AUTOMATION PRODUCTS GROUP, INC.

Operator's Manual

DCR-1003 and DCR-1004

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Automation Products Group, Inc.
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• Warranty and Warranty Restrictions

APG warrants its products to be free from defects of material and workmanship and will, without charge, replace or repair any equipment found defective upon inspection at its factory, provided the equipment has been returned, transportation prepaid, within 24 months from date of shipment from factory.

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All associated equipment must be protected by properly rated electronic/ electrical protection devices. APG shall not be liable for any damage due to improper engineering or installation by the purchaser or third parties. Proper installation, operation and maintenance of the product becomes the responsibility of the user upon receipt of the product.

Returns and allowances must be authorized by APG in advance. APG will assign a Return Material Authorization (RMA) number which must appear on all related papers and the outside of the shipping carton. All returns are subject to the final review by APG. Returns are subject to restocking charges as determined by APG's "Credit Return Policy".

• Introducing

The DCR-1003, 1004 controllers with DST series sensors were specifically designed to provide a rugged and reliable non-contact sensor system that is easily programmed yet flexible enough to use in a wide range of applications.

The DCR-1003, 1004 controllers have a large display to show readings and parameters. They also include a mode display to provide easy setup of the programmable modes. The controller can be configured to monitor level, flow, volume or differential. The DCR-1003 comes standard with four relay outputs. The DCR-1004 or analog version, also includes a standard 4-20 mA output with optional configurations of 0-20 mA or voltage outputs.

The DST series sensors are non-contact ultrasonic which measure the distance to a surface through air. The standard DCR-1003, 1004 sensor is the DST-1002. It is a totally sealed PVC sensor with a range of 25 ft. Several other versions of DST are available to fit almost any application.

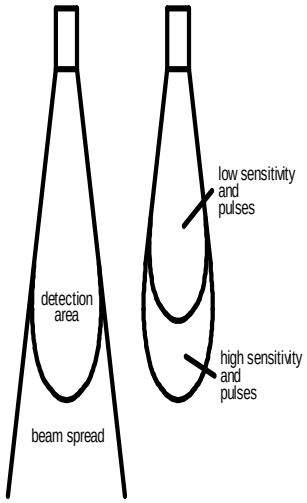
Typical applications include:

- Monitoring water levels in a well
- Monitoring open channel flow
- Determining material volume in a tank
- Taking differential measurements
- Obstacle avoidance
- Product dimensioning

• Understanding Ultrasonics

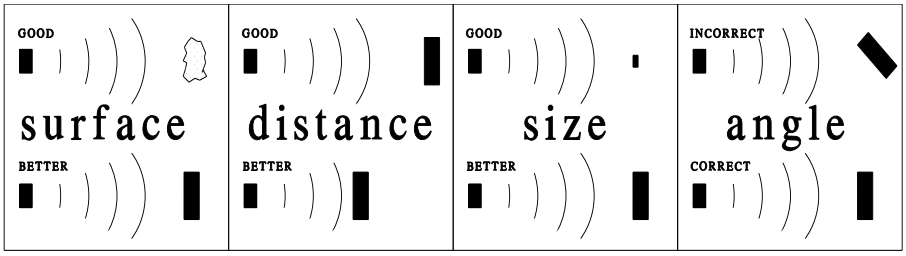
Ultrasonic sensors measure distance using a transducer to send out ultrasonic bursts. Each burst contains a series of 1-20 pulsed sound waves that emit in the shape of a cone, reflect off the target, and are received by the sensor. The time required for the sound burst to travel to and from the target is converted into a distance measurement by the sensor.

Ultrasonic sensing is affected by several factors including the target surface, distance, size, and angle. The following considerations will help ensure the best possible target conditions.



Surface

The ideal target surface is hard and smooth and perpendicular to the face of the transducer. This surface will reflect a greater amount of signal than a soft, sound wave absorbent surface. A target with poor sound wave reflection characteristics will reduce the operating distance of the sensor and decrease its accuracy.



Distance

The shorter the distance from the sensor to an object, the stronger the returning echo will be. Therefore, as the distance increases, the object requires better reflective characteristics to return a sufficient echo.

Size

A large object will have a greater surface area to reflect the signal than a small one, therefore, a large target will be detected at a greater distance than a small target. The surface area recognized as the target is generally the portion closest to the sensor.

Angle

The inclination of the object's surface facing the ultrasonic sensor affects the reflectivity of the object. The portion perpendicular to the sensor returns the echo. If the entire surface is at a great enough angle, the signal will be reflected away from the sensor and no echo will be detected. Generally a target at an angle greater than 5 degrees off perpendicular will not be detected.

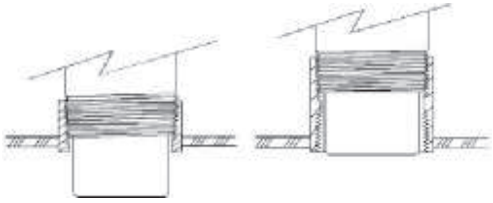
• Installation

Installing the DST Sensor

The DST sensor should be installed so that it has a clear sound path to the intended target. The path should be free from obstructions and as open as possible. Follow the guidelines mentioned in this manual under "Understanding Ultrasonics", found on page 5.

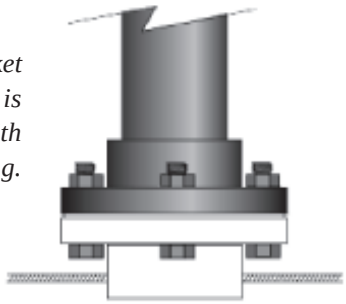
NPT and Flange Mounting

- Mounting in a coupler or half coupler welded to the top of tank. **(see drawings below)**
- Coupling should extend through the top of tank.
- Coupler must be aligned perpendicular to the target level.
- Screw sensor in only hand tight**.**
- To avoid false Echoes, the coupler should be installed where there is a clear sound path perpendicular to the detection surface and where the sound path will not intersect vessel fill spouts, rough vessel walls, ladders…etc.



BEST *GOOD*

**Soft gasket material is recommended with flange mounting.*



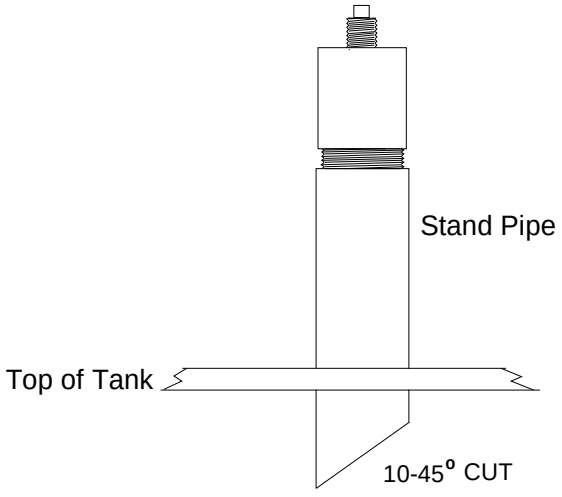
Stand Pipe Mounting

The stand pipe should be as large in diameter and as short in length as possible. Mount the sensor above the highest anticipated material by at least the published blanking distance.

The stand pipe should be seamless to provide a smooth path for the sound waves to propagate into the tank. Because the sound waves will concentrate along the inside wall of the pipe, any seams from couplers, nipples, and welds will cause echo returns that will be picked up by the sensor. The sensor blanking will need to be changed to a distance greater than the length of the pipe (found on page 15; mode 5).

The end of the stand pipe should extend inside the tank and be cut to a 45° angle. Make sure that the cut is clean and free from burs. If the standpipe is cut at 90°, there will develop a standing wave echo at the end of the pipe that will be seen by the sensor as a target. If a 45° cut is not feasible in your application, then the cut should be made as close to 45° as possible (often, even a 10° cut will shrink the standing wave enough to allow the sensor to see past it).

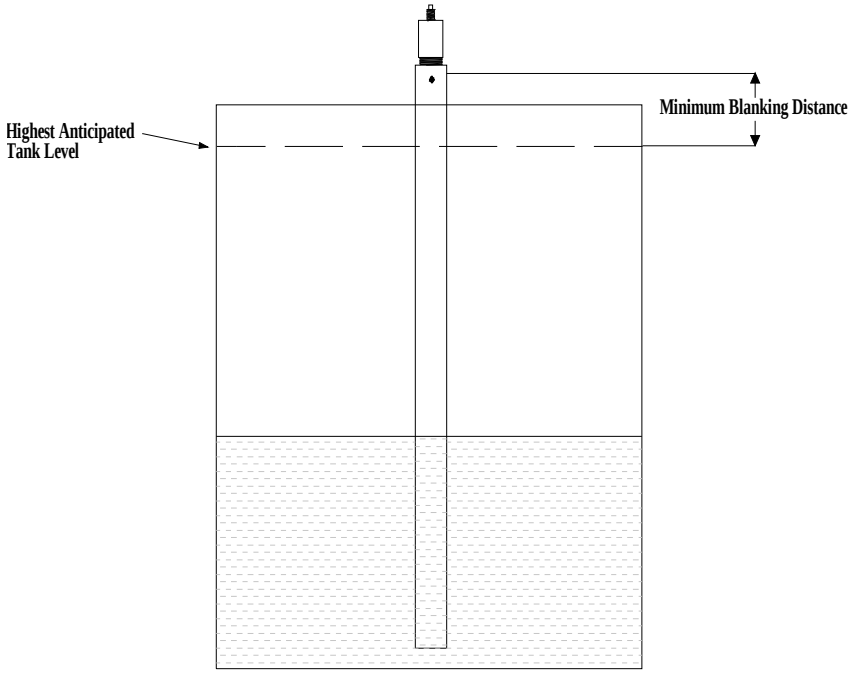
To avoid false Echoes, the stand pipe should be installed where there is a clear sound path perpendicular to the detection surface and where the sound path will not intersect vessel fill spouts, rough vessel walls, ladders…etc. Any angle off perpendicular will degrade the performance of the sensor.



Stilling Well Mounting

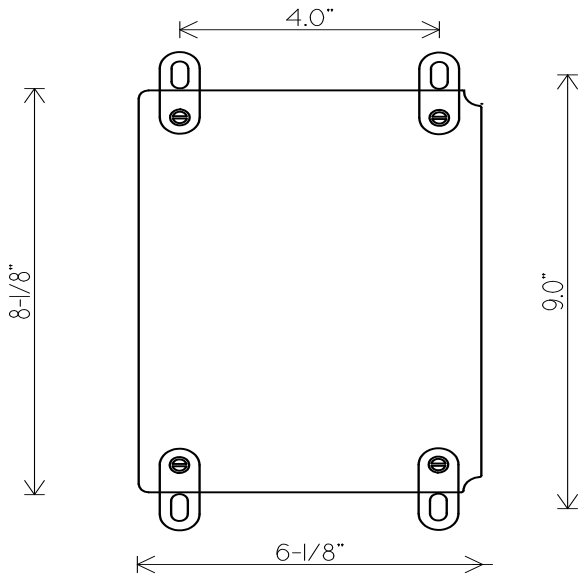
Provides access to difficult areas and eliminates problems with foam.

- Extend the pipe above the highest anticipated level by at least the published blanking distance.
- Provide a vent hole at the top of the tube. Keep the hole inside the blanking distance of the sensor to prevent false echoes.
- Use only in liquid materials that will not leave deposits on the inside of the pipe (material build-up will result in false echoes).
- Pipe must have smooth walls and should be seamless to provide a smooth path for the sound waves to propagate into the tank. Because the sound waves will concentrate along the inside wall of the pipe, any seams from couplers, nipples, and welds will cause echo returns that will be picked up by the sensor.



Installing the DCR-1003, 1004

The DCR-1003, 1004 should be installed using the 4 mounting feet provided. The enclosure must be mounted out of direct sunlight and should have good clearance to the left for opening the hinged cover.



DCR-1003 and DCR-1004 Mounting Dimensions

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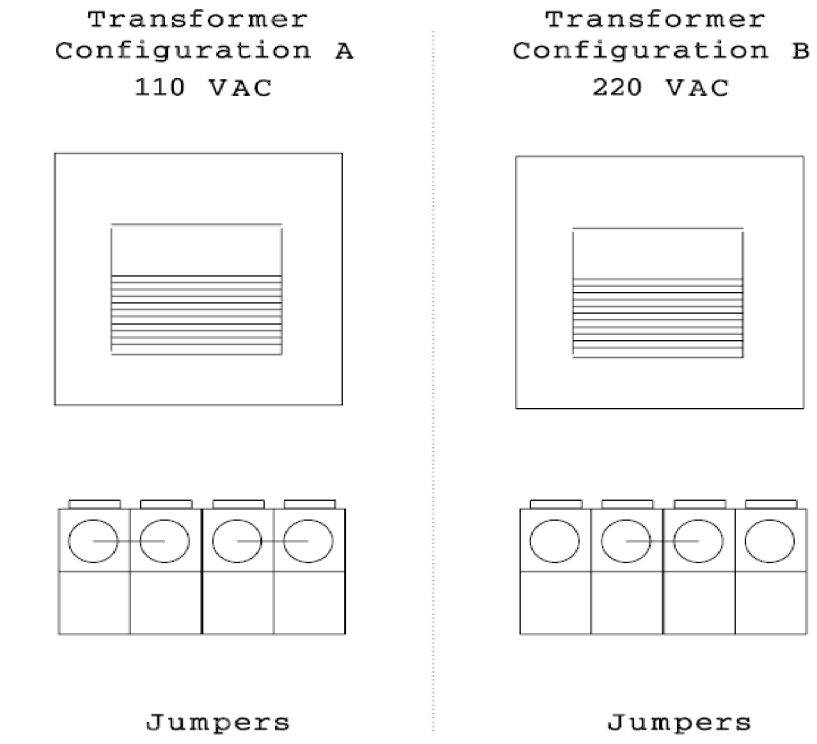
• Wiring

Step 1: Connect the DST to the DCR Controller using RG-6 coaxial cable with 'F' series connectors. If more than one DST is to be connected for a differential application, the two sensors should be connected to the DCR using an external splitter.

Step 2: To obtain access to the DCR'S terminal strip, open the DCR's plexiglass cover and raise the hinged panel by loosening the knurled thumb screws.

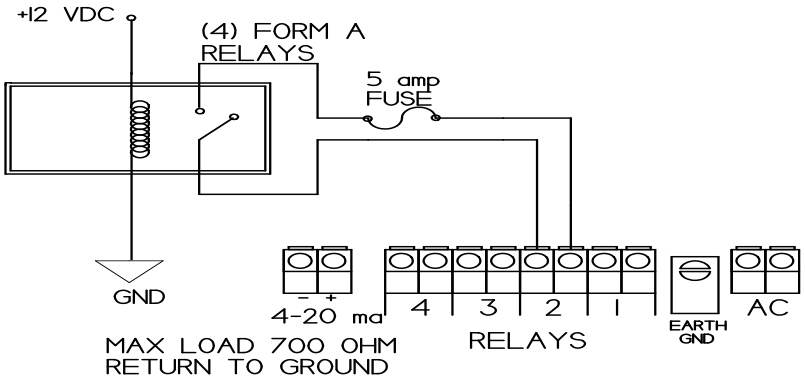
Step 3: The DCR-1003, 1004 is shipped from the factory configured for 100-120 VAC input power. If 200-230 VAC is to be used, change the jumpers configuration to 220 VAC as shown in the diagram below.



Step 4: Wires can be pulled into the DCR-1003, 1004 through the strain reliefs on the enclosure, or the strain reliefs may be removed and 1/2 in. conduit used in their place.

The spring loaded terminal can be wired using solid or stranded wire between 16 - 20 AWG. Wires should be stripped, leaving a .4 in. bare wire. The wires can then be inserted into the terminal by depressing the associated orange lever with a #5 1/8 in. screwdriver. While the lever is depressed, the conductor should be pushed into the terminal until it bottoms out. The lever should then be released, securing the conductor in the terminal.

Follow the legend on the circuit board when wiring the DCR. The DCR-Controller should never be used without the earth ground terminal being connected.



Step 5: Perform an internal check to ensure that all wires are properly connected and secured.

Step 6: Close the hinged panel and make the power connection. The LED display should turn on and the COM light illuminate.

• Programming

The DCR-1003, 1004 has a four-digit LED readout, a two-digit display showing the modes, and four lights labeled TRIPS 1, 2, 3, and 4. These lights indicate the status of the relays. The keypad, located under the clear cover, is used to program the DCR-1003, 1004. The front cover makes reading the displays easy while preventing the buttons on the keypad from being accidentally bumped.

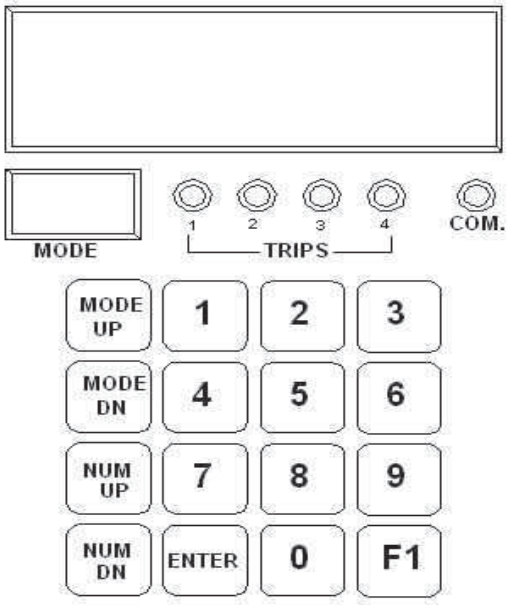
The different modes of the DCR-1003, 1004 can be easily accessed using the mode buttons, MODE UP and MODE DN. They operate similar to a digital watch. To cycle forward through the modes, hold down the MODE UP key. To cycle backward through the modes, hold down the MODE DN key.

To select a mode, press the MODE UP or MODE DN key until the desired mode number is displayed. Pressing either the NUM UP, NUM DN, or one of the numeric keys will display the selected mode setting on the large LED display.

To change the selected mode setting, hold down the NUM UP or NUM DN key until the desired setting is displayed. If the setting is not a menu item, such as a multiplier or distance, then it may be keyed using the numeric keypad. To change non-numeric values (i.e.., ON, OFF, NEG, POS) or a menu number, use the NUM UP and NUM DN keys.

Enter the new value by pressing the ENTER key or either of the mode keys. The display will then show the DST distance reading.

To leave a mode without entering the setting, press the function key, F1, and the DCR-1003, 1004 will return to displaying the DST reading.



Mode Sequence

For best results when programming your DCR, follow the steps below. Following the steps **in sequence** will eliminate most of the problems encountered when setting up the DCR controller.

1. **MODES 1-2** Determine units to be displayed
2. **MODES 4-6** Determine settings to get a reliable distance reading on your target
3. **MODES 7-10** Determine appropriate filtering for your application
4. **MODE 3** Select application type *(MODE 2 will need to be adjusted for volume and flow applications)
   1. Distance: skip to step 5
   2. Volume: setup **Modes 29-35**
   3. Differential: setup **Modes 36-37**
   4. Open Channel Flow: setup **Modes 38-43**
5. **MODES 12-23** Setup relay outputs (disable relays that are not used in your application)
6. **MODES 24-26** Setup analog output
7. **MODE 44** Set temperature compensation
8. **Advanced setup** *(not required in most applications) MODES 27-28, 45-48

Operation

The operation modes are used to do basic initialization of the DCR.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
1	*Units*	Range = 1 - 3 1 - inches 2 - feet 3 - meters Default = 2	Selects the units to be displayed Select by NUM UP or NUM DN
2	*Decimal Point*	Range = 0000.- 0.000 Default = 00.00	Selects the decimal point position Select by NUM UP or NUM DN
3	*Operating Mode*	Range = 1 - 4 1 - distance 2 - volume 3 - differential 4 - open channel flow Default = 1	Selects mode of measurement for the application Select by NUM UP or NUM DN
4	*Sensitivity*	Units = % Range = 0 - 100	Sets sensitivity as a percentage of maximum

If using a DST version 2000 sensor, Mode 4 will display the sensor selected sensitivity. The sensitivity is not user adjustable.

5	*Blanking Distance*	Units = mode 1 Range = 0 - 36 ft. Default=see sensor specs	Sets a dead zone in front of the DST where echoes are ignored. Minimum blanking is predetermined with the DST series sensor and should not be set lower than the sensor spec.
6	*Pulses*	Default=see sensor specs Range = 1-20	Sets the number of pulse waves sent out in each ultrasonic burst (adjusts strength of transmitting signal).

If using a DST version 2000 sensor, Mode 6 will display the sensor selected pulse setting. The pulse setting is not user adjustable.

Filtering (Modes 7-9)

The filtering modes are provided to adjust how fast the system will respond to target changes. The default settings should be appropriate for most level applications. However, the filtering can be changed to increase or decrease reaction time to keep up with fast moving targets and filter out unwanted targets.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
7	*Sample Rate Delay*	Units = seconds Range = 0.075 – 1.0 sec. Default = .250 seconds	Sets the delay between each sample (or reading) taken by sensor
8	*Samples Averaged*	Range = 1 - 50 Default = 20 samples	Sets the number of samples to be saved in the buffer memory and averaged together. The average is then displayed as the output (distance, volume, or flow). Samples are sent to the buffer on a First-In-First-Out (FIFO) basis. When the number of samples in the buffer is equal to the number entered in mode 8, the samples are averaged and the result is displayed as the output.
9	*Out-of-Range Samples*	Range = 1-50 Default = 10 samples	Sets the number of consecutive sample readings outside the *window that will be ignored before the new target is accepted. If a target is detected outside the window and is sampled in succession the number of times entered in mode 9, then it will be accepted as a target by the sensor. *(see mode 10)
10	*Window*	Units = mode 1 Range = 0 - 20 ft. Default = 2.00 ft.	Sets the window of target acceptance. The window is equal to + or – the value entered in mode 10 from the current

			distance reading. If a target is sampled outside of this window it will be ignored until it is consecutively sampled the number of times set in mode 9. When the sensor accepts a new target, the window automatically shifts to the new target.
11	*Loss of Echo*	Units = seconds Range = 0 - 9999 Default = 5	Sets the delay before the output will show a loss of echo condition. A loss of echo condition exists when the sensor looses all targets (receives no echo returns). Loss of echo condition will result in a display reading of "0" in volume and flow modes, or the maximum distance of the sensor in distance mode.

Example 1: Rapid Level Changes

If the DCR-1003, 1004 filtering is too slow and the level to be monitored is changing rapidly, the display will seem to jump between readings instead of scrolling smoothly as the level changes. To reduce the filtering and quicken the response, modes 7 to 10 should be changed.

Filtering Guideline 1 - Target Level Rate of Change

A smooth and steady outputs and display reading of the target is almost always desirable. If the level being monitored is changing rapidly and the filtering is set too slow, the display will jump between readings instead of scrolling smoothly as the level changes. However, if the level is changing slowly and the filtering is set too fast, the display will track even small waves and ripples, resulting in a constant variation in the output.

MODE	DESCRIPTION
7	Set the *sample rate delay* as high as is practical in your application to allow more time for the previous sound wave to dissipate before transmitting the next wave. This will minimize the chances of multiple-echo interference.
8	Set the *samples averaged* as high as is practical in your application to help minimize the effects of waves and ripples on a liquid target. A greater number of target readings averaged together will result in a more stable displayed output of a wavy surface.
9	Set the *out-of-range samples* as high as is practical in your application to filter out unwanted intermittent objects and still assure the intended target is being tracked smoothly.
10	Set the *window* as small as is practical in your application to help isolate the intended target (rarely needs to be set to less than 0.33 ft.). A smooth slower moving surface will allow for a small window setting, while a wavy and fast moving surface will require a larger window setting.

Filtering Guideline 2 - Ignoring Intermittent Obstacles

To prevent splashing, agitators, or other intermittent objects from being detected even though they are occasionally in the ultrasonic detection beam

MODE	DESCRIPTION
7 & 9	Modes 7 and 9 should be increased. If the sample rate delay (Mode 7) is set to 0.250 seconds, and the out-of-range samples (mode 9) is set to 10, then the DCR will require only 10*0.250 or 2.5 consecutive second of readings outside the window (mode 10) before the new target will be recognized. If the numbers are increased to 0.500 seconds and 40 out-of-range samples, then the DCR will require a much greater time of 0.500*40 or 20 consecutive second of readings outside the window before the new target will be recognized.
10	Should be kept to a small value to help qualify only echoes from the target surface.

Outputs

The DCR-1003 comes standard with 4 relay outputs fused at 5 A each. The DCR-1004 is equipped with relays and an analog output. Detailed explanations of the two output types are given in the RELAY and ANALOG sections.

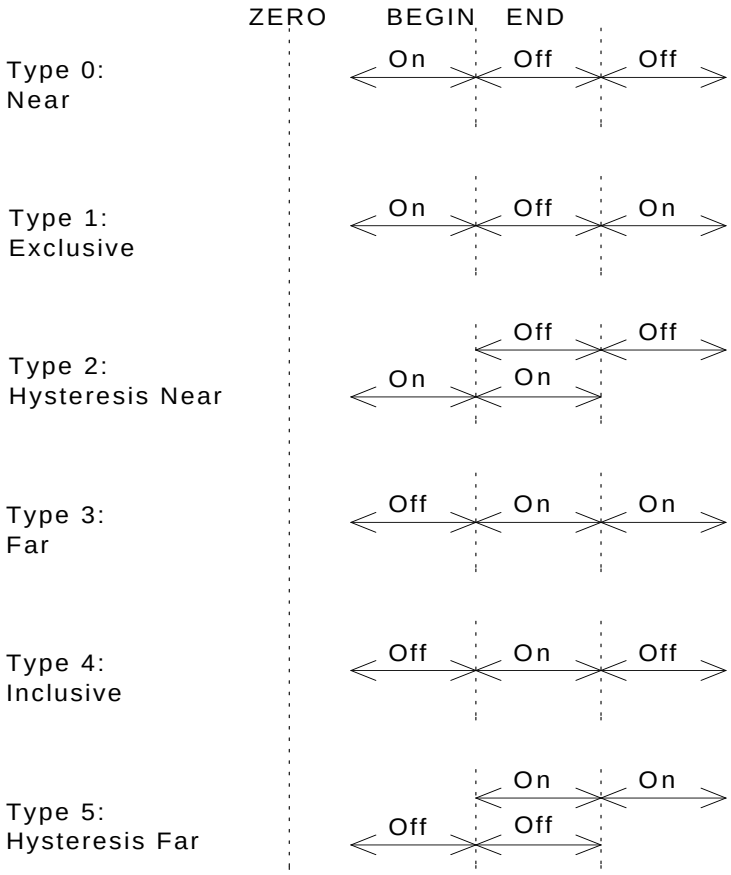
RELAY

The four relays are fully programmable for 'BEGIN' and 'END' points and 'TYPE' of operation. The LEDs on the DCR indicate the status of the normally open relays. When the LED is on, the relays are energized and the contact is closed. For performing a distance to level measurement the zero point of distance will be at the transducer. For volumetric or open channel monitoring, the zero point will be at the empty point of the tank or flume. For distance measurements the relay trip points will be programmed in the units selected in mode 1. For volumetric or flow, the relays are in volume or flow.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
12	*Begin Trip 1*	Units = mode 1 Default = 2.5 ft.	Sets the begin point of Trip 1
13	*End Trip 1*	Units = mode 1/mode 3 Default = 2.9 ft.	Sets the end point of Trip 1
14	*Trip 1 Type*	Range = 0 - 7 0 - near 1 - exclusive 2 - hysteresis near 3 - far 4 - inclusive 5 - hysteresis far 6 - disable 7 - fail-safe Default = 0	Selects the type of function Trip 1 will perform Set by NUM UP or NUM NUM DN
15	*Begin Trip 2*	Units = mode 1/mode 3 Default = 3 ft.	Sets the begin point of Trip 2
16	*End Trip 2*	Units = mode 1/mode 3 Default = 3.4 ft.	Sets the end point of of Trip 2

17	*Trip 2 Type*	Range = 0 - 7 Default = 0	Selects the type of function function Trip 2 will perform
18	*Begin Trip 3*	Units = mode 1/mode 3 Default = 3.50 ft.	Sets the begin point of Trip 3
19	*End Trip 3*	Units = mode 1/mode 3 Default = 3.90 ft.	Sets the end point of Trip 3
20	*Trip 3 Type*	Range = 0 - 7 Default = 0	Selects the type of function Trip 3 will perform
21	*Begin Trip 4*	Units = mode 1/mode 3 Default = 4.0 ft.	Sets the begin point of Trip 4
22	*End Trip 4*	Units = mode 1/mode 3 Default = 4.40 ft.	Sets the end point of of Trip 4
23	*Trip 4 Type*	Range = 0 - 7 Default = 0	Selects the type of function Trip 4 will perform

Trip Type Explanation



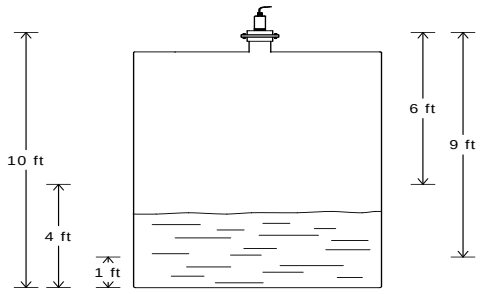
Type 6: Trip Point Disable

Type 7: Relay remains closed (trip light on) unless an error is detected in communication, loss of echo, or loss of power.

NOTE: The Zero line represents the face of the sensor when operating in "Distance" mode and the bottom of the tank when indicating volume or level.

Example 3- Relay Settings for Distance to Level

A 10 ft deep lift station requires that a pump turn on when a level is closer than 6 ft. to the DST. The pump must stay on until the level drops to 9 ft. from the DST. An alarm relay is to be energized under normal operation and should open for failure in power, communication, invalid readings, high level closer than 5 ft., or loss of echo.

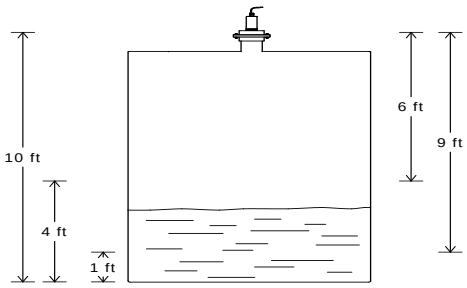


To program the DCR-1003, 1004 for this application, the following modes must be set:

MODE	VALUE	DESCRIPTION
Operation		
5	2.00	Do not set closer than the minimum distance recommended for the DST sensor type being used
Relay		
12	6.00	Set the pump begin point at 6 ft. from the DST
13	9.00	Set the pump end point at 9 ft. from the DST
14	2	Use the hysteresis near type of gate to keep the pump on while pumping the level down
15	5.00	Begin the alarm trip point at 5 ft.
16	10.00	End the alarm trip point at 10 ft. because any reading greater will indicate loss of echo or communication
17	4	Any signal higher than 5 ft. or lower than 10 ft. will cause the alarm relay to open

Example 4- Relay Settings For Product Level Rather than Distance to Level

A 10 ft. deep lift station requires that a pump turn on when a level reaches 4 ft. and stay on until the level drops to 1 ft. from the bottom of the station. An alarm relay is to be energized under normal operation and should open for failure in power, communication, invalid readings, high level above 5 ft., or loss of echo.



To program the DCR-1003, 1004 for this application, the following modes must be set:

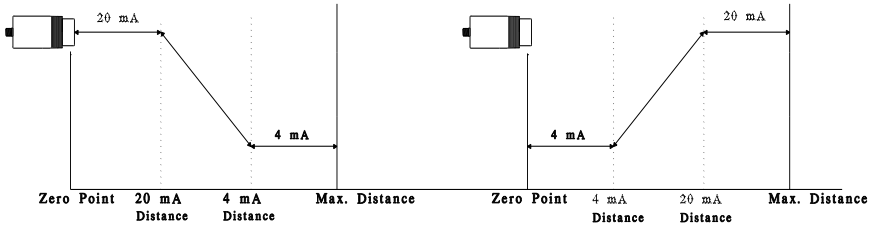
MODE	VALUE	DESCRIPTION
Operation		
3	2	Select Volumetric Monitoring for this application so the display will read the distance from the tank bottom to the level
5	2.00	Do not set closer than the minimum distance recommended for the DST sensor type being used
Relay		
12	1.00	Set the pump begin point at 1 ft. from the bottom
13	4.00	Set the pump end point at 4 ft. from the bottom
14	5	Use the hysteresis far type of trip to keep the pump on while pumping the level down
15	0.00	Begin the alarm trip point at the bottom because any signal below the zero point will indicate loss of echo or communication
16	5.00	End the alarm trip point at 5 ft. for high level alarm
17	4	Any signal higher than 5 ft. or lower than 0 ft. will cause the alarm relay to open
Volume		
29	1	Flat bottom tank
32	10	Distance from sensor to bottom of tank. The Controller subtracts the measured distance from the Tank Span to display product level.

ANALOG

The analog output is only available on controller model DCR-1004. The analog circuit comes standard with 4-20 mA, but may be configured for 0-20 mA. A hardware change will allow 0-5 V, or 0-10 V as the output.

The desired analog output should first be selected in mode 24. The two end points must then be entered. For performing a distance to level measurement, the zero point of distance will be at the transducer and the 4-20 limits will be programmed in the same units as mode 1. For volumetric or open channel monitoring, the zero point will be at the empty point of the tank or flume and the end points must be set in the units used in the volume or flow measurement. Keep this in mind when referring to the diagram below.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
24	*Analog Output Select*	Range = 0 - 1 0 = 4 to 20mA 1 = 0 to 20mA Default = 0	Selects the type of analog output output to be used Set by NUM UP or NUM DN
25	*0,4 mA Distance*	Units = mode 1 Default = 3.00 ft.	Sets the minimum distance of the analog output slope
26	*20 mA Distance*	Units = mode 1 Default = 4.00 ft.	Sets the maximum distance of the analog output slope
27	*0,4 mA Calibration*		Fine tunes the minimum current sourced on the analog output
28	*20 mA Calibration*		Fine tunes the maximum current sourced on the analog output



Applications

The DCR Controller can be configured for four different types of applications. They are:

- **Distance**: Measuring the distance to an object
- **Volume:** Determining the volume, or level of a product in a tank
- **Differential**: Calculating the differential measurement between two levels or measurements
- **Open Channel Flow**: Taking flow rate measurements over a weir or flume

DISTANCE

Measuring the distance to a target is the most basic application. The DCR Controller will do this without any special settings. The zero distance point is .5 inches behind the face of the DST-X002 and DST-X003, at the transducer face on the DST-X001.

Example 5: Distance Measurement

A batch plant operator needs a display to show the level of rock in a hopper 5 meters deep.

To program the DCR-1003, 1004 for this application, the following values must be entered in the modes indicated. Many of them are the same as the preset values but are shown again for example purposes.

MODE	VALUE	DESCRIPTION
Operation		
1	3	Set units to meters because the output is to be displayed in meters
2	.0	Change the display so that it will have a 10 cm resolution
3	1	Select distance monitoring for application
4	80	Adjust percent of sensitivity with 100 being maximum
5	.60	Do not set closer than the minimum blanking spec. for the DST sensor.

VOLUME

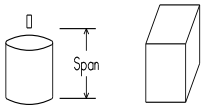
A very popular use for the DCR-1003, 1004 is to do volumetric conversions for the amount of product in a tank. If 0 is selected as the tank type , the zero point is at the DST, and the display will show the distance to the product. If tank type 1 - 5 are selected, the zero point is the bottom of the tank, and the display will show how much product is in the tank.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
29	*Tank Type*	Range = 0 - 5 0 - distance to level 1 - level indication 2 - horizontal flat ends 3 - horizontal with spherical ends. 4 - spherical tank 5 - conical bottom Default = 0	Selects the type of tank to be monitored Set by NUM UP or NUM DN

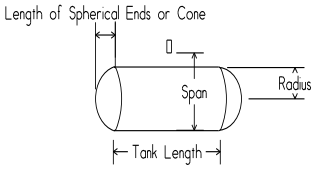
Converting the output into units of volume other than ($ft.^3$), ($in.^3$) ,or (m^3) (determined in mode 1) is often preferred. To accomplish this, a conversion factor needs to be entered into modes 30 and 31. For example, converting the output from cubic inches to liters requires a conversion factor of 0.0164 (1 $in.^3$ = 0.0164 liters). **If you are using tank type 1**, you must multiply the area of the bottom of the tank by the conversion factor and enter the result into modes 30 and 31. For example, if you have a flat-bottom tank (type1) with a diameter of 110 in, you must first figure the area of the tank bottom. (Area of a circle = tt x r^2) 3.1415 x 55^2 = 9503.0375 IN^2. The area is then multiplied by a conversion factor. 9503.0375 x 0.0164 = 155.8498. This is the number you would enter into modes 30 and 31. **This is only necessary with tank type 1**. If one of tank mode 2-5 is selected, then the only the conversion factor needs to be entered in modes 30 and 31. For example, to convert from ($ft.^3$) to gallons will require a conversion factor of 7.4805 (1 $ft.^3$ = 7.4805 gallons) to be entered into modes 30 and 31. Using the values entered in modes 30-35, along with the measured distance to the level, the DCR calculates the volume in gallons.

30	*Constant Above Decimal Point*	Range = 0 - 9999 Default = 1	Sets the portion of the multiplier above the decimal point. Used for converting between units of volume. The relay and analog outputs must be programmed in the same units used here.
31	*Constant Below*	Range = .0000 - .9999	Sets the portion of the multiplier

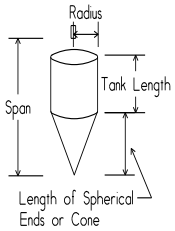
	Decimal Point	Default = .0000	below the decimal point.
32	*Span*	Units = mode 1 Default = 12.00 ft.	Sets the empty distance from the transducer
33	*Tank Length*	Units = mode 1 Default = 10.00 ft.	Sets the length of a horizontal tank or the length to a conical bottom
34	*Length of Spherical Ends*	Units = mode 1 Default = 2.00 ft.	Sets the length of the bottom cone or spherical or Cone ends (tank type 3 or 5)
35	*Tank Radius*	Units = mode 1 Default = 5.00 ft.	Sets the radius of the cylinder (not used in tank type 0 or 1)



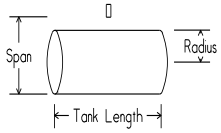
1 - flat bottom



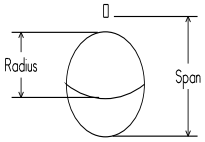
3 - horizontal with spherical ends



5 - conical bottom



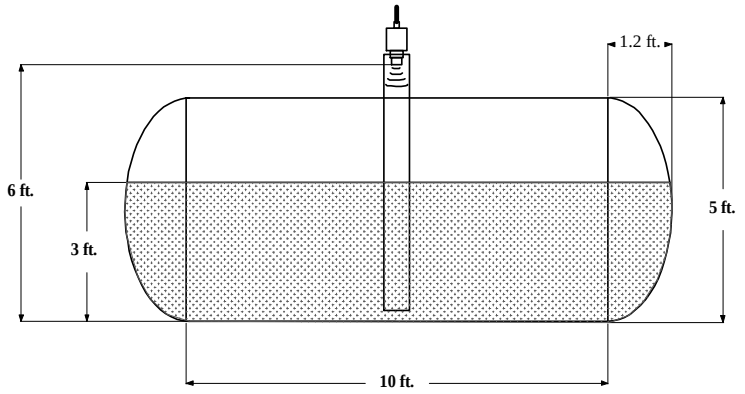
2 - horizontal with flat ends



4 - spherical tank

Volume Example 1

Gallons of diesel fuel need to be displayed in the horizontal tank with spherical ends shown below.



To program the DCR for this application will require the following steps:

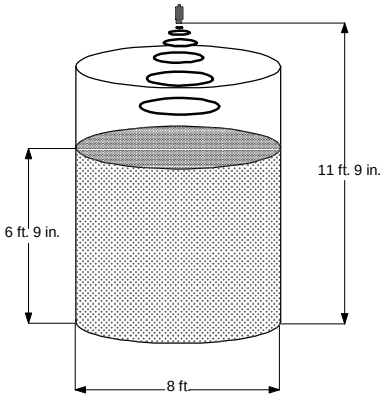
MODE	VALUE	DESCRIPTION
1	2	Set the units to feet.
4-10	---	Determine settings to achieve reliable reading of the target.
3	2	Select volume as operating mode
2	0000.	Move the decimal point to the far right. The tank has a capacity of more than 1500 gallons and we need 4-digits above the decimal to display the volume.
29	3	Choose tank type 3
30	7	The conversion factor for *ft.^{3} to gallons is 7.4805. The portion of the conversion factor above the decimal point is 7
31	4805	The portion of the conversion factor below the decimal point is 4805
32	6	Set the span. This is the distance from the sensor face to the bottom of the tank in *feet.
33	10	Set the tank length between the spherical end in *feet.
34	1.2	Set length of spherical ends to 1.2 *ft.
35	2.5	Set the tank radius to 2.5 *ft.
12-26	---	Set outputs. **Must be setup in gallons.**

Because the units set in mode 1 are set to feet, any **tank dimensions entered must also be in feet.*

This does NOT include output settings, outputs are setup in the units of volume being used.

Volume Example 2

Liters of water need to be displayed in the cylindrical flat bottom tank shown below.



MODE	VALUE	DESCRIPTION
1	2	Set units to feet
4-10	---	Determine settings to achieve reliable reading of the target.
3	2	Select volume as operating mode.
2	0000.	Move the decimal point to the far right.
		The tank has a capacity of more than 15,000 liters. Because we can't display 15000 with 4-digits, we will have to display the output in 10's of liters. (A reading of 1200 would represent 12000 liters)
29	1	Select flat bottom tank
		The conversion factor for ft^3 to liters is 28.317 Because this is a flat bottom tank (type 1), we need to multiply the area of the flat bottom by the conversion factor. area = tt x r^2 = 3.1415 x 4^2 = 50.264 $ft.^2$ area **x** conversion factor = 50.264 x 28.317 = 1423.3257 Because the display is limited to 4 digits it becomes necessary to display 10's of liter. To do this we must shift the decimal point of the conversion one place to the left. The conversion to be entered into modes 30,31 becomes 142.3325.
30	142	Set the conversion above the decimal point
31	3325	Set the conversion below the decimal point
32	11.75	Set the span in *feet. This is the distance from the sensor face to the bottom of the tank (9 in. = 0.75 ft.)
33-35	---	No settings are necessary. Because we selected tank type 1, modes 33-35 are not used and any number in these modes will be ignored by the DCR.
12-26	---	Set outputs. **Must be setup in liters for this example.**

Because the units set in mode 1 are set to feet, any **tank dimensions entered must also be in feet.*

This does NOT include output settings, outputs are setup in the units of volume being used.

DIFFERENTIAL

The DCR-1003, 1004 can determine the difference between two levels. This is accomplished by installing two DSTs at the same height, one over each level to be monitored. The DSTs are then programmed as different sensor numbers, # 1 and # 2. The DCR-Controller will take the two level readings and display the difference.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
36	*Change Sensor Number*	Units = sensor # Range = 1 - 2 Default = none	Selects which number to assign to the sensor connected to the DCR.
ONLY ONE SENSOR SHOULD BE CONNECTED WHEN USING THIS MODE			Set by NUM UP or NUM DN
37	*Display Control*	Units = sensor # Range = 0 - 2 0 - display differential 1 - display sensor #1 2 - display sensor #2 Default = 0	Selects which sensor distance will be displayed. Default is the difference between DST #1 and DST #2.

Example 7: Differential Reading

A mechanical rake is to be engaged for cleaning a screen when the upstream level is 2 feet higher than the downstream level. To program the DCR-1003, 1004 for this application, the following modes must be changed from their preset values.

MODE	VALUE	DESCRIPTION
Operation		
3	3	Select Differential Monitoring for application
5	2.00	Do not set closer than the minimum distance recommended for the DST sensor type being used
Relay		
12	2.00	Begin trip point # 1 when the difference between levels is greater than 2 ft.
13	3.00	Set the end point beyond the begin point
14	3	Set the trip type to ‘far’, meaning the relay will energize for display readings greater than 2 ft.

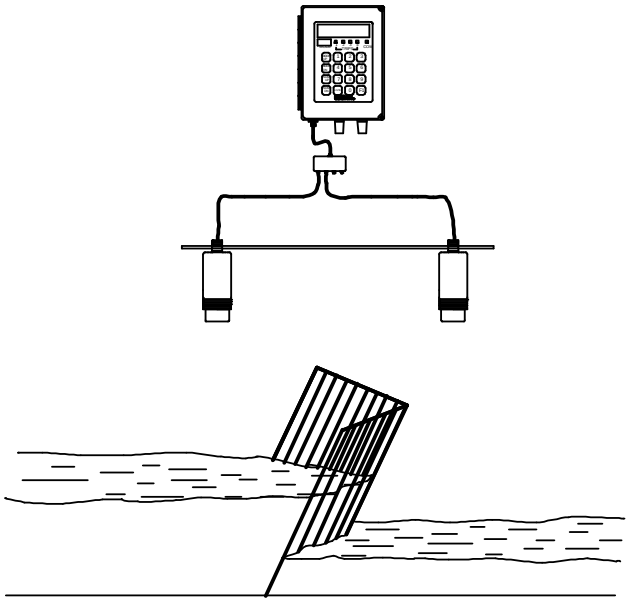
Differential

CONNECT ONLY ONE OF THE DST SENSORS TO THE DCR-1003, 1004

36	2	Program the DST that is connected to the DCR-Controller to be sensor # 2. The other DST will be sensor # 1 as set at the factory

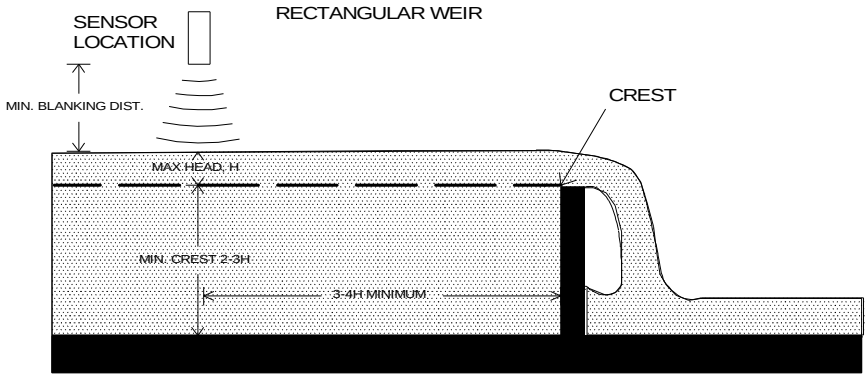
CONNECT BOTH DST SENSORS TO THE DCR- CONTROLLER BY USING THE COAXIAL SPLITTER (obtained from APG)

37	1	The display will show the distance from DST # 1 to the level. Confirm that the DST is detecting the proper level
37	2	The display will show the distance from DST # 2 to the level. Confirm that the DST is detecting the proper level
37	0	Display the differential measurement between DST # 1 and # 2



OPEN CHANNEL FLOW

The DCR-1003, 1004 and DST ultrasonic system can be used to compute the flow of a liquid in an open channel such as rivers, canals, and partially filled conduits. The flow is determined by using the DCR/DST system to measure the liquid level upstream from a weir or flume. Weirs and flumes are simply special shaped dams or restrictors built in a channel. Each type of weir or flume has an associated equation for calculating flow. By programming the specified constants into the DCR Controller and installing the DST sensor to monitor the upstream depth of the weir or flume, an exact flow measurement can be continually obtained. All relay and analog outputs must be programmed in the units of flow.



The standard flow equation for a weir or flume is:

$Q = KH^X$

where Q = *flow*
K = *constant*
H = *head, or water depth to zero point*
X = *exponent*

The equation for the weir or flume being used can be obtained from the respective manufacturer. Two examples will show how the DCR/DST system can monitor flow.used to convert distance to flow.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
38	*Constant Above Decimal Point*	Range = 0 - 9999 Default = 1	Sets the portion of the multiplier (K) above the decimal point, used for converting distance to flow
39	*Constant Below Decimal Point*	Range = .0000 - .9999 Default = .0000	Sets the portion of the multiplier (K) below the decimal point, used for converting distance to flow
40	*Decimal Point*	Range = 0000. - 0.000 Default = 00.00	Sets the decimal point position of the display. Same as mode 4.
41	*Span*	Units = mode 1 Range = 0.000 - 9999 Default = 12.00 feet	Sets the measured distance from .5" behind the DST face to the zero flow level
42	*Exponent Above Decimal Point*	Range = 0 - 9999 Default = 1	Sets the portion of the exponent (X) above the decimal point, used to convert distance to flow
43	*Exponent Below Decimal Point*	Range = .0000 - .9999 Default = 0	Sets the portion of the exponent (X) below the decimal point, used to convert distance to flow

Example 8: Weir

The inlet flow to an irrigation reservoir is to be monitored and displayed in cubic feet per second (CFS). A 5 ft. rectangular weir without end contractions is to be used as the primary measuring device.

The associated flow equation for the 5 ft. weir is:

*Flow in CFS = 16.65 * H^1.5*

where H = the height of the pool above the weir crest

By mounting the DST sensor more than 2.00 ft. above the maximum pool height, and locating the sensor upstream from the weir crest as recommended for this weir type, the flow can be calculated.

**NOTE: The DCR-1004 does NOT work with contracted-end weirs.*

To program the DCR-1003, 1004 for this application, the following modes must be set:

MODE	VALUE	DESCRIPTION
Operation		
3	4	Select Open Channel Monitoring for application
5	2.00	Do not set closer than the minimum distance recommended for the DST sensor type being used
Open Channel Flow		
38	16	Constant ‘K’ above the decimal point
39	6500	Constant ‘K’ below the decimal point
40	.00	Secimal to two places
41	SPAN	Distance from .5 in. behind the transducer face to the top of the weir crest using a tape measure
42	1	Exponent ‘X’ above the decimal point
43	5000	Exponent ‘X’ below the decimal point

Example 9: Flume

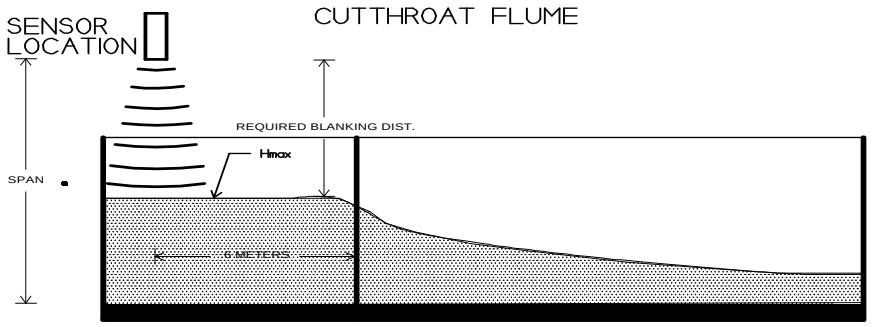
A 1 meter wide cutthroat flume has been installed on the outlet of a water treatment plant. Flow is to be displayed in liters/sec. (LPS).

The associated flow equation for the 1 meter flume is:

*Flow in LPS = 11.48 * H^1.56*
where H is the upstream head measurement as specified for this flume type.

To program the DCR-1003, 1004 for this application, the following modes must be set:

MODE	VALUE	DESCRIPTION
Operation		
1	3	Set units to meters because the output is to be displayed in liters per second.
3	4	Select Open Channel Monitoring for application
5	0.60 m	Do not set closer than the minimum blanking distance recommended for the DST sensor type being used
Open Channel Flow		
38	11	Constant 'K' above the decimal point
39	4800	Constant 'K' below the decimal point
40	.0	Decimal to one place
41	SPAN	Distance from .5 in. behind the transducer face to the bottom of the flume using a tape measure
42	1	Exponent 'X' above the decimal point
43	5600	Exponent 'X' below the decimal point



Temperature Compensation

As air temperature changes, so does the speed of sound. This change can cause .18% drift in distance for every °C change. Mode 44 allows compensation in the readings for this change. The DST contains an internal thermistor which measures temperature in degrees F. By turning temperature compensation on, the effects of temperature changes may be reduced by 50%.

For the DST temperature sensor to operate properly, it must be shielded from radiant heat. Because the temperature sensor is internal to the DST, it requires several minutes to react to air temperature changes.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
44	*Temperature Compensation*	Range = OFF, ON, temp in F Default = OFF	Selects internal temperature compensation for changes in the speed of sound, on, off, or view sensor temperature set by NUM UP or NUM DN

Calibration

For most open air applications, the factory-set calibration should be correct. Variations between the distance measured by the DCR/DST System and the actual distance are caused by environmental conditions such as temperature, humidity, or chemical atmospheres. These environments can be compensated for by using a calibration factor which alters the reading to match the application conditions.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
45	*Distance Offset*	Units = mode 1 Range = 0.000 - 9999 Default = 0	Sets an offset for the display when measuring distance to a level
46	*Offset Polarity*	Range = NEG, POS Default = NEG	Selects the direction of the offset, adds or subtracts offset to reading, set by NUM UP or NUM DN
47	*Calibration Above the Decimal Point*	Range = 0 - 9999 Default = 1	Sets the integer portion of the calibration factor
48	*Calibration Below the Decimal Point*	Range = .0000 - .9999 Default = 0	Sets the fractional portion of the calibration factor

Example 11: Calibration

1 Point Calibration

The Calibration Factor is used to bring the displayed reading in line with the measured distance. To obtain the measured distance, measure from the level to be detected to .5 in. behind the DST face. (.5 in. behind the DST face is the electrical zero of the sensor.) The calibration factor is determined by dividing the actual distance measured, by the displayed distance. Enter this number in the calibration modes 45 and 46.

2 Point Calibration

If a more precise calibration is required, a two point calibration should be used. This is accomplished by using the linear equation of $Y = AX + B$ *where;*

Y = measured distance *X = DCR Reading*
A = Multiplier *B = Offset*

The multiplier (A) can be determined by taking ultrasonic readings at two known distances and dividing the difference of the known distances (D) by the difference of the ultrasonic (U) readings *(A) = (D_2-D_1)/ (U_2-U_1) where;*

D_2 = far known distance *U_2 = Ultrasonic reading at D_2*
D_1 = close known distance *U_1 = Ultrasonic reading at D_1*

Enter this multiplier in Modes 47 and 48. The multiplier can then be entered in the above equation to calculate the offset $B = D_2 - (A)U_2$. The offset should be entered using Modes 45 and 46.

Utilities

Reset

When the DCR is powered up, 'NO' is loaded in mode 49. This saves the user-selected modes into the DCR. If the mode adjustments get scrambled or if the factory preset values are wanted, press the NUM UP key. If 'YES' is entered, the DCR will perform a reset, loading all the modes with the default parameters.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
49	Reset	Range = no - yes Default = no	Reset the mode parameters to their factory preset values (default) Set by NUM UP or NUM DN

Software Version

Mode 50 displays the software version for the DCR. The value corresponds to the operating version and the approximate date of manufacture.

MODE	DESCRIPTION	PARAMETERS	EXPLANATION
50	Software Version		Displays the software version

• Quick Reference Sheet

MODE	DESCRIPTION	PARAMETERS
Operation		
1	Units	_____
2	Decimal Point	_____
3	Operating Mode	_____
4	Sensitivity	_____
5	Blanking	_____
6	Pulses	_____
Filtering		
7	Sample Rate	_____
8	Samples Averaged	_____
9	Out-of-Range Sample	_____
10	Out-of-Range Span	_____
11	Loss of Echo Delay	_____
Relay		
12	Begin Trip 1	_____
13	End Trip 1	_____
14	Trip 1 Type	_____
15	Begin Trip 2	_____
16	End Trip 2	_____
17	Trip 2 Type	_____
18	Begin Trip 3	_____
19	End Trip 3	_____
20	Trip 3 Type	_____
21	Begin Trip 4	_____
22	End Trip 4	_____
23	Trip 4 Type	_____
Analog		
24	Analog Output	_____
25	0 or 4 mA Distance	_____
26	20 mA Distance	_____

MODE	DESCRIPTION	PARAMETERS
Analog (continued)		
27	0 or 4 mA Trim	_____
28	20 mA Trim	_____
Volume		
29	Tank Type	_____
30	Mult Above	_____
31	Mult Below	_____
32	Span	_____
33	Tank Length	_____
34	Sphere. Length	_____
35	Tank Radius	_____
Differential		
36	Change Senor #	_____
37	Display Control	_____
Open Channel Flow		
38	Constant Above	_____
39	Constant Below	_____
40	Decimal Point	_____
41	Tank Span	_____
42	Exponent Above	_____
43	Exponent Below	_____
Calibration		
44	Temp Comp	_____
45	Distance Offset	_____
46	Offset Polarity	_____
47	Calibration Above	_____
48	Calibration Below	_____
Utilities		
49	Reset	_____
50	Software Version	_____

• Trouble Shooting

The DCR-1003, DCR-1004 and DST sensor are a rugged, reliable level measurement system that is easy to install and setup. But occasionally problems will occur during set up. A list of symptoms and possible corrective actions are provided for troubleshooting.

SYMPTOM	CAUSE	ACTION
DISTANCE DISPLAY ON COM. LED IS OFF	Short circuit on the transducer	• Verify coaxial connections and wiring on cable or connector • Sensor failure
COM. LED FLASHING EVERY .5 SECONDS	Communication error	• Check coaxial cable and connectors for tight connection • Sensor failure in communication circuit
COM. LED FLASHING EVERY SECOND	Loss of echo	• Poor target characteristics see "understanding ultrasonics" section • Sensor failure in transducer circuit
DISPLAY READS ----	Display overflow	• Change calibration, multiplier, or decimal point position • DST & DCR are incompatible, upgrade DST software
DISPLAY WILL NOT CHANGE BUT LEVEL DOES	Sensor is seeing the wrong target	• Remove detected object at measured distance • Mount the sensor away from tank seams or obstructions
DISPLAY WILL ONLY READ AT CLOSE DISTANCE	Sensor is receiving strong echoes in its blanking distance	• Check transducer installation for smooth sound propagation into tank or to desired target • Increase blanking distance mode 2

• Maintenance

The DCR-1003, 1004 controller and DST sensor do not require maintenance. However, a periodic visual inspection of the system would be in order.

The DST should be kept as clean as possible for optimum performance. Dust buildup may be removed from the transducer with a cloth or by low pressure air. The DST-PVC can be cleaned with soap and water.

If the DST is visibly effected by the environment, a different type of transducer may be required.

• Specifications

	DCR-1003	**DCR-1004**
Outputs	4 relays (5 A 110 VAC)	4 relays (5 A 110 VAC) with 4-20 mA or 0-20 mA
Supply Voltage	110-220 VAC	110-220 VAC
Total Current Draw	0.1 A	0.1 A
Housing	fiberglass	fiberglass
Rating	NEMA 4X, IP65	NEMA 4X, IP65
Dimensions	8.5 x 6.5 x 4.25 in. (216 x 165 x 108 mm)	8.5 x 6.5 x 4.25 in. (216 x 165 x 108 mm)
Resolution	maximum of .01 in. (.25 mm)	maximum of .01 in. (.25 mm)
Display	4 character digital LED	4 character digital LED
Operating Temp.	-30 to 50°C	-30 to 50°C
Connector	Terminal Strip	Terminal Strip
Sample Rate	1-12 Hz	1-12 Hz
Programmable Settings	microprocessor controlled modes	microprocessor controlled modes
Sensor Connector	F connector	F connector

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