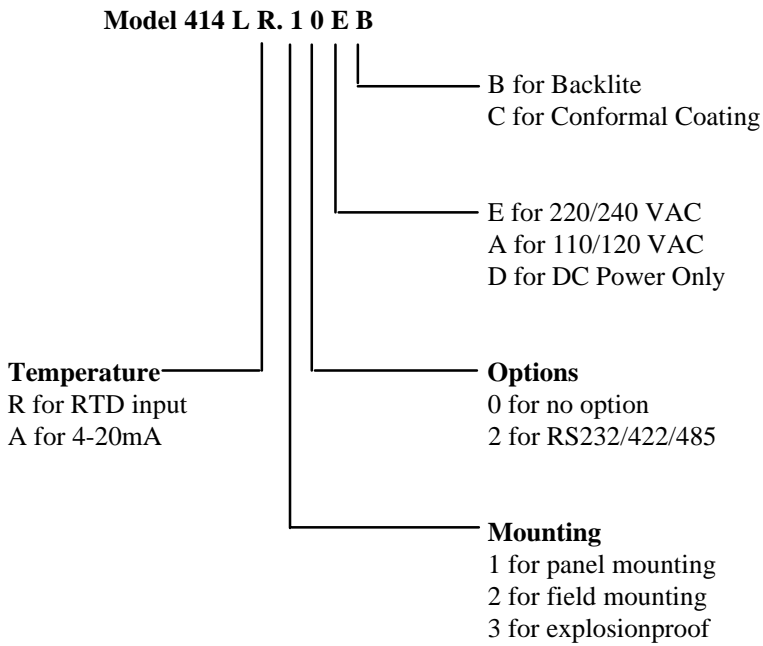
Generic Immunity Standard EN 50082-1 Residential, Commercial & Light Industry Environment.

Generic Immunity Standard EN 50082-2 Industrial Environment.

In order to comply with these standards, the wiring instructions in Section 7.1 must be followed.

1.1 MODEL NUMBER DESIGNATION

The Model number of an instrument describes which input and output options are installed and the AC mains voltage rating.



The Model Number of the instrument is displayed on first entering the Calibration Mode (see Section 6).

2. SPECIFICATION

General

Display:	6 digit LCD. 0.7" (17.8mm) high digits.
Display Update Rate:	0.25 seconds.
Transducer Supply:	8-24VDC field adjustable. 50mA maximum.
Power Requirements:	11.5 to 28.5 volts DC. 130mA typical current (no options). AC Mains: Set internally to 95 - 135 VAC or 190 - 260 VAC.
Operating Temperature:	0 to 55°C standard.
Dimensions:	5.7" (144mm) wide x 2.8" (72mm) high x 7.0" (178mm) deep.
Cutout:	5.5" (139mm) wide x 2.6" (67mm) high.

Frequency Input

Frequency Range:	Minimum: 0.25Hz on Rate. 0Hz on Total.
	Maximum: 10KHz for a single input. 2.5KHz for a quadrature input.
Input Circuits:	Will accept most sine logic and proximity switch inputs (see section 7.1.1).
Scaling Range:	0.1000 to 50,000.

RTD Input (Model 414LR)

Temperature Measurement Range:	-100°C (-148°F) to 200°C (392°F).
Measurement Accuracy:	0.1°C
RTD Type:	Platinum PT100.
Linearity Correction:	Internally Compensated.

4-20mA Inputs

Measured: Flow, temperature or density.
Input Impedance: 250 ohms.
Measurement Accuracy: 0.05%
Isolation: Inputs are not isolated.

Relay Outputs

Maximum Switching Power: 1250VA.
Maximum Switching Voltage: 250VAC, 30VDC.
Maximum Switching Current: 5 Amps.

Pulse Output

Pulse Width: 10mSec (negative going pulse).
Maximum Duty Cycle: 49 pulses per second.
Scaling: The pulse output is scaled and outputs one pulse each time the accumulated total increments.

Non-linearity

Number of Points: 10 correction points maximum.
Correction between Points: Linear interpolation used.

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Temperature Correction

Density Correction for
General Liquids:

A five point temperature density table can
be programmed.
Temperature Range: -273°C to 200°C.
(-459°F to 392°F).

LPG:

To API/ASTM Tables 34 and 54

Accuracy: 0.04% for metric.
0.12% for US.
Temperature Range: -45°C to 60°C.
(-49°F to 140°F).

Volume Correction for
Petroleum:

Correction to API/ASTM Tables as follows;
Crude: Tables 24A and 54A.
Gas, Jet, Oils: Tables 24B and 54B.
Lube Oil: Tables 24D and 54D.

Accuracy: 0.075%
Temperature Range: -100°C to 200°C.
(-148°F to 392°F).

Volume Correction for
General Liquids:

Correction to any base temperature using a
constant co-efficient of volume expansion.

Accuracy: 0.05%
Temperature Range: -273°C to 200°C.
(-459°F to 392°F).

Density Meter Input

A density meter with 4-20mA output can be
connected, in place of a temperature sensor,
to provide a mass flow reading.
(Model 414LA only.)

3. OPERATION

The Model 414L uses a low power CMOS microprocessor to perform all control functions and calculations.

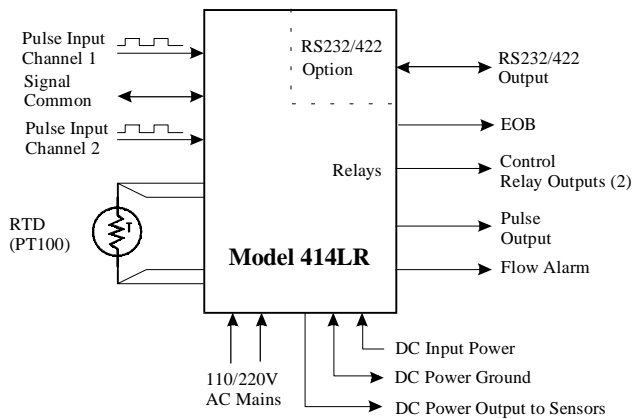
The instrument is fully programmable with all operating parameters and calculation constants user programmable. (See Section 6 entitled "Calibration" for information on programming.) All parameters and constants are stored in a non-volatile memory which retains data without battery backup for a minimum of 10 years.

Two versions of the instrument are available and have the following features:

Model 414LR

- ◆ Temperature Input directly from a PT100 RTD.
- ◆ Frequency Input from a single flowmeter with a single or dual frequency output.

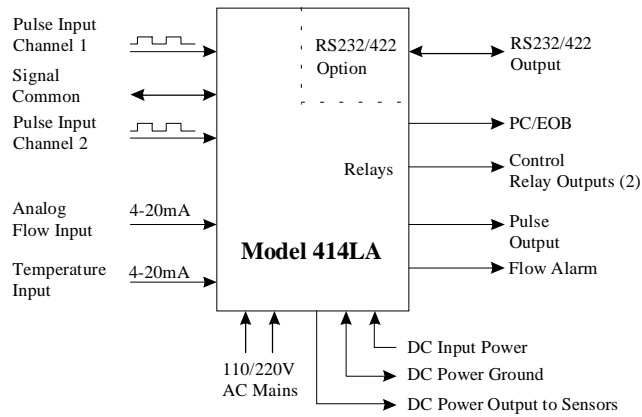
The dual frequency unit (termed "Quadrature") is often required in custody transfer applications to ensure the integrity of the flow signal and to measure bi-directional flow.



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Model 414LA

- ◆ Temperature Input from a temperature transmitter (4-20mA).
- ◆ Either a Frequency Input (Single or Quadrature) or Analog (4-20mA) from a single flowmeter.





On both the Models 414LR and 414LA, a DIL switch on the rear panel enables the frequency input circuit to be set to interface with a wide range of flowmeters, including turbine flowmeters and flowmeters with Namur type sensors.

3.1 FRONT PANEL OPERATION

The four key operation makes the operation of the Batch Controller very easy.

SETTING THE BATCH QUANTITY

The Batch quantity is programmed as follows:

<i>Switch Action</i>	<i>Display</i>	<i>Comments</i>
Press BATCH SET	Batch	"Batch" is displayed for one second followed by the batch quantity last entered. The Batch Set LED lights.
	"1" 2345	The most significant digit flashes indicating that it can be changed.
Press 	"2" 2345	Pressing the DISPLAY key will increment the digit. The up arrow on the Display key indicates to increment digit.
Press 	2 "2" 345	Pressing the RUN key will change digit and enable the next digit to be incremented. The right arrow on the RUN key indicates to change digit.
Press BATCH SET	Set	Once the desired number is entered, press the BATCH SET key to return to the Run mode. The Batch Set LED will extinguish.

Once programmed, the Batch quantity will be retained in the non-volatile memory and will not alter until changed by the user.

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The Batch quantity can only be set while the instrument is in non-operational state such as when the batch is complete, or if the batch process has been interrupted. However, the Batch key can be pressed while in the run state and the Batch quantity checked. All digits will flash to signal the quantity cannot be changed.

STARTING A BATCH

To start the process the RUN key is pressed. The Run LED will light and the instrument will begin to totalise from zero or, if programmed for the count down mode, the display will decrement from the batch quantity.

The batcher has two output relays and these are energised and de-energised as described in section 3.2.

STOPPING

The process can be stopped at any time by pressing the STOP switch. Once the process has been interrupted in this way it can be continued by pressing the RUN switch or the process can be aborted and the instrument reset by pressing the STOP switch a second time.

When the process is interrupted, the STOP LED will flash to prompt the operator to either restart or abort the batch.

RESETTING

The instrument can be programmed to reset in one of two ways.

- ◆ At the end of a batch, the STOP key must be pressed to reset the Batch Total. If the instrument is programmed to count down, the Batch Total will then revert to the preset quantity. If it is programmed to count up, the Batch Total will clear to zero.
- ◆ If Auto Reset is programmed, the Batch Total will automatically reset when the RUN key is pressed and then commence the next batch.

BATCHING ON GROSS OR NET TOTAL (MASS)

The Batch Controller can be programmed to batch on either the Gross Total (uncompensated) or the compensated Net Total or Mass Total. Care should be taken when batching in Net or Mass units, so that a vessel cannot be accidentally overfilled.

Note that the Gross Total is the total without temperature compensation and the Net Total is the total after temperature compensation. Both totals are reset on each batch.

DISPLAYED INFORMATION

The display will normally show the Batch Total, which is the total count for the current batch. The Batch Total can be either the Gross, Net or Mass depending on which value is programmed to control the batch.

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

Rate

On the first press of the DISPLAY key, the display shows RATE for one second followed by the net flowrate (or MASS Flowrate).

Gross or Net Total

Since the batch can be controlled via the Gross or Net Total (or MASS), the next value displayed on pressing the DISPLAY key will depend on which value is used. If the batch is controlled via the Gross Total, the Net Total (or MASS Total) will be displayed. If the batch is controlled via the Net Total (or MASS Total) the Gross Total will be displayed.

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Accumulated Total

On the next press of the DISPLAY key, the display shows ACC for one second followed by the actual total. The Accumulated Total is temperature compensated and cannot be reset during normal operation.

Temperature

If temperature compensation is selected, the next press of the DISPLAY key will show the product temperature as:

xxx F or xxx C

If the instrument is programmed for a Density Meter input, the density (and not temperature) will be displayed. The displays will read "DNS" for one second followed by the actual density value.

If the DISPLAY key is again pressed, the display will revert to the Batch Total display. In any display function, if the DISPLAY key has not been pressed for 5 seconds, the display will automatically go back to the Batch Total display.

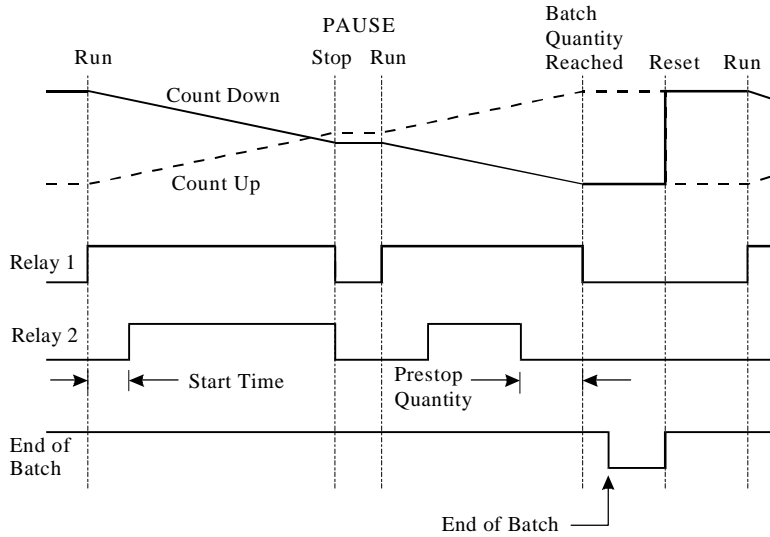
LIMIT ON BATCH SIZE

To prevent accidental entry of large batch quantities, a maximum batch limit can be programmed during calibration. The operator is then prevented from entering a batch quantity which exceeds this value.

3.2 BATCH OPERATIONS

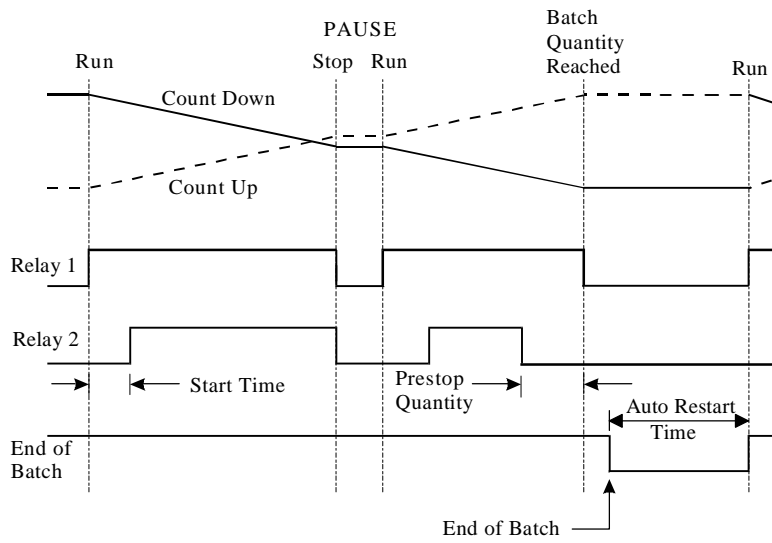
The Batch Control functions can be programmed, during Calibration, to operate in one of two ways.

1. At the end of the batch, the STOP key must be pressed to reset the Batch Total. (This must be done before another batch can be started.)



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2. If Automatic Reset is programmed, a new batch is commenced each time the RUN key is pressed.



The Batch Controller can also be programmed, during Calibration, to either count up from zero on each batch, or to count down from the preset batch quantity.

3.2.1 Control Relay Outputs

The two output relays can be set up to control single valve or a dual valve with slow stop and/or slow start. Alternatively, the second relay can be used to control a pump.

The relay operation is shown on the previous two pages.

A time delay between the Start and the time when relay 2 energises can be programmed to provide a soft startup. The delay can range from 0 (no delay) to 79 minutes and 59 seconds.

A Prestop quantity (ie. the quantity to the end of the batch) can also be programmed to provide a slowdown of flow at the end of the batch, thereby enabling precise quantities to be batched.

The process can be stopped at any time by pressing the STOP key, whereby both relays will immediately de-energise. The process can then be aborted and the batcher reset by pressing the STOP key again, or the process continued by pressing the RUN key.

If the process is continued and the instrument was previously in the slow start or main control phases (ie. not the prestop phase), the timer will be reset and a slow start will occur with a full time delay to ensure a correct start up. The totals will not be reset and the batch quantity will remain unchanged.

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3.2.2 Signal Timeout

The Signal Timeout period defines a time interval which is used to detect if the flow has stopped. If there is no signal input for a time greater than the Signal Timeout period the flow is deemed to have stopped. A Signal Timeout period has two functions:

- ◆ To detect the loss of signal midway through a batch when the relays are energised. In this case, the Batcher will enter a Flow Alarm condition and de-energise the relays.
- ◆ After the preset batch quantity has been reached and the relays de-energised, some overrun of flow may occur due to slow valve closure, etc. In this case, the Signal Timeout is used to determine when the flow has ceased and thereby accurately determine the amount of overrun.

It is recommended that Signal Timeout periods are kept fairly short, but long enough such that the period is significantly longer than the time period between successive input pulses from the flowmeter at the minimum flowrate.

The instrument enables the user to program a time interval of up to 99 seconds to detect an absence of signal input. **If the Signal Timeout is set to 0, this function is disabled.**

Flow Alarm

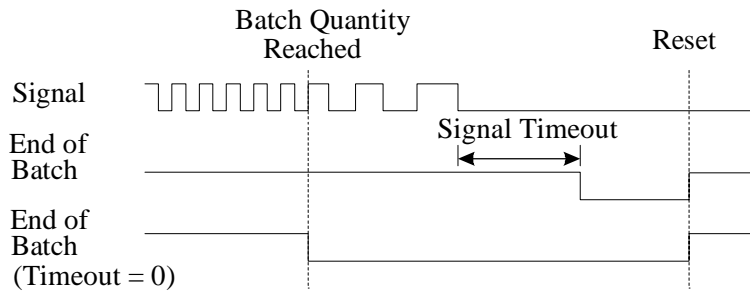
If a Signal Timeout is set at greater than zero and loss of signal is detected midway through a batch, a Flow Alarm signal is output on terminal 7. In addition, both relays are de-energised. The Flow Alarm output and condition is maintained until acknowledged by pressing the STOP switch. The alarm condition is also signalled to the operator by the flashing STOP LED. Once acknowledged, the process can then be reset via the STOP switch or continued by pressing the RUN key.

3.2.3 End of Batch

The End of Batch is defined as being when the Batch Quantity is reached, the flow has stopped and the Signal Timeout period has expired.

If the Signal Timeout is set to zero, the End of Batch is defined as being when the Batch Quantity is reached, regardless of whether the flow has stopped.

The Batch Controller cannot be reset or restarted until the End of Batch and similarly, for an RS232/422/485 interface, data will not be output until the End of Batch has been determined. Consequently, it is strongly recommended that the Signal Timeout period be kept fairly short.



Although the above diagram shows a pulse input from the flowmeter, an analog flow input has the same effect and the flow is defined as being stopped when the flow signal is at 4mA (or below the cutoff value).

End of Batch Signal

An End of Batch signal from an open collector transistor is output on terminal 30 and the output is identical to the Output Pulse circuit as shown in section 3.7.

When reaching the End of Batch, the output transistor is switched on, and will remain in the "on" state until the instrument is reset.

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3.2.4 Auto Restart

The Batch Controller can be programmed to continually repeat the batch process. This mode of operation is selected during the programming procedure.

The process is started by pressing the RUN key whereby the normal batch operation is commenced. After reaching the End of Batch (see section 3.2.3), the Batch Controller will then wait for a pre-programmed period before automatically resetting and starting the batch process once again.

The STOP button can be pressed at any time to interrupt the batching process and continued using the RUN key. If, however, the process is to be aborted, the STOP key is again pressed. The Batch Controller is reset and to restart the auto batching process the RUN key is pressed.

3.2.5 Automatic Overrun Compensation

The Batch Controller can be programmed to automatically compensate for any overrun at the end of a batch.

Typically, this could be due to the slowness of a valve to close or a pump to stop pumping on receiving a signal from the Batch Controller. The result is that the batch quantity will always read higher than the batch quantity set.

The Automatic Overrun Compensation can be enabled or disabled during the Calibration routine and this feature should only be used if the overrun is repeatable. The user is cautioned against using Automatic Overrun Compensation if the overrun is erratic, such as may occur with changing back pressures or sticking valves.

In calculating the amount of overrun to be compensated for, the Batch Controller uses the average overrun on the last three batches.

The overrun is defined as the difference between the batch quantity set by the user and the batch total once the flow has stopped.

With Automatic Overrun Compensation, the **Signal Timeout must be set to a value greater than zero.**

Once the Batch Controller de-energises both relays, the instrument looks for a Signal Timeout, indicating that the maximum interval between pulses has occurred and that the flow must, therefore, have stopped. It then uses the overrun quantity measured during this period and averages this together with the overrun on the last two batches. The resulting value is then subtracted from the next batch.

3.3 SINGLE AND QUADRATURE INPUTS

In most industrial flowmetering applications, a frequency producing flowmeter has only a single output.

However, in many custody transfer applications, it is a requirement that the flowmeter has 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 414L can interface to flowmeters fitted with two sensors and connections to the flowmeters are outlined in Section 7.1.1.

The 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 (energise), the output relays will de-energise and the stop LED will flash, indicating that the batch can be continued by pressing the RUN key or aborted using the STOP key. The display will also periodically flash the error message, ERR 13.

2 Bi-directional Flow.

The 414L 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.

3.4 CALCULATION OF RATE AND TOTAL

3.4.1 Frequency Input

For instruments without temperature compensation, the volumetric flowrate at flow conditions, R , is calculated as follows:

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

where f is the input frequency in Hz.
 H is the timebase of rate and is 1 for seconds, 60 for minutes, 3600 for hours and 86,400 for days.
 S is the Scaling Factor.

The Scaling Factor, S , is equal to the K-factor of the flowmeter expressed in pulses per unit volume.

The flowrate, R , as expressed in the above equation, is the volumetric flowrate at flow conditions. With temperature compensation, the flowrate, R , is corrected to give the flowrate at a base temperature, or the mass flow. Temperature Correction is covered in detail in Section 4.

The user programs the Scaling Factor and selects the timebase during the Calibration procedure as detailed in Section 6 of 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.

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3.4.2 Analog Input

On Model 414LA, where the analog input is selected rather than frequency, the flowrate at flow conditions, R , is calculated as follows:

$$R = A^n \times S$$

where A represents the input signal and is 0 at 4mA and 1 at 20mA.
 S is the Span and is the flowrate at 20mA.
 n is 1 for linear input or $\frac{1}{2}$ for inputs from differential pressure devices.

The user programs S and selects n during the Calibration procedure, as detailed in Section 6 of this manual.

Note that the Model 414L will only handle flow signals from differential pressure type flow devices (ie. when $n = \frac{1}{2}$) for:

1. No temperature compensation.
2. Density Correction for general liquids.
3. A density meter input.

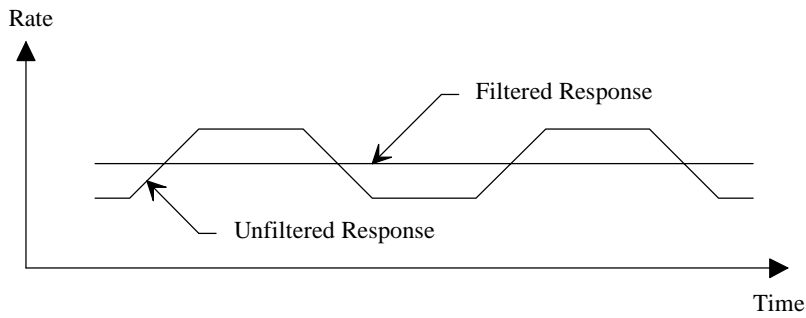
A cutoff can also be programmed for analog inputs which prevents the display of flowrate and integration of the input signal at low flowrates. The cutoff is programmed as a percentage of S .

Note that when the input signal drops below 3.5mA a signal error will occur. The instrument will beep and the display will alternate between the current total and the word "SIGNAL".

3.4.3 Filtering

Frequency fluctuations caused by pulsating flow through a flowmeter, often makes the Rate impossible to read with any precision. The Batch Controller has a digital filter which will average out these fluctuations and enable the Rate to be read to four digit accuracy. The ability to select a suitable filtering level means that highly accurate and stable readings can be obtained without excessive lag.

The diagram below shows a pulsating signal input together with the effect of filtering.



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.

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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 that if A is set to 1 there is no filtering of the input signal.

3.5 TOTAL CONVERSION

The Total Conversion feature enables the rate to be displayed in one engineering unit (eg. gallons/minute) and the totals to be displayed in another engineering unit (eg. 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 in a barrel). All totals, including the Batch Quantity and Batch Total, will now be in barrels.

Some common units are given below together with the Total Conversion constant (TOTCON) which should be programmed.

<u>Rate*</u>	<u>Totals</u>	<u>TOTCON</u>
Gallons (US)/	Barrels (oil)	42.000
Litres/	Kilolitres	1000
ml/	Litres	1000
Mgallons/	Acre-feet	0.32587

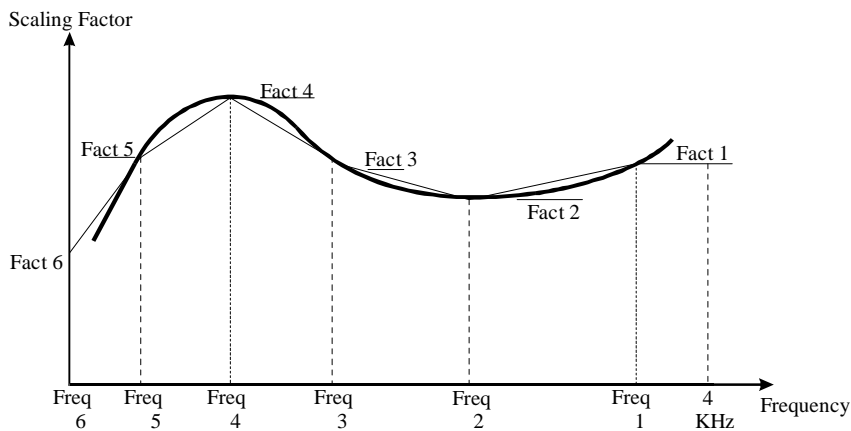
* Units per second, minute, hour or day. The timebase is programmed separately during Calibration.

3.6 NON-LINEARITY CORRECTION

Non-linearity correction enables the instrument to correct for known non-linearities in the flowmeter. This feature is not selectable for analog flow inputs.

Up to 10 frequencies and scaling factors can be programmed. Data on the flowmeter non-linearity can usually be supplied by the flowmeter manufacturer in the form of a Calibration Certificate, and is the result of individual tests on a flowmeter over a range of flowrates. The Certificate will list a number of flowrates or frequencies with the measured K-factor (eg. pulses per gallon or litre) at each flowrate.

The following diagram graphs the change in scaling factor with frequency for a hypothetical flowmeter. The heavy black line represents the actual scaling factor of the flowmeter, while the light black line is the approximation used in the instrument.



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 flowmeter) 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 6 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.

3.7 THE 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 kilograms, a pulse is produced each 0.01 kilograms.

The pulse is a current sinking pulse of approximately 10mSec produced by an open collector transistor. 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 that due to the uneven pulse output spacing on this output, the pulse output cannot be used to drive rate indicators.

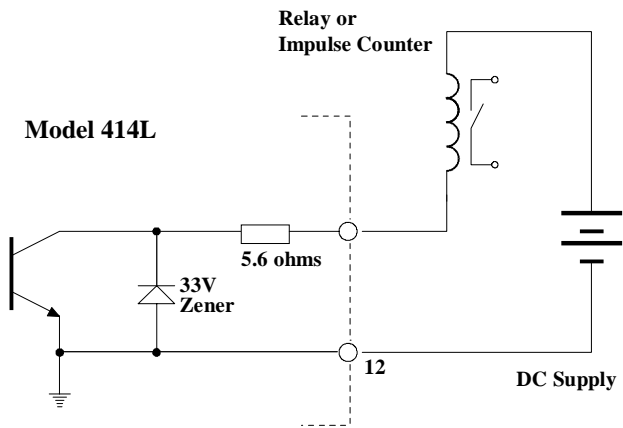
The **FLOW ALARM** uses an identical circuit to the Output Pulse, and is on terminal 7.

The Flow Alarm is used by the Quadrature Input, if selected, and will output an error signal if there is a difference between the input pulses as described in Section 3.3. The Flow Alarm will also output an alarm condition if the flow times out during a batch (ie. there is no flow registered for a time greater than the Signal Timeout period, providing the Signal Timeout is greater than 0).

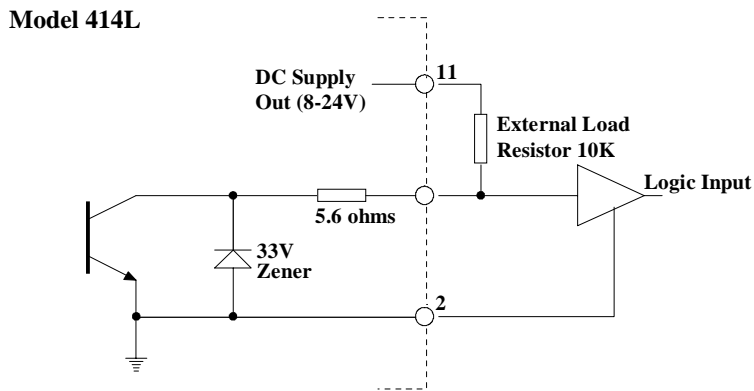
If an analog flow input signal is selected, the Flow Alarm output will activate if the flow signal falls below 3.5mA.

The Flow Alarm output will switch "on" (ie the signal goes low) whenever an alarm condition exists. The Alarm will switch "off" (ie the signal goes high) when the alarm is reset by pressing the STOP key.

Connection of Output Pulse and Flow Alarm are as follows:



Driving an External Relay or Impulse Counter



Driving a Logic Input such as a PLC or Electronic Counter

4. TEMPERATURE COMPENSATION

Temperature compensation gives the instrument the capability to correct for changes in volume of the measured liquid with temperature. There are three methods of compensation which can be selected.

1. Density correction for general liquids with known temperature density characteristics. A five point temperature-density curve can be programmed and the MASS flow calculated
2. Volume correction for general liquids using a thermal coefficient of expansion with temperature. 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 for a wide range of petroleums, to a base temperature of 60°F/15°C.
4. Correction for LPG to US and International standards, to a base temperature of 60°F/15°C.

4.1 TEMPERATURE INPUT (RTD OR 4-20mA)

The Model 414L is available with either a PT100 Platinum RTD input or with a 4-20mA input. The input option must be specified on ordering.

The temperature inputs are continually checked to ensure that they are within the specified limits and an Input Error will be displayed as "Err 12" if the 4-20mA input drops below 3.5mA or if the RTD resistance is outside the valid resistance ranges.

RTD Input

Instruments with RTD inputs are identified by the Model number **414LR**. A four wire temperature measurement is used to give high accuracy and, internally, the software will compensate for the non-linearity of the RTD. Details of the installation are given in Section 7.2.

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

4-20mA

A two wire 4-20mA input from a temperature transmitter or density meter can be input to instruments with the Model number designation **414LA**.

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 both programmable during the Calibration routine.

4.2 VOLUME CORRECTION FOR GENERAL LIQUIDS

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

$$\text{Volume Corrected Flowrate} = \frac{\text{Volumetric Flowrate}}{1 + (T_f - T_b) \cdot a}$$

where T_f is the flow temperature (°C or °F).
 T_b is the base temperature (°C or °F).
 a is the Thermal Coefficient of Expansion per °C or °F.

The Volumetric Flowrate is the flowrate defined in section 3.4.1.

The Thermal Coefficient of Expansion, "a", for a liquid can be determined empirically or can be found in chemical engineering texts. A list of coefficients is given on the following page for a number of petroleum products at 15°C.

Thermal Coefficients of Expansion at 15°C (60°F)

PRODUCTS	DENSITY AT 15°C (kg/litre)	COEFFICIENT OF EXPANSION/°C
LPG - Propane	0.510	0.00290
- Butane	0.580	0.00200
Aviation Gasoline	0.695	0.00120
Petrol	0.740	0.00110
Aviation Jet A-1	0.0795	0.00094
Lighting Kerosene	0.790	0.00094
Power Kerosene	0.810	0.00087
Heating Oil	0.820	0.00087
Automotive Distillate	0.840	0.00084
Industrial Diesel Fuel	0.855	0.00082
Fuel Oil: High Sulphur	0.980	0.00070
Low Sulphur	0.900	0.00075
Bitumen	1.020	0.00063
Crude Oil (Bass Strait)	0.796	0.00087
Benzene	0.880	0.00120
Toluene	0.870	0.00110
Xylene	0.860	0.00100
White Spirit	0.780	0.00095
Mineral Turpentine	0.820	0.00087
Lube Oils		
SAE 10	0.880	0.00077
20	0.890	0.00076
30	0.890	0.00076
40	0.900	0.00074
50	0.900	0.00074
Water	1.000	0.00031

4.3 DENSITY CORRECTION FOR GENERAL LIQUIDS

If density correction for general liquids is selected, a five point temperature density table can be programmed. The instrument uses this table to determine the density of the product after measuring the temperature of the fluid.

For known fluids, the temperature-density characteristics are well documented in standard chemical reference books. One to five correction points can be programmed, and the user inputs the number of points during programming.

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.

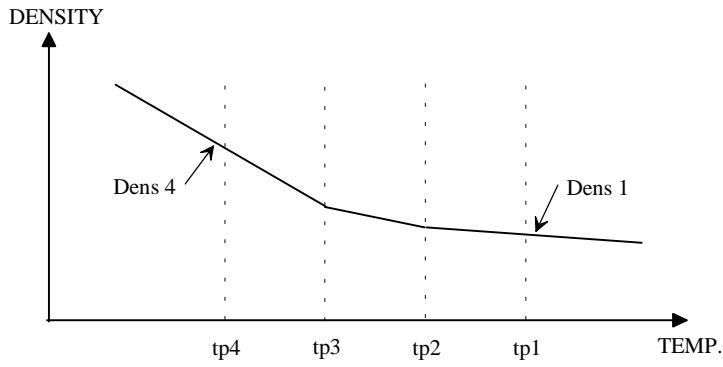
The flow equation for volumetric flowmeters is:

$$\text{Mass Flow} = R \times \text{Density}$$

where R is the flowrate defined in sections 3.4.1 and 3.4.2.

Density is the density determined from the temperature-density table.

When programming the temperature-density table, the density can be programmed in any units, but the units must be consistent with the flowrate R, and the required units for MASS flow. For example, if R is in litres and the mass is required in kilograms, then the density must obviously be programmed as kg/litre.



The above figure shows the temperature-density points for a 4 point table. Above tp4, the curve has the same gradient as between tp3 and tp4, and below tp1, the curve has the same gradient as between tp1 and tp2.

Differential Pressure Devices

For differential pressure devices the Mass flowrate is defined as:

$$Mass\ Flow = S \times A^{1/2} \times Density^{1/2}$$

$$where\ S = \frac{Mass\ Flowrate\ at\ 20mA}{(Density\ at\ reference\ conditions)^{1/2}}$$

The Mass flowrate at 20mA and the corresponding reference density are provided by the flowmeter supplier and S is then calculated from the above equation and programmed during Calibration.

For differential pressure devices, the Gross Total is calculated as:

$$Volume\ Flow = S \times A^{1/2} \times \frac{1}{Density^{1/2}}$$

4.4 COMPENSATION FOR PETROLEUM LIQUIDS

The petroleum correction program uses the American Petroleum Institute equations described in API Standard 2540. For US units, the equations leading to Table 24A, 24B and 24D are used and, for metric units, Table 54A, 54B and 54D equations are used. These Tables are entitled:

Table 24A	Correction of Volume for Generalized Crude Oils to 60°F against Relative Density 60/60°F.
Table 24B	Correction of Volume for Generalized Products to 60°F Against Relative Density 60/60°F
Table 24D	Correction of Volume for Generalized Lubricating Oils to 60°F against Relative Density 60/60°F.
Table 54A	Correction of Volume for Generalized Crude Oils to 15°C against Density at 15°C.
Table 54B	Correction of Volume for Generalized Products to 15°C Against Density at 15°C.
Table 54D	Correction of Volume for Generalized Lubricating Oils to 15°C against Density at 15°C.

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 density is programmed as the Relative Density (SG) and the volume is referenced to 60°F. For Metric units, the density is programmed as the Density in kg/m³ and the volume is referenced to 15°C.

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

Product Group	Relative Density	Density (kg/m³)
Crude Oil	0.751 - 1.000	750 - 1000
Jet Fuels, Kerosene		
+ Solvent	0.751 - 0.850	750 - 850
Gasoline	0.641 - 0.800	640 - 800
Lube Oil	0.851 - 0.960	850 - 960
Diesel, Heating		
+ Fuel Oils	0.801 - 1.100	800 - 1100

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

4.5 COMPENSATION FOR LIQUEFIED PETROLEUM GAS (LPG)

The LPG correction program uses the American Petroleum Institute tables to volume correct the LPG to a reference temperature of 60°F for US units and 15°C for Metric units. The program uses an internally stored table to correct to the following standards:

US units API Table 34 for correction of volume to 60°F against relative density 60/60°F for liquefied petroleum gases.

Metric units API Table 54 for Reduction of Volume to 15°C against density at 15°C for liquefied petroleum gases.

For US units the density is programmed as the Relative Density (SG) and the volume is referenced to 60°F. For Metric units the density is entered as kg/litre 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 to 0.600
Metric units	0.500 to 0.600 kg/litre

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

4.6 DENSITY CORRECTION

Density correction is available on the Model 414LA where a density meter is connected across the temperature inputs (Terminal 5) in place of a temperature transmitter. The densitometer must have a 4-20mA output.

During Calibration, the density at 4mA and 20mA can be programmed and the mass flow for volumetric flowmeters is:

$$\text{Mass Flowrate} = R \times \text{Density}$$

where R is the flowrate defined in Sections 3.3.1 and 3.3.2.

Density is the density input.

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

Differential Pressure Devices

For differential pressure devices the Mass flowrate is defined as:

$$\text{Mass Flow} = S \times A^{1/2} \times \text{Density}^{1/2}$$

$$\text{where } S = \frac{\text{Mass Flowrate at 20mA}}{(\text{Density at reference conditions})^{1/2}}$$

The Mass flowrate at 20mA and the corresponding reference density are provided by the flowmeter supplier and S is then calculated from the above equation and programmed during Calibration.

The Gross Total is calculated as:

$$\text{Volume Flow} = S \times A^{1/2} \times \frac{1}{\text{Density}^{1/2}}$$

5. OPTIONS

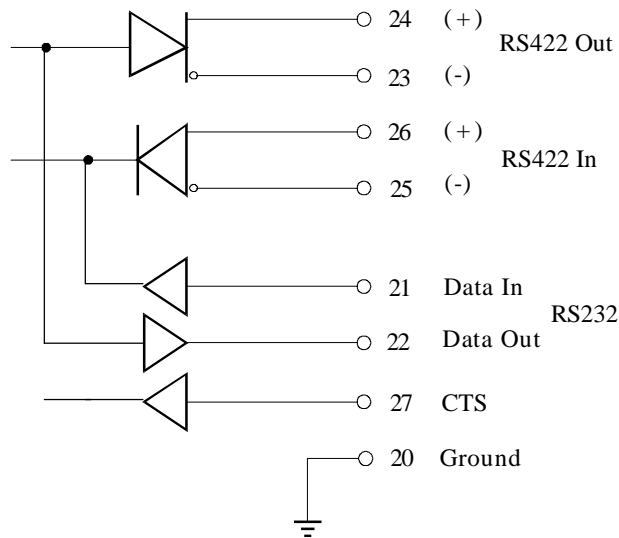
5.1 THE RS232/422/485 INTERFACE OPTION

With this option installed, the circuits for both the RS232 and RS422/485 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.

5.1.1 Hardware

The following diagram provides an overview of the RS232/RS422/RS485 communications hardware. All three 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 a computer over a short distance. The RS422 and RS485 interfaces are used for communication over a long distance or in applications requiring multipoint communication.



5.1.2 Multipoint Communication

Multipoint Communication is a system whereby a number of instruments can be addressed over a dual twisted pair interface. Up to 32 instruments can be connected to a common bus using the RS422 and RS485 interface as shown below.

To convert the RS422 interface to an RS485 interface, the RS422 (-) Data In Terminal must be connected to the RS422 (-) Data Out Terminal and the RS422 (+) Data In Terminal must be connected to the RS422 (+) Data Out Terminal. These connections will convert the RS422 4 wire interface to the RS485 2 wire interface, as shown in figure 2.

Each instrument can be programmed with a unique address which is used by the Master Controller (ie 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.

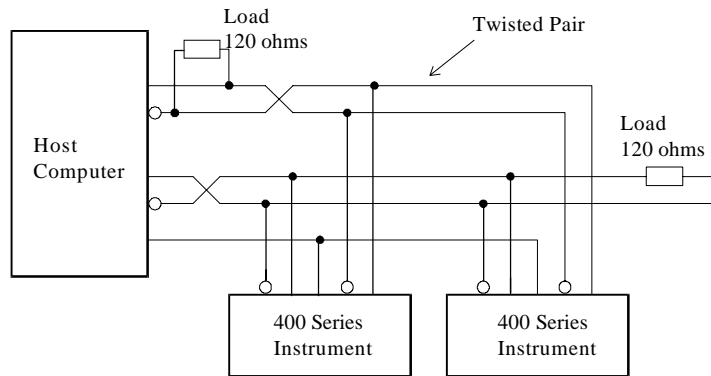


Figure 1 RS422 Interface

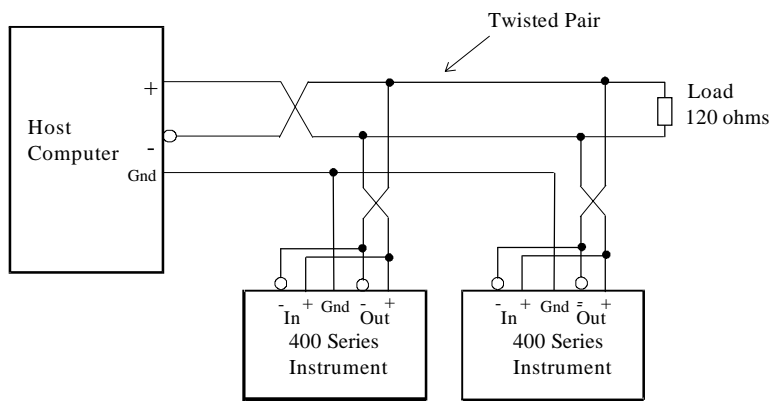


Figure 2 R485 Interface

5.1.3 Communication Protocol

The Model 414L has a real time clock and enables the time and date to be set and printed on tickets. The date format can be European (days/months/years) or USA (months/days/years), while the time is on a 24 hour clock.

Note that 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 baudrate, parity and word 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 414 is communicating.

The software protocols can be selected during Calibration to provide standard interfaces to a number of printers and computers. Since other interfaces will continue to be added, the user should consult the manual "*The RS232/422/485 Communications Option for the 400 Series, Version 2*", for the latest protocols and printer drivers.

Printer

A ticket is printed each time a batch is complete. 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.
- 3 Contrec Model 624.
- 4 EPSON TM290-2 Slip Printer.
- 5 Contrec Model 632-2.
- 6 Syntest SP-210.

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

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A CTS input is provided, and will prevent the instrument from transmitting any further characters to the 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 can be left unconnected.

Computer

The instrument receives and transmits messages in ASCII, with all command strings to the instrument terminated by a carriage return. While replies from the instrument are terminated with a carriage return and a line feed.

Xon/Xoff protocol is also supported, and the instrument will automatically determine if the message sent by the host computer is preceded by an Xoff character. If it does recognise an Xoff as the first character of a command string, the instrument will automatically switch to Xoff/Xon protocol, and begin & end all messages with Xoff and Xon characters respectively. Xoff/Xon protocol is only available when the RS232 interface is selected.

During Calibration, the instrument can be programmed to operate in a full duplex or half duplex transmission mode. In 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.

For more information on the computer interface please consult the manual "*The RS232/422/485 Communications Option for the 400 Series, Version 2*".

6. CALIBRATION

The Calibration routine enables the Setup Parameters to be programmed, as well as enabling the input signals to be checked.

The calibration routine can be entered in two ways:

- 1 By connecting a wire link (or switch) to the rear terminal strip across terminals 1 and 2 or,
- 2 By pressing the STOP key and while still holding, press the DISPLAY key. Both keys must then be held for approximately 6 seconds. This second method of access can be disabled during the calibration so that it is only possible to enter the calibration routine via the link across terminals 1 and 2.

The key switch actions during Calibration are as follows:

- | | |
|------------------|--|
| RUN | will change a flashing digit, to the next digit. |
| DISPLAY | will increment a flashing digit or change a parameter selection. |
| BATCH SET | will reset a flashing digit to zero. |
| STOP | will step through the program sequences. |

Note that the arrows in the RUN and DISPLAY key switches indicate that these switches can be used to change and increment digits respectively.

In stepping through the program sequence, the Parameter Description is always displayed first, followed by actual value or parameter. When a value or parameter can be changed, it is always shown as flashing, and the LED's in the switch panels are lit if that key switch can be used to change a value.

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On first entering the Calibration routine, the display will show:

CAL	Setup Program parameters (see section 6.1).
Batch	Enter Batch parameters (see section 6.2)
Option	Option - if installed (see Section 6.3).
Test	Check Input Signals (see section 6.4)
End	Exit to Normal Operation.

The user can toggle between these modes using the DISPLAY switch and by using the STOP switch, select the appropriate mode.

To exit Calibration, step through the Setup program, Batch program or Test program until the end, and press the STOP switch when **End** is displayed, (ensure the calibration link is not connected).

6.1 PROGRAMMING THE SETUP PARAMETERS

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
1	CAL	Select the Calibrate mode to setup program parameters.	
	BATCH	Select Batch to enter Batch Setup parameters.	6.2
	OPTION	Option (if installed).	6.3
	TEST	Select the test mode to check input signals.	6.4
	END	Exit to normal operation.	
	<i>The following steps are displayed if CAL is selected.</i>		
2	RESTOT	Reset all <u>totals</u> to zero.	
		To reset all totals (net, gross and accumulated) press the BATCH SET key once.	
3	FL INP	Select either a single frequency input or a quadrature input (ie two pulses from a single flowmeter). The analog input on the Model 414LA can also be selected.	3.3
	single	Single Input.	
	quad	Quadrature Input.	
	analog	Analog Input (only for Model 414LA)	
4	CORRCT	Select either a linear input or non-linear correction for the flowmeter input. If an analog input is selected the input relationship is either linear or square root.	3.6
	Linear	Linear Correction, or	
	Nonlin	Non-Linear Correction (only on freq input).	
	Sq rt	Square Root Input (only if analog input).	3.4.2

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<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
-------------	----------------	--------------------	---------------------

5	SCALE		
---	--------------	--	--

If linear correction is selected, the scaling factor is programmed as follows.

Fact Enter the Scaling factor (K-factor) of the flowmeter. The program then steps to step 8. 3.4.1

If non-linearity correction is to be programmed, up to 10 frequencies and scaling factors can be entered.

Freq 1 Freq1 is programmed to the first frequency point in the range of 0 to 9999Hz. 3.6

Fact 1 This is the K-factor of the flowmeter (ie. pulses per gal, etc) at Freq1. 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.

Freq2 Freq2 is programmed to the second frequency point. If any Freq is set to 0, no further correction points can be programmed and the non-linearity correction is limited to that number of points.

Fact 2 Scaling Factor 2.

to

Fact 10 Scaling Factor 10. Note that Freq10 is not displayed since it must always be zero.

Step	Display	Description	Text Ref
		<i>If an <u>Analog input</u> is programmed, the value, S, is entered.</i>	
	Fact	This is the value, S, which must be entered.	
6	CUTOFF x.xx	Displayed only if an analog input is selected. The Cutoff prevents display and integration of the flowrate below x.xx% of the span.	3.4.2
7	F dPt	Number of decimal points with which the <u>Rate</u> is to be displayed between 0 to 0.00000.	
8	t.base	The <u>Timebase</u> with which the Rate is calculated must be entered as:	
	60secs	units/min	
	hours	units/hour	
	days	units/day	
	secs	units/second	
9	FILTER	The <u>filter constant</u> for filtering the rate display.	3.4.3
	1	No filtering.	
	to		
	99	Very heavy filtering.	
10	TOTCON	A <u>division factor</u> to convert the totals to different units from those used for rate (ie gallons/min and barrels).	3.5
	1	Rate and totals have the same engineering units.	
	x.xxx	Other factors can be programmed between 0.01 and 2000.	
11	t.dPt	Number of decimal points with which the <u>Net</u> (resettable) total is displayed between 0 to 0.000.	

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<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
12	A.dPt	Number of decimal points with which the <u>Accumulated</u> (non resettable) total is displayed between 0 to 0.000.	
13	t.c.	The type of <u>Temperature Compensation</u> can be selected as follows:	4
	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 414L Only).	

If "none" (no temperature compensation) 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.	4.6
15	d20	The density at 20mA input is programmed. <i>The program will now go to Step 20.</i>	

All other selections result in the following steps being displayed:

14	t.	Select either <u>US units</u> or <u>metric</u> units as the basis of the temperature compensation	
	•F	US units.	
	•C	Metric units.	

If the instrument has a direct RTD input (Model 405LR) the temperature can be adjusted (offset) to correct for the RTD tolerance.

15	ADJ t	Adjust the temperature displayed during <i>test</i> .	4.1
	xx.xx	Input the offset. (The first digit is 0 for positive or - for negative.)	

Step	Display	Description	Text Ref
		<i>If the instrument has a 4-20mA temperature input (Model 405LA), then the 4mA and 20mA points are entered.</i>	
15	IP4	Enter the temperature that corresponds to 4mA in either °F or °C depending on the units selected in Step 15.	4.1
16	IP20	Enter the temperature that corresponds to 20mA.	

Program steps 17 to 19 depend on which option for temperature compensations was selected in Step 13 and are individually described.

Volume Correction for General Liquids

17	REF °F (°C)	Program the base temperature for the compensation. Enter the temperature in °F or °C depending on the units selected in Step 15.	4.2
18	COEF A	Enter the thermal coefficient of change "a" as a%. Hence if the coefficient of expansion is 0.0029/°C enter the % change as 0.29000.	

The program will now go to Step 20.

Density Correction for General Liquids

17	NotP x	Number of temperature-density correction points up to five. If x is set to 1, a fixed density can be programmed (ie. the density is not dependant on the temperature).	4.3
18	tp1	Temperature point 1.	
19	dens1	Density 1.	

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<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
Petroleums			
17		Select the <i>petroleum type</i> .	4.4
	CRUDE	Crude oils as per tables 24A & 54A.	
	LUBE	Lube oils as per tables 24D & 54D.	
	OILS	Fuel oils & heating oils, and diesel (tables 24B & 54B).	
	JET	Jet fuels, kerosenes and solvents (tables 24B & 54B).	
	GAS	Gasolines and naphthenes (tables 24B & 54B).	
18	dn 60°F <i>or</i> (dn 15°C)	If US units are selected this is the Relative Density (SG). If Metric units are selected, the Density at 15°C in kg/m ³ is programmed.	

The program will now go to Step 20.

Liquid Petroleum Gas

17	dn 60°F	If US units are selected, the Relative Density (SG) is programmed. If Metric units are selected, the Density in kg/litre is programmed.	4.5
20	ACCESS	Enable access to calibration routine via the front keyboard only.	
	Front	Enable access via front keyboard.	
	No Acc	Disable access via front keyboard.	

6.2 ENTERING THE BATCH PARAMETERS

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
1	BATCH	Enter Batch Parameters.	
	OPTION	Option (if installed)	6.3
	TEST	Check Input Signals.	6.4
	END	Exit to normal operation.	
	CAL	Program Setup Parameters.	6.1
<i>The following steps are displayed if BATCH is selected.</i>			
2	TOTAL	Batch on Gross total; or on Net Total or Mass.	3.2
	Net	Net or Mass.	
	Gross	Gross.	
3	BATCH L	Maximum Batch Size which can be entered.	3.2
	xxxxxx	Set to 0 if no limit on batch size.	
4	AUTO S	Automatic <u>restart</u> feature.	
	Off	Disable.	
	On	Enable.	
	xx:xx	If enabled, automatically restarts the batch xx:xx (mins:sec) after the end of the last batch.	3.2.4
5	START. T	<u>Slow start</u> time.	
	xx:xx	Time, in (minutes:seconds), when Relay 2 will energise once the batch has started.	3.2

56 Calibration

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
6	PREST xxxx	<u>Prestop Quantity.</u> Quantity at which Relay 2 will de-energise before the end of the batch. (Eg. If the batch quantity is 100 litres and Prest is 2 litres, relay 2 will de-energise after 98 litres.)	3.2
7	COUNT dn up	The <u>Batch Total</u> counts Up or Down. Count down from the batch quantity. Count up from zero.	3.2
8	T OUT	The <u>Signal Timeout</u> in seconds. (Setting to 00 disables this feature.)	3.2.2
9	AOC En Dis	<u>Automatic Overrun Compensation.</u> Note that the Signal Timeout must be greater than 0 (ie enabled) for this feature to work. Enable. Disable.	3.2.5
10	AUTO R Off On	<u>Auto Reset</u> (not displayed if Auto Restart is programmed - Step 3 above). Batch Total must be manually reset before starting the next batch. The Batch can be automatically reset and started by pressing only the RUN key.	3.2

6.3 PROGRAMMING OPTIONS

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
1	OPTIONS	Options (if installed).	
	<i>Test</i>	Check the Input Signals.	6.4
	<i>End</i>	Exit to normal operation.	
	<i>CAL</i>	Program Setup Parameters.	6.1
	<i>Batch</i>	Set Batch Parameters.	6.2
<i>If the RS232/422/485 option is installed, the following will be displayed:</i>			
2	DF	Date Format.	5
	Eur	European (ie. days/months/years).	
	USA	USA (ie. months/days/years).	
3	Date	Enter date as:	5
	xx:xx:xx	Years:Months:Days.	
4	HOUR	Enter time as a 24 hour clock.	
	xx:xx	Hours:Minutes.	
5	BAUD	Baudrate	
	xxx	300, 600, 1200, 2400, 4800 and 9600.	
6	DATA	Word length.	
	7	7 bits.	
	8	8 bits.	
7	PARITY	Parity.	
	NP	No Parity.	
	OP	Odd Parity.	
	EP	Even Parity.	

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<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
8	SIGNAL rs232 rs422	Signal Type. RS232. RS422/RS485.	
9	ID NO 0 1 - 99	Unit Identification Number. None. Id number.	
10	P TYPE xx 00 01 02 03 04 05 20	Printer/Computer Type. Standard Computer Printer. EPSON CTM 290 Slip Printer. Contrec Model 624 Printer. EPSON TM290-2 Slip Printer. Contrec Model 632-2 Printer. Syntest SP 210 Printer. Computer.	

If a Printer Protocol is selected, the following message is displayed:

10	UNIT xx	Units of measurement printed.
	00	None.
	01	Litres (Ltrs).
	02	Gallons (Gals).
	03	Barrels (bbls).
	04	Pounds (lbs).
	05	Grams (gms).
	06	Kilograms (kgs).
	07	Tons (ton).

If a Computer Protocol is selected, the following message is displayed:

10	ECHO On Off	ECHO Command. Echo (Full Duplex). No Echo (Half Duplex).
----	--	--

6.4 CHECKING THE INPUT SIGNAL

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
1	TEST	Check the Input Signals.	
	OPTIONS	Options (if installed).	6.3
	CAL	Program Setup Parameters.	6.1
	BATCH	Set Batch Parameters.	6.2
	END	Exit to normal operation.	

The following steps are displayed if **TEST** is selected.

- 2 **Sr x.xx** Software revision number.
- 3 *If the instrument is a Model 414LA and temperature or density correction is selected, the display will show:*

**T4-20 or
D4-20
xx.xx** Displayed for 1 second to indicate input from the 4-20mA temperature input. The input current is then displayed.

If the instrument is a Model 414LR and temperature correction is selected, the display will show:

**RTD
xxx.xx** Displayed for 1 second to indicate the RTD. The measured temperature is then displayed.

- 4 *Use the DISPLAY switch to step to the Flow Input.
If the Flow Input is a Single frequency input, the display will show:*

**Freq
xxxx.x** Displayed for 1 second followed by the actual frequency. Frequency in Hz.

60 Calibration

<i>Step</i>	<i>Display</i>	<i>Description</i>	<i>Text Ref</i>
		<i>If the Flow Input is a Quadrature frequency input, the display will show:</i>	
	qfreq	Displayed for 1 second followed by the actual frequency.	
	xxxx.x	Frequency in Hz. If the flow is reversing a negative sign will appear.	
		<i>If the Flow Input is an analog signal the display will show:</i>	
	F4-20	Displayed for 1 second followed by the actual current.	
	xx.xx	mA.	
		<i>If the RS232/422/485 option is installed, the display will then show:</i>	
5	CLOC	Clock.	
	xx:xx:xx	Time in Hours:Mins:Sec.	

7. INPUT CIRCUITS

7.1 FLOW INPUTS

7.1.1 Frequency Inputs

The Model 414L has two pulse input circuits:

- ◆ Channel 1 is used with both single and quadrature input signals. The Channel can interface directly to
 - Turbine Flowmeters
 - Open Collector Outputs
 - Reed Switches
 - Logic Signals
 - Namur Sensors

- ◆ Channel 2 is used only when a quadrature input is selected, and becomes the 0° input while Channel 1 becomes the 90° input. Channel 2 can interface directly to
 - an Open Collector
 - a Reed Switch
 - a Logic Signal
 - a Namur Sensor

The frequency input circuits for the Model 414L can be configured by the user to interface with most flowmeters. A small 8 pole DIL switch on the rear of the instrument is used to set up the input circuit to operate with different types of signals.

The input circuit is shown on page 64 and examples of flowmeter interconnections are given on pages 65 and 66.

62 Input Circuits

Switch Settings

The following are recommended switch settings for different input signal types.

Note, input types d and e are only available on Channel 1. Channel 2 is limited to signal types a to c.

Input Signal Type	Input Terminals				Switch Settings							
	CH1		CH2									
	+	-	+	-	1	2	3	4	5	6	7	8
a. Logic Signal, CMOS, Pulse	9	8	3	8	off	off	off	off	on	off	off	off
b. Open Collector or Reed switch	9	8	3	8	off	off	off	off	on	off	on	off
c. Namur Proximity (set DC out to 8 volts)	11	9	11	3	on	off	on	on	on	on	off	off
<i>Channel 1 Only</i>												
d. Switch or Reed Switch with debounce circuit (200Hz max)	9	8			off	off	off	off	on	off	on	on
e. Coil (20mV P-P minimum)	9	8			off	on	off	off	off	off	off	off

General Specification

Switching Threshold: 2.5 Volts (except for input type c and e)

Maximum Input Voltage: 50V peak

Input Impedance

Input type a: 100K on channel 1
10K on channel 2

Input types b & d: 10K

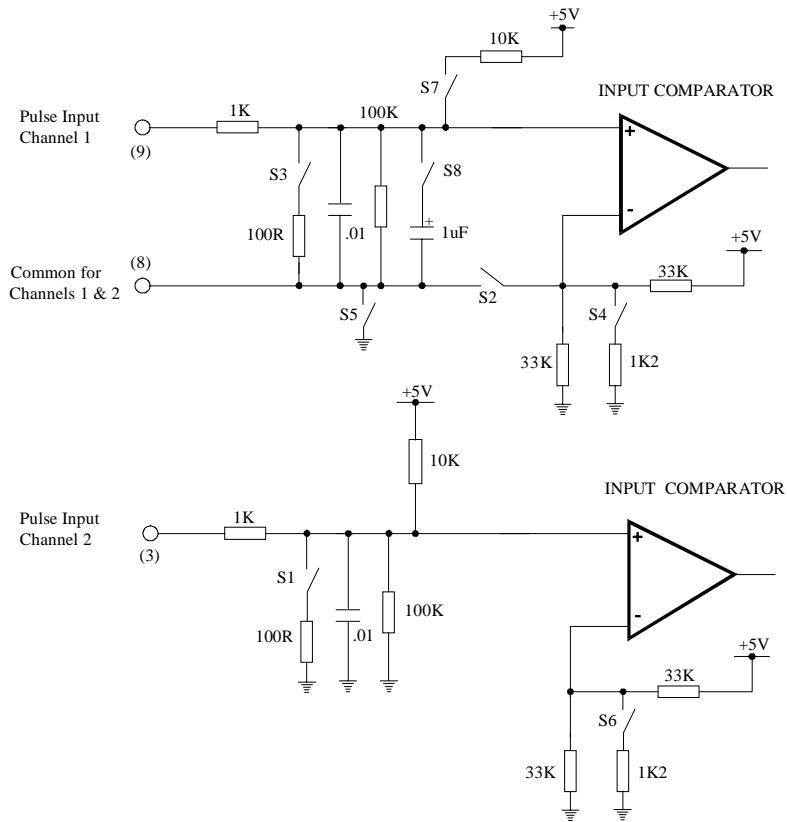
Input type c: 1K

Input type e: 100K

Powering of Sensors

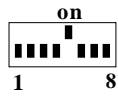
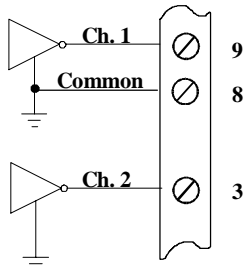
The Model 414L has a regulated DC output which can be used to power sensors. A trimpot on the rear of the instrument allows the voltage to be adjusted in the range of 8-24 Volts and the output can supply a maximum of 50mA.

Note that when using this DC output to power opto-sensors, some flowmeter manufacturers require that a current limiting resistor be used. Please refer to the flowmeter manufacturers data sheet if this is the case.



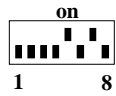
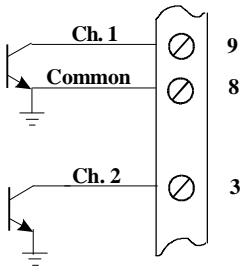
The Frequency Input Circuits

1. Squarewave, CMOS or Pulse



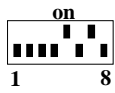
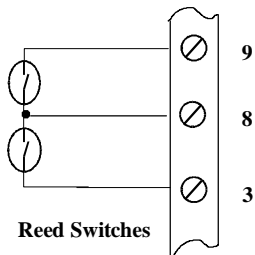
eg. vortex, pre-amplifiers or magnetic flowmeters

2. Open-Collector



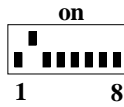
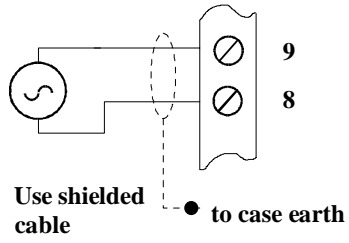
eg. preamplifiers and opto-sensors

3. Reed Switch



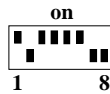
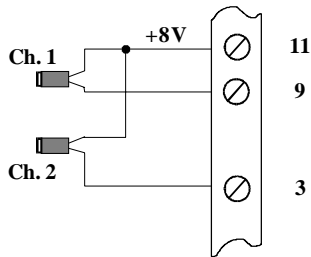
eg. positive displacement flowmeters with reed switch outputs.

4. Coils



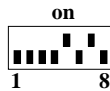
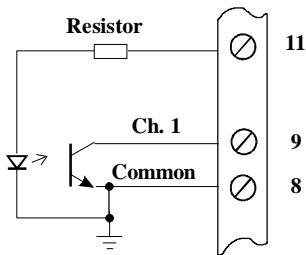
eg. millivolt signal from a turbine flowmeter (single input only)

5. Namur Proximity Switch



eg. positive displacement flowmeters with 2 wire proximity switch outputs

6. Opto-Sensors



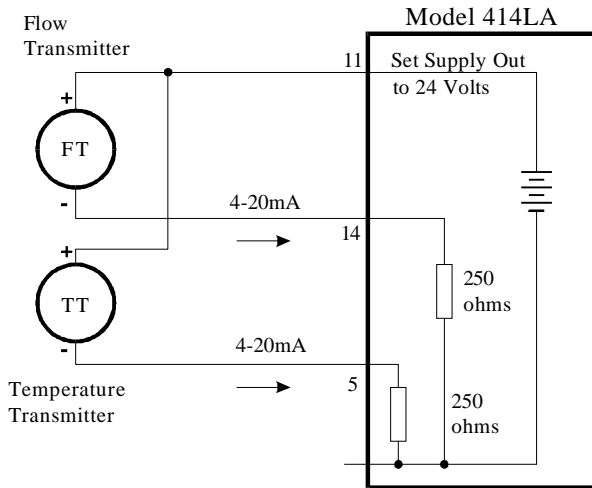
eg. pre-amplifiers and opto-sensors.

Note that the current limiting resistor may be required. See the flowmeter manufacturer's data.

7.1.2 Analog Flow Input

On instruments with the Model number, 414LA, there is provision to accept an analog (4-20mA) input from a flowmeter. When the analog input is selected, the pulse inputs cannot be used.

The flowmeter and temperature (or density) sensors are connected as follows:



Shielding: When shielding the input signals, the shield should be connected to the case earth and not connected at the transmitter end (ie ground at the instrument end only).

7.2 TEMPERATURE OR DENSITY INPUT

The Batch Controller can be supplied with either of two temperature inputs:

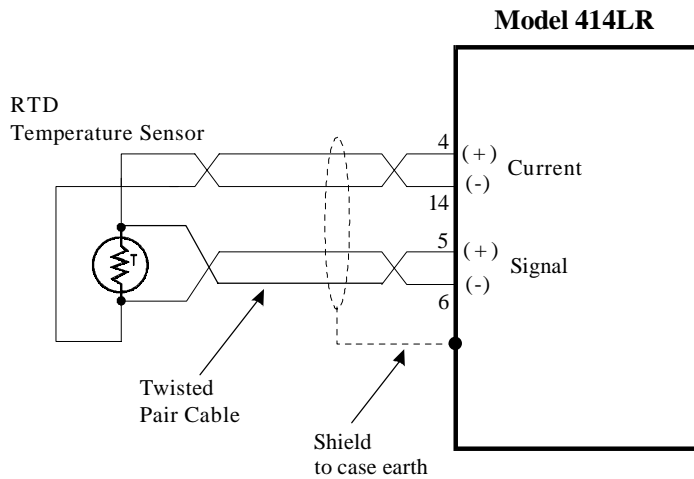
- * Direct 4 wire Platinum RTD (PT100) Model 414LR
- * 4-20mA Input for temperature or density Model 414LA

RTD

Four wire RTD measurement is the most accurate form of measurement and can be used for measurements with the RTD up to 100 meters from the instrument. It is recommended to use shielded cable when interfacing to RTD's.

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

With the direct RTD measurement the program automatically corrects for the non-linearity in the RTD.



When wiring the RTD, care must be taken to ensure the (+) of the Current on terminal 4 is connected to the same side of the RTD as the (+) of the signal on terminal 5. The RTD has no polarity and can be connected in either direction.

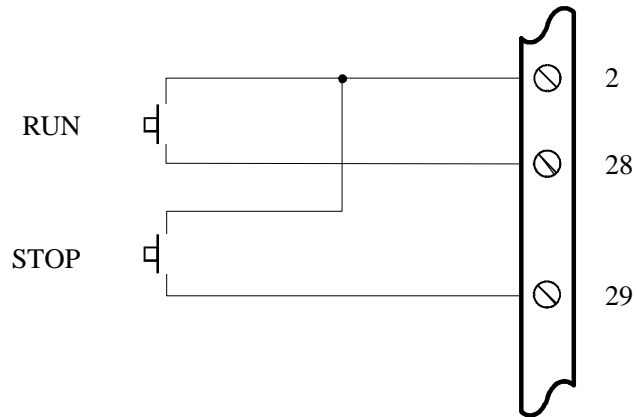
4-20mA

With a 4-20mA input, the program enables the 4mA point and the 20mA point to be programmed. Unlike the direct RTD measurement, no correction is made for the non-linearity of the temperature or density sensor.

7.3 REMOTE RUN AND STOP SWITCHES

Remote push-buttons can be connected to the Model 414L to start and stop batches. The switch functions are identical to the RUN and STOP switches on the front of the instrument.

The switches are wired as follows:



8. INSTALLATION

8.1 GENERAL

Terminal designations for the Model 414L Batch Controller are given on the following pages. The cutout hole in the panel should be 5.5" (139mm) wide x 2.6" (67mm) high. Two side clips are supplied to secure the instrument into panel.

A case earthing point is provided via an earth lug on the side of the case. Note that this earthing point is for the case only and there is complete electrical isolation between this point and all electronic circuits. For EMC purposes, or when the instrument is connected to mains, this point must be connected to a good earth using a multi-stranded, braided wire or strap. All relay outputs are totally isolated from the case and from the internal circuitry.

The two output relays are changeover relays and both the "normally open" and the "normally closed" terminals are available on the rear terminal strips. All relay outputs are totally 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 the mains. The mains voltage is factory set to either 95 - 135 VAC (110 VAC nominal) or 190 - 260 VAC (220 VAC nominal). An internal mains transformer provides full isolation between the mains and the electronic circuits.

The DC Ground terminal 12 provides a common ground for the 12 - 28 Volt power input, the 8 - 24 Volt output, the pulse output and End of Batch output.

It is good practice to use shielded cable for all signal connections to the Model 414. Care must be taken to separate signal cables from power cables so as to minimise interference.

Overall shields should be connected to the case earth at the instrument end only. This connection should be as short as possible and connected to the earthing lug on the side of the case.

In order to comply with the requirements for Electromagnetic Compatibility as per EMC-Directive 89/336/EEC of the Council of European Community, this wiring practice is mandatory.

Although it is also possible to connect shields to the signal ground (terminal 2) this is not in accordance with EMC directives.

RC Networks for Interference Suppression

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

- ◆ To limit the amount of electrical noise caused by arcing across the contacts which may, in extreme cases, cause the microprocessor to act erratically.
- ◆ 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 dependent entirely on the load. However, if the user is unsure of the type of snubber to use, values of 0.25uF and 100ohms will usually suffice. Note that only mains approved RC suppression networks should be used.

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

8.2 WIRING DESIGNATIONS FOR THE MODEL 414L

<i>Terminal</i>	<i>Model 414LR</i>	<i>Model 414LA</i>
1	Calibration Link	Calibration Link
2	Signal Ground	Signal Ground
3	Flow Pulse Input (Channel 2)	Flow Pulse Input (Channel 2)
4	PT100 I (+)	Not To Be Used
5	PT100 Signal (+)	Temperature Input (4-20mA)
6	PT100 Signal (-)	Not To Be Used
7	Flow Alarm	Flow Alarm
8	Flow Common (-)	Flow Common (-)
9	Flow Pulse Input (Channel 1)	Flow Pulse Input (Channel 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	PT100 I (-)	Flow Input (4-20mA)

<i>Terminal</i>	<i>RS232/422 /485 Option</i>
20	RS232 Signal Ground
21	RS232 Data In
22	RS232 Data Out
23	RS422/485 (-) Data Out
24	RS422/485 (+) Data Out
25	RS422/485 (-) Data In
26	RS422/485 (+) Data In
27	RS232 CTS

<i>Terminal</i>	<i>Relay Output Switches</i>
28	Remote RUN Switch
29	Remote STOP Switch
30	End of Batch
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

9. TROUBLE SHOOTING

Batcher does not reset.

The Signal Timeout has been set to an excessively long period and has not timed out at the end of the last batch.

Batch will not start or relay 1 will not close.

Ensure that the instrument has not timed out as controlled by the Signal Timeout and that a Flow Alarm condition does not prevail. Pressing the Stop switch will cancel this condition. Check for a fault on the flow input before restarting.

Batcher stops midway through a batch.

This could be due to the Signal Timeout having timed out. Check for a fault in the system. Ensure that the Signal Timeout period is significantly longer than the period between pulses from the flowmeter at the minimum flowrate.

No display.

Check power to the instrument.

All 88888888 displayed.

The Batcher will display all eights on power up for 4 seconds as a display test. If it continues to display all eights after this period, this is symptomatic of the power supply voltage being low. Check the power input voltage.

Not counting.

If the Batcher does not count with the flowmeter connected and flow passing through it, first check the connections and then ensure the DIP switches on the rear of the instrument are set as per section 7.

It is possible to manually test the input circuit of the Batcher by setting the input configuration for a Reed Switch (see Section 7) and pulsing across the signal (+) and (-) with a wire link. When doing this, the scaling factor should be set to 1 and the resolution to whole numbers.

Counting erratically

This can be caused by two factors:

- setting the input circuit incorrectly
- lack of shielding on the input.

Shield the input signal with the shield earthed at the Batch Controller only.

Instrument acting erratically

Erratic operation can be the result of severe electrical interference. Considerable attention has been given to designing the Batch Controller to withstand electrical interference.

However, in extreme cases, loads may be encountered which are exceptionally inductive and may require additional protection. One measure is to use an RC Suppression Network as described in Section 8.

Another remedy for this problem is to use an isolating relay to switch the load, and use the Batcher to drive the isolating relay. The isolating relay should be mounted away from the Batcher and from signal wiring.

76 Trouble Shooting

No end of batch, pulse output or flow alarm.

This fault is usually caused by lack of a pullup resistor or load on the output. The outputs themselves have no internal pullups and rely on an external load.

9.1 ERROR CODES

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 are given below:

Error Codes

Input Errors

- 11 Invalid input configuration programmed.
- 12 The Temperature or Density Input is out of range.
- 13 Flow error due to a Quadrature error (see Section 3.3) or Signal Timeout (see Section 3.2.2).
- 14 Communications Input error (RS232/422/485 Interface).
- SIGNAL Analog flow input signal is below 3.5mA (414LA only). (See Section 3.4.2.)

Output Errors

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

Calibration Errors

- 30 Zero Value not Allowed.
- 31 Outside Allowable Temperature Range.
- 32 Outside Allowable Density Range.
- 33 Invalid Printer Type.
- 34 Invalid Volume Units selected.

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