A Higher Level of Performance

User Manual

Sultan Flow

Open Channel Flow Measurement

AWFR Series

For more information, please visit >

www.hawkmeasure.com

Contents

Principle of Operation

The Sultan Flow measurement system operates by transmitting an ultrasonic signal from its transducer towards the liquid being monitored. The reflected signal or echo is received by the transducer and processed. The time between transmission of the ultrasonic signal and reception of the echo is measured, and using the speed of sound through air, the distance from the transducer to the liquid level is calculated. Flow through the channel or structure is then calculated from the level measurement and the user entered properties of the channel.

The Sultan Flow system uses sophisticated software to locate and track the correct echo without being affected by echoes from fixed objects or changes in the liquid surface. When the liquid level or surface conditions change, the system follows preselected signal tracking parameters. In the event of a total loss of signal, the system adopts signal recovery routines to relocate the correct liquid level.

The system employs automatic gain control to compensate for changes in echo amplitude due to variations in environmental conditions. Continuous current, voltage and relay outputs are provided. These outputs can be programmed for failsafe conditions in the event of a loss of signal or system malfunction.

Certifications

- ATEX, CSA, IEC (Remote Transducer)
- Conforms to British standards for Flow calculations

Primary Areas of Application

- Open Channel Flow
- Water treatment
- Sewage treatment
- Irrigation
- Industrial waste water
- Power waste water
- Environmental monitoring
- Special flow requirements for unusual flow channels

Features

- Capable of monitoring liquid flow under the most difficult conditions
- Suits a broad range of flumes, weirs and flow control structures
- Real time diagnostic display
- Flexible, multi point or calculated scaling of display and outputs
- Programmable totalizer
- Programmable pulse per flow output
- Programmable failsafe mode
- Fast acting temperature compensation
- 3G remote setup options and configuration
- 4-20mA, HART, Modbus, Goshawk with 32 point flow table (via PC).

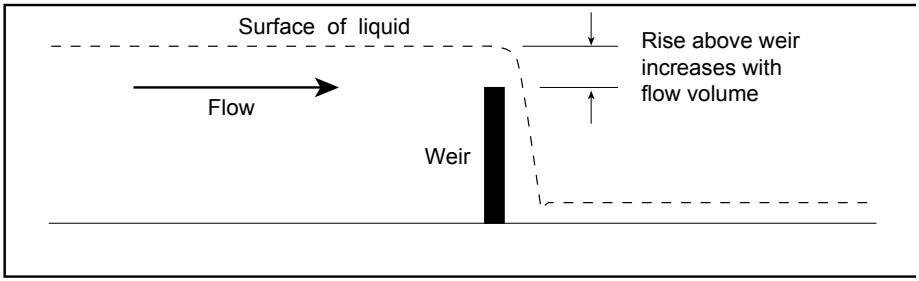
Open Channel Flow Measurement Principles

Obstructions in channel cause rise in level

An obstruction in a channel represents a reduction of the cross-section of the channel. Since practical liquids are essentially incompressible, the volume of liquid flowing past an obstruction must equal the volume flowing towards it. It follows that the liquid must divert around the obstruction

If a barrier to flow is installed across the bottom of a channel, the liquid level rises as it flows over it - this leads to the use of the weir in open-channel flow measurement. If the cross-sectional area of a channel is reduced, the liquid level must rise as it flows past - this leads to the flume.

Figure 1.



The height of the liquid surface above the Weir is called the Flow Head (h). The head is known to be related to the Volume Flowrate(q), allowing the flowrate to be calculated from measurement of the head. The formula is of me form:

$$q = kh^{\alpha}$$

Where the exponent α is typically about 1.5 and the constant k depends upon the channel and weir dimensions.
Different shapes of weir have been developed to provide improved accuracy under different conditions, but the principle is the same for all. These various weirs have different exponents, but most within the range of 1.3 to 1.7.

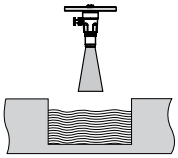
Flumes, in which the channel width is narrowed have become preferred for accuracy and robustness (eg. self scrubbing). Many flume profiles have been developed, each having its advantages and disadvantages for a given application.

A similar exponential relationship exists between head and flowrate in these flumes,and each type has a different exponent,commonly in the range of 1.3 to 1.8.

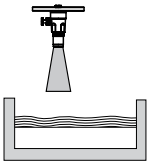
Software Supported Weir / Flume Applications

The Sultan Flow supports programmable Weir / Flume types where you can input the dimensions of the flume, weir, constriction / throat and the Flow unit will automatically calculate the flow rate based on the inputted dimensions. These include Rectangular Flumes, Rectangular Weirs and V-Notch Weirs.

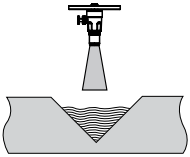
Rectangular Flume



Rectangular Weir



V-Notch Weir



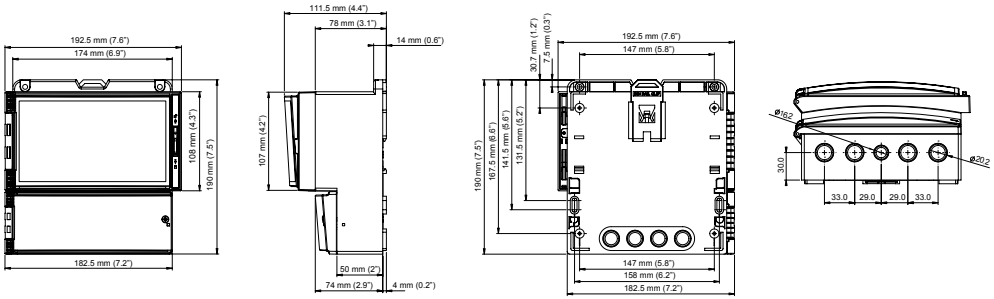
Software Supported Exponential Applications

Some Flow applications only require an Exponential value to be programmed. You need to select the Exponent Flow Type parameter. Typical Exponential Flow designs include Suppressed Rectangular Weir, Cipolletti (Trapezoidal) Weir, Venturi Flume, Parshall Flume, Leopold Lagco Flume, plus other types of exponential device.

Typical Exponential values are shown below.

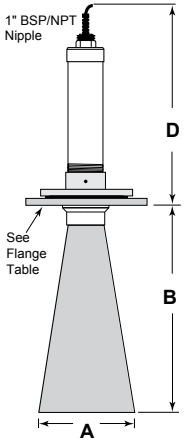
Application Type	Typical Exponent
Suppressed Rectangular Weir	1.50
Cipolletti (Trapezoidal) Weir	1.50
Venturi Flume	1.50
Parshall Flume	1.50-1.60
Leopold Lagco Flume	1.55

Remote Transmitter

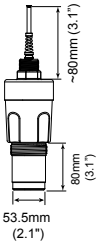


Remote Transducers

3" / 3.5" Type



2" Type

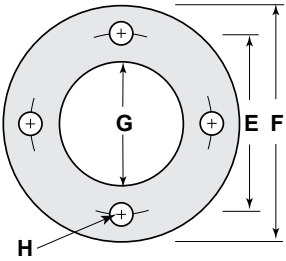


Cone / Transducer Dimensions Table								
Sensor Frequency	**Selected Flange**	**A**		**B**		**C**		**D**	
		mm	**in.**	**mm**	**in.**	**mm**	**in.**	**mm**	**in.**
5 kHz	10"	236	10.0	455	17.9	840	33.1	750	29.5
10 kHz	10"	236	10.0	455	17.9	540	21.3	450	17.7
	8"	195	8.0	280	11.1	540	21.3	450	17.7
15 kHz	10"	236	10.0	455	17.9	440	17.3	350	13.8
	8"	195	8.0	280	11.0	440	17.3	350	13.8
20 / 30(T6)[1] kHz	4"	98.5	4.0	280	11.0	390	15.4	300	11.8
30(T4)[1] / 40 / 50 kHz	4"	98.5	4.0	280	11.0	350	3.8	260	10.2

There are 2 versions of 30kHz transducers.
AWRT30T6 is a 3" type. AWRT30T4 is a 2" type.

Flanges

Standard ANSI/DN/JIS Flange Dimensions										
Size	Flange Type	E (PCD)		F (OD)		G (ID)		H (Hole)		No. Holes
		mm	in.	mm	in.	mm	in.	mm	in.	
4”	FA4 ANSI class 150	190.5	7.5	229	9.0	100	4	19	0.75	8
	FD4 DIN100 PN10/16	180	7.1	220	8.7	100	4	18	0.71	8
	FJ4 JIS B2220-1984 10kg	175	6.9	210	8.4	100	4	19	0.75	8
6”	FA6 ANSI class 150	241.5	9.5	279	11.0	150	6	22	0.87	8
	FD6 DIN150 PN10	240	9.4	285	11.2	150	6	23	0.91	8
	FJ6 JIS B2220-1984 10kg	240	9.4	280	11.0	150	6	23	0.91	8
8”	FA8 ANSI class 150	298.5	11.8	343	13.5	200	8	22	0.85	8
	FD8 DIN200 PN10	295	11.6	340	13.4	200	8	22	0.85	8
	FJ8 JIS B2220-1984 10kg	290	11.4	330	13.0	200	8	19	0.91	12
10”	FA10 ANSI class 150	362	14.3	406	16.0	250	10	25	1.02	12
	FD10 DIN200 PN10	350	13.7	395	16.0	250	10	23	0.85	12
	FJ10 JIS B2220-1984 10kg	355	14.0	400	15.7	250	10	25	0.99	12



FLANGE TYPE:
A = ANSI Flange
J = JIS Flange
D = DIN Flange

Wiring Terminal Compartment

The Sultan Remote Transmitter has wiring information printed inside the flip lid of the unit.

Ensure your power source is deactivated.

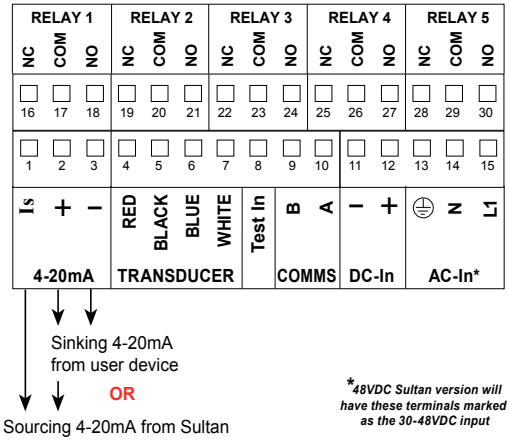
Unscrew the lower flip lid to access the wiring terminals.

Pass cables through the cable entry gland before wiring into the terminal block.

To connect a wire, remove the required terminal block with thin nose pliers. Place the wire in firmly screw down the connection. The transducer terminals are labeled by colour on the PCB.

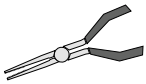
If you are connecting HawkLink communications, connect the blue wire to B and the white wire to A. The black wire can be connected to the DC- or GND terminal next to A.

Tighten cable entry gland(s) and cover to ensure sealing is effective.



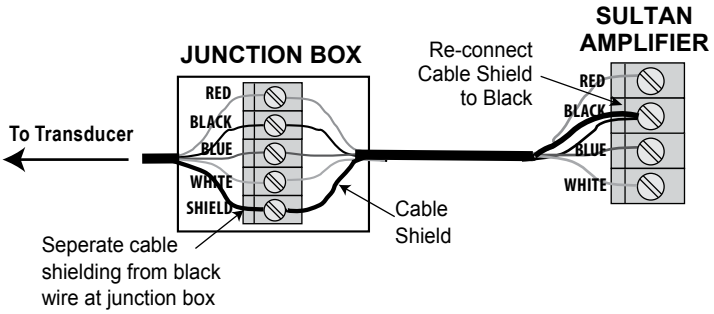
*48VDC Sultan version will have these terminals marked as the 30-48VDC input

Inputs / Outputs may vary. Consult Part Numbering



Use long nose pliers to extract terminals

Transducer Cable Extension

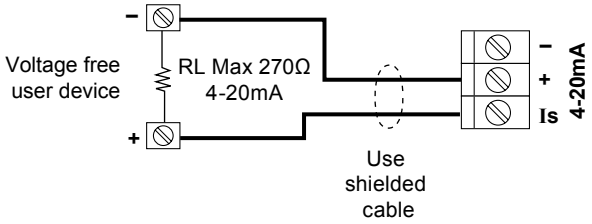


Wiring 4-20mA Output

When connecting the 4-20mA output to a user device such as a PLC input, DCS or indicator, use a voltmeter to check the field wires to be used for the 4-20mA signal. If DC voltage around 24V is present, use sinking connection. If no voltage is present, use sourcing connection.

SOURCING Type Output

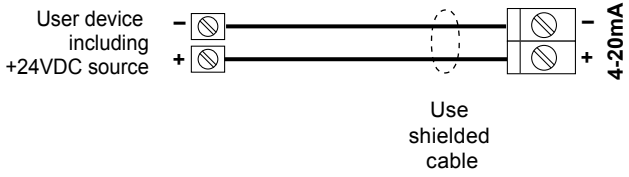
Sultan output is sourcing current and provides voltage to drive a passive load, PLC input, indicator or other user device.



NOTE:
Isolated current output can be made common with +DC or GND if required. (e.g. RL – connected to GND)

SINKING Type Output (also 2 wire loop powered)

Sultan output is sinking current. Voltage to drive current loop must be provided by PLC, indicator, other user device or external DC supply.



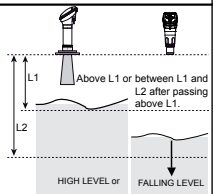
NOTE:
RL Max = 750Ω if user DC Supply 24V.

Relay Actions

Sub-Menu	Description	Options
RlyL1 1-5	Adjust Relay switch point (L1 must be < L2)	Adjustable
RlyL2 1-5	Adjust Relay switch point (L2 must be > L1)	Adjustable

- Set Relay Parameters in Output Adjustment menu
- The two relay levels are RlyL1 and RlyL2
- The display will show RlyL1 1, the last 1 indicated the Relay number (eg 1 to 5)
- L1 and L2 distances are measured from the transducer face

	Relay Action				
	Energise EN	DeEnergise DEN	FailSafe FS system operating normally	FailSafe FS power/system/ measurement failure	OFF
State 1	NC COM NO ○	NC COM NO ☼	NC COM NO ☼	NC COM NO ○	NC COM NO ○
State 2	NC COM NO ☼	NC COM NO ○	NC COM NO ☼	NC COM NO ○	NC COM NO ○
POWER FAILURE	NC COM NO ○	NC COM NO ○	NC COM NO ○	NC COM NO ○	NC COM NO ○



Relay Status
Remote Amplifier terminal function labels
LED Status

Cone / Flange Assembly

1

Remove red cap (including cardboard).

2

Screw the flange assembly fully down onto the cone (as far down as it will go until the parts are tightly fastened).

Note! Direction of flange, smallest ring this way up ↑

3

Screw the transducer tightly down onto the flange and cone assembly.

4

Tighten the locking ring down to the flange to fix the components in place .

COMPLETE ASSEMBLY

(Appearance above flange may differ for integral and smart units).

User mountings should only connect to the larger (lower) isolated mounting flange. No other part of the sensor assembly should touch any other structure or object.

Installation Guide - Remote Transmitter

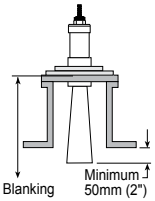
Select a suitable mounting position that is not in direct sunlight. If necessary, utilize a sunshade. Observe the minimum and maximum temperature limits (c-f).
Do not mount near sources of high E.M.F. such as high current cables, motor starters, or S.C.R. variable speed drives.
Avoid mounting in high vibration areas such as handrails and rotating plant. Use rubber absorption mounts if mounting in light vibration areas.

Installation Guide - Remote Transducer

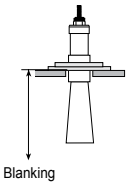
Minimum Insertion

If mounted to an enclosed environment (roof or stand pipe) the transducer face or cone must be at least 50mm (2 inches) within the environment.

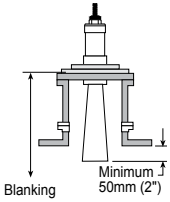
Nozzle mount



Flush mount



Stand pipe mount



Transducer Location

It is vital that the Transducer has a clear view of the liquid surface at all times. See 'Transducer Point Of Measurement' for further mounting information.

Blanking Distance

The unit will ignore any echoes and will never measure within its Blanking distance.

Minimum values must be respected. Where possible use the conservative values ***(Refer to Blanking Distance table.)***

Blanking Distance Table

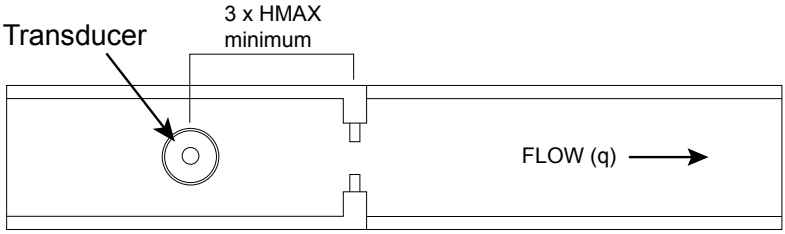
Transducer	Minimum	Nominal	Conservative
AWRT50	0.25m (10”)	0.3m (1ft)	0.35m (1.2ft)
AWRT40	0.3m (1.1ft)	0.35m (1.2ft)	0.4m (1.4ft)
AWRT30	0.35m (1.5ft)	0.4m (1ft)	0.5m (2.2ft)
AWRT20	0.5m (2.2ft)	0.6m (1.3ft)	0.8m (2.6ft)
AWRT10	1.0m (3.3ft)	1.1m (3.5ft)	1.3m (4.2ft)
AWRT5	1.2m (3.9ft)	1.4m (4.6ft)	1.5m (5ft)

Always use conservative nominated distances if possible.

Transducer Point Of Measurement

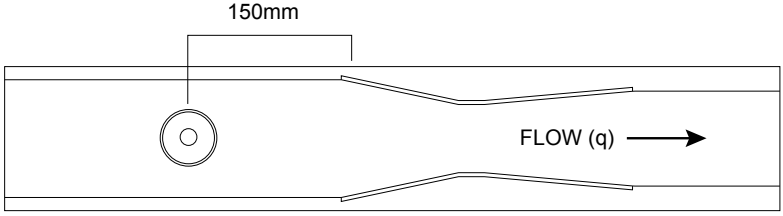
Suppressed Rectangular,Trapezoidal and V-notch weirs

The head is measured upstream at a minimum distance of 3 times maximum head from the weir plate to ensure the surface of the liquid is not affected by turbulence or draw down.



Venturi Flumes

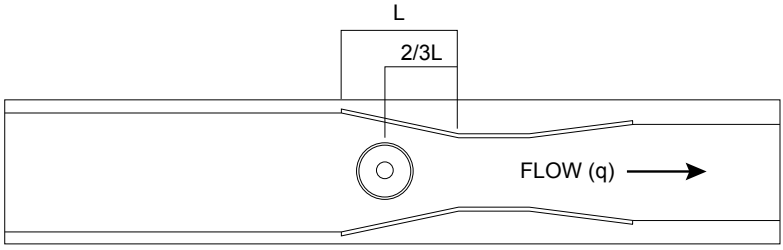
The point of measurement should be 150mm upstream from the beginning of the converging section.



Venturi Flume

Parshall Flumes

2/3 the length of the converging section upstream of the throat section.



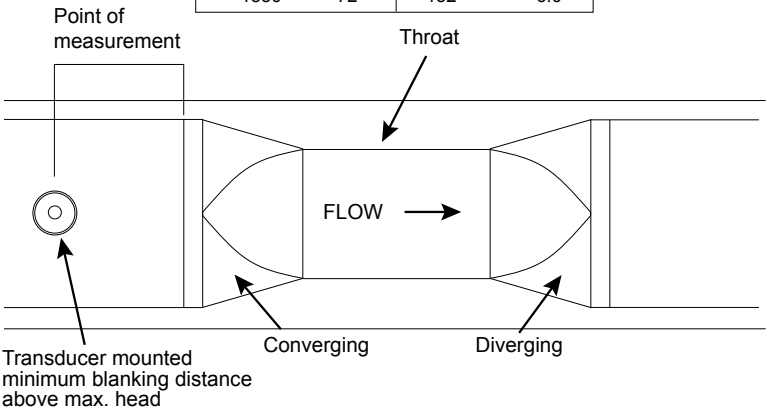
Parshall Flume

Transducer Point Of Measurement

Leopald Lagco Flumes

The head is measured at a point upstream of the beginning of the converging section as detailed in the table below (See DRWG 4).

Flume Size		Point of Measurement	
mm	inches	mm	inches
100 - 305	4 - 12	25	1.0
380	15	32	1.3
455	18	38	1.5
530	21	44	1.8
610	24	51	2.1
760	30	64	2.5
915	36	76	3.0
1065	42	89	3.5
1220	48	102	4.0
1370	54	114	4.5
1520	60	127	5.0
1675	66	140	5.5
1830	72	152	6.0

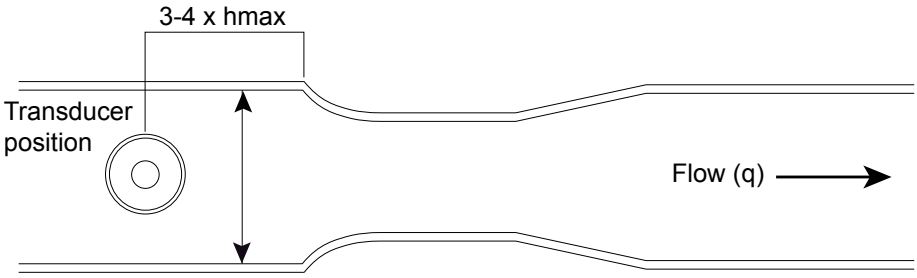


DRWG 4

Transducer Point Of Measurement

BS3680 Flumes

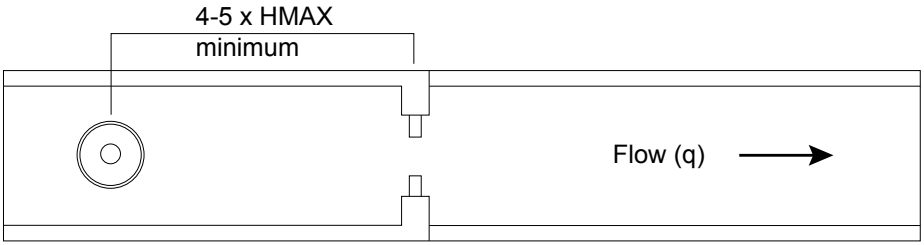
For a Rectangular and U-throated flume, the head is measured at 3 to 4 times the maximum head upstream from the beginning of the converging section, to ensure the surface of the liquid is not effected by turbulence.



BS3680 flume

BS3680 Weirs

For a Rectangular and V-notch weirs, the head is measured at a point 4 to 5 times the maximum head upstream from the weir plate, to ensure the surface of the liquid is not affected by turbulence or drawdown.



BS3680 Weir

Other Applications

Please consult the manufacturer of the device for details of where the point of measurement should be located but ensure that it is chosen such that the surface of the liquid is not effected by turbulence or drawdown.

Installation should only be performed by suitably qualified personnel.

A. Confirm mounting is within recommended specifications.

B. Check the selected unit matches the required application specifications.
For Hazardous Locations see appropriate safety instructions available at http://www.hawkmeasure.com

C. Check the wiring is correct and all connections are secure.

D. Apply power to the unit.

When power is applied the unit will start its normal load sequence.
The following messages will cycle on the display.

Hawk
Serial Number
Type
Software Revision
MB Address
Tx Serial
Tx Model
Tx SoftVr

Menu Navigation

1  Navigate up, increase value

2  Navigate down, decrease value

3 

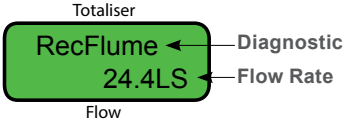
Proceed, select, save

4 

Go back, return unit to operational mode

Displayed Diagnostics

Pressing the arrow buttons cycles through various unit diagnostics on the top line of the display



(Flow Type)	Selected Flow Type (example, RecFlume)
(Display Mode)	Selected Display Mode (example, Flow)
(Totaliser Value)	Totaliser Value since last reset
(Date)	Programmed Date
(Time)	Programmed Time
Head (Value)	Measured height from Low Level
Tx 1	Transducer Number
Normal Recover Failed	Unit functioning normally Unit searching for new echo Unit in failsafe condition
WinFw	Start (near) point of Tracking Window
WinBk	End (far) point of Tracking Window
Temp	Temperature reading at Transducer
Noise	Acoustic or electrical noise interference on Transducer. Low values (1.9%) are normal
Rec Gn	Amount of Recover Gain applied
Gain	Amount of Gain used at measured distance
E Size	Echo size. 0.8V to 2.5V is normal range
Echo	Distance reading of unfiltered Echo

Quickset Menu

Quickset menu contains the standard setup parameters required for the unit functions.

Quickset

Parameter	Description	Options
DispMode	Select default Display mode	• Space • Head • Head% • Flow
HeadUnit	Select displayed measurement unit	• Inches • Feet • Metres • Centimeters
Lo Level	Set Low Level (4mA) distance	Adjustable
Hi Level	Set High Level (20mA) distance	Adjustable
Damping	Adjust output response time & smoothness	Adjustable
Vol Unit	Select displayed Volume unit	• Gallon • M Litres • Litres • Cube ft • Cube mtr
Time Unit	Select displayed Time Unit	• Day • Hour • Minute • Second
FlowMeth	FlowMeth adjusts the flow calculation method between Ratiometric and Absolute. Ratiometric The ratiometric method uses the value for the maximum flowrate instead of the flow constant (k). Absolute the absolute method which requires the determination of the weir or flume constant (k).	• RatioMtr • Absolute
FlowType[1]	Select pre-set flow application types and program channel characteristics.	Rec Flume Rec Weir V-Notch Exp Flow Tbl

[1] *See 'Programming Flow Types on Page xx*

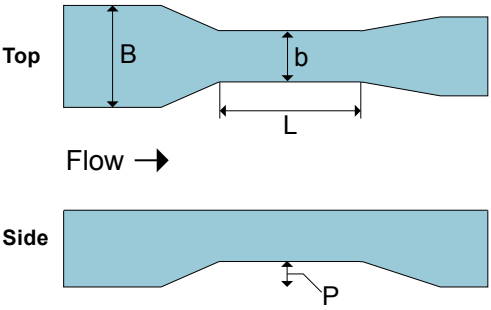
Quickset Menu (con't)

Total Mode		Enable Disable
ClockSet	Program Time & Date. After selecting 'Yes', press arrows to move between Time and Date. Press CAL to edit and move between Hours / Minutes / Seconds or Date / Month / Year	Yes No
FailSafe	Set Analogue failsafe output and Failsafe timer (in seconds)	3.50mA 20.20mA LastKnown 4mA 20.00mA
1: SenAdd	Adjust Transducer lookup address. Do not adjust this parameter without expert knowledge.	

Programming Flow Types

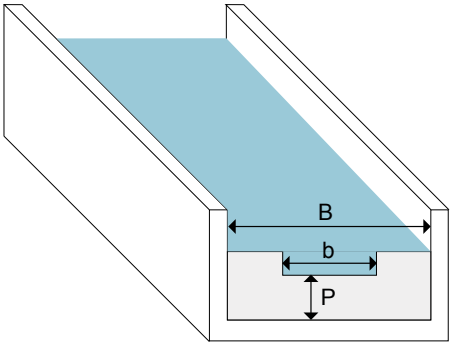
Each selectable Flow Type has various sub parameters depending on the channel shape.

Flumes



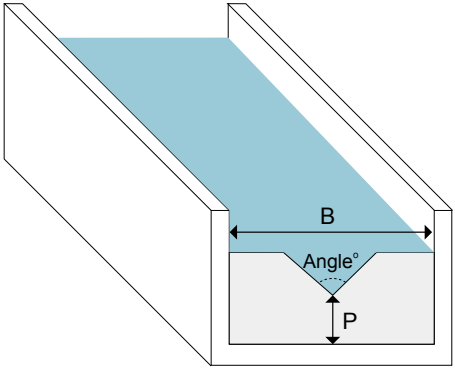
Reference	Parameter	Description
b	Throat b	Width of flume throat
B	AWidth B	Width of flume channel
L	Throat L	Length of flume throat
P	Hump P	Height of flume hump. If no hump is present, adjust to 0.00
	Rough Ks	Approximate Constant (k). Consult flume manufacturer specification
	Avg Temp	Average ambient temperature at transducer (this will over ride the automatic temperature compensation in the transducer
	Max Flow	Maximum Flow Rate possible. If this value is exceeded the unit will display 'Overflow'
	LoCutOff	If the application can have a non-flowing liquid level present use LoCutOff to ignore this liquid level. The value is measured from the programmed Low Level up. For example, if a flume has a 20mm high hump then you can program LoCutOff to be 20mm as this 20mm of liquid level will not be flowing

Rectangular Weirs



Reference	Parameter	Description
b	CWidth b	Width of weir
B	AWidth B	Width of channel
P	CHight P	Height to Weir crest
	Rough Ks	Approximate Constant (k). Consult weir manufacturer specification
	Max Flow	Maximum Flow Rate possible. If this value is exceeded the unit will display 'Overflow'.
	LoCutOff	If the application can have a non-flowing liquid level present use LoCutOff to ignore this liquid level. The value is measured from the programmed Low Level up. For example, if a flume has a 20mm high hump then you can program LoCutOff to be 20mm as this 20mm of liquid level will not be flowing

V-Notch



Reference	Parameter	Description
B	AWidth B	Width of channel
P	CHight P	Height to V Notch crest
L	Throat L	Length of flume throat
°	Angle °	V Notch angle in degrees
	Rough Ks	Approximate Constant (k). Consult weir manufacturer specification
	Max Flow	Maximum Flow Rate possible. If this value is exceeded the unit will display 'Overflow'
	LoCutOff	If the application can have a non-flowing liquid level present use LoCutOff to ignore this liquid level. The value is measured from the programmed Low Level up. For example, if a flume has a 20mm high hump then you can program LoCutOff to be 20mm as this 20mm of liquid level will not be flowing

Exp (Exponential) Applications

Some Flow applications only require an Exponential value to be programmed. You need to select the Exponent Flow Type parameter. Typical Exponential Flow designs include Suppressed Rectangular Weir, Cipolletti (Trapezoidal) Weir, Venturi Flume, Parshall Flume, Leopold Lagco Flume, plus other types of exponential device. Consult flume manufacturer for information about possible Exponential values.

Reference	Parameter	Description
	Exponent	Exponential Flow calculation based on liquid height
	K Factor	Flow constant (k). Consult flume manufacturer specification
	Max Flow	Maximum Flow Rate possible. If this value is exceeded the unit will display 'Overflow'
	LoCutOff	If the application can have a non-flowing liquid level present use LoCutOff to ignore this liquid level. The value is measured from the programmed Low Level up. For example, if a flume has a 20mm high hump then you can program LoCutOff to be 20mm as this 20mm of liquid level will not be flowing

Typical Exponential values are shown below.

Application Type	Typical Exponent
Suppressed Rectangular Weir	1.50
Cipolletti (Trapezoidal) Weir	1.50
Venturi Flume	1.50
Parshall Flume	1.50-1.60
Leopold Lagco Flume	1.55

Output Adjustment

The Output Adj menu contains parameters related to adjusting analogue, switch & communication protocol relayed settings.

Parameter	Description	Options				
Fill Damp						
Emty Damp						
4mA Adj	Fine tune the 4mA output current	Adjustable				
20mA Adj	Fine tune the 20mA output current	Adjustable				
Analog	Invert analogue from 4-20mA to 20-4mA	4-20mA	20-4mA			
Simulate	A simulated distance reading is transmitted as analogue (distance measured from sensor face)	Adjustable				
Comm Type	• Adjust communication protocol settings. • Standard Analogue and Switch models include Modbus as default.	Modbus[1]	HART[1]	Profibus (DP)[1]	DeviceNet[1]	FF/ PA[1]
RlyMod 1-5	Configure Relay actions	De-energise[2]	Energise[2]	Failsafe[2]	Off[2]	
TempLogData	View logged temperature data					
FlowLogData	View logged flow data					
TotalLogData	View logged totaliser data					
StartLogData						
LCD Light	Turn LCD back light on or off	On / Off				
HART PV Sel	Select primary variable for HART[3]	Level	Flow	Totaliser		

[1]*See 'Comms Type* [2]*See 'Relay Actions'* [3]*HART units only. Consult Part Numbering*

Comms Type

Sub-Menu	Description	Options
DeviceID	Adjust unit device ID for Modbus, HART, Profibus DP	1-255
FBusAdd	Adjust unit Device ID for FF/PA, DeviceNet	1-255
BaudRate	Adjust comms network speed	Comms dependant

Relay Actions

Sub-Menu	Description	Options
RlyL1 1-5	Adjust Relay switch point (L1 must be < L2)	Adjustable
RlyL2 1-5	Adjust Relay switch point (L2 must be > L1)	Adjustable

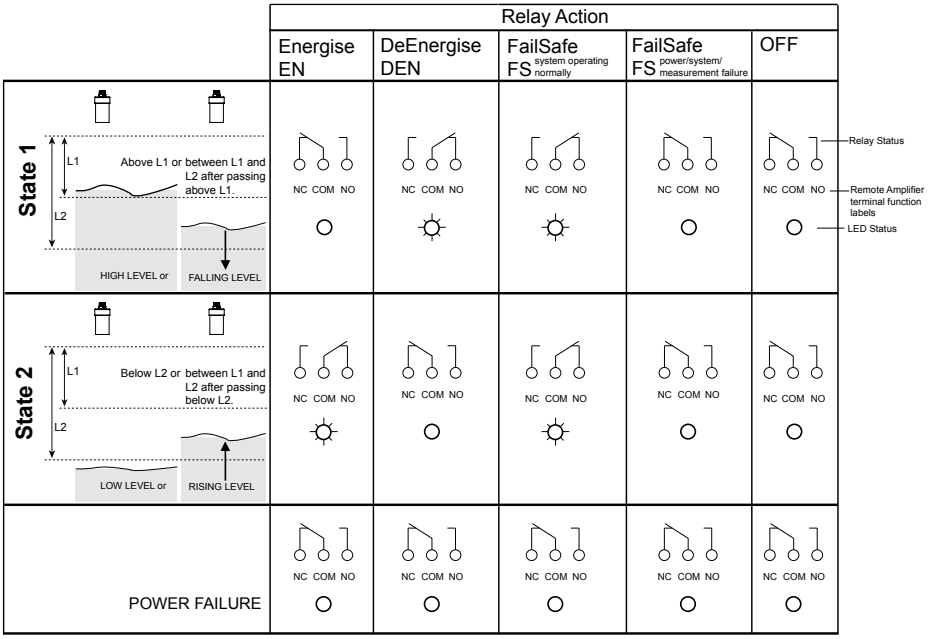
Set Relay Parameters in Output Adjustment menu

The two relay levels are RlyL1 and RlyL2

The display will show RlyL1 1, the last 1 indicated the Relay number (eg 1 to 5)

L1 and L2 distances are measured from the transducer face

L1 must be equal to or less than L2.



Advanced

The Advanced menu contains parameters for Gain control, manually adjustment of speed of sound, offset and restoring the amplifier and transducer to their default state.

These settings typically do not require adjustment unless there are special circumstances. Do not adjust Advanced settings without expert knowledge or consulting your local representation.

Parameter	Description	Options
Gain4	Primary sensitivity adjustment. This value is automatically(1) set by the selected Interface range in Quickset. Higher values for lighter densities.	Adjustable
GainStep3	Adjustment of sensitivity for DistStep3 zone.	Adjustable
DistStep3	Depth of zone measured from the sensor face for non-variable GainStep3.	Adjustable
Threshold	Minimum echo size which the unit will accept as a valid echo	Adjustable
EmptyDist	Unit will not consider any echoes beyond this distance valid. This is automatically calculated by the 'Low Level' parameter.	Adjustable
Temp Trim	Create manual measurement offset for a specific temperature.	Adjustable
Dist Trim	Create manual measurement offset for a specific distance.	Adjustable
Velocity	Adjusts the internal speed of sound calculation.	Adjustable

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