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Continous Flow Meter for Irrigation Use Manual by

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UNITED STATES DEPARTMENT OF THE INTERIOR

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and related resources in an environmentally and
economically sound manner in the interest
of the American public.

ABSTRACT

The Water Resources Research Laboratory of the U.S. Bureau of Reclamation has developed a continuous flow meter and recorder to measure flow volumes over open channel water measurement devices. The meter has been specifically designed for irrigation water management. This document is both the user and technical manual for the continuous flow meter.

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INTRODUCTION

There is increasing demand on the world's water supply as various entities vie for water use. Today, water managers must provide water for multiple uses including agricultural, municipal, industrial, protecting environmental habitat, and fisheries. Water measurement and recording are key to effective management of an irrigation system (Reclamation, 1997).

New irrigation facilities are usually equipped with measurement and recording devices for conservation and equitable distribution. Managers of older irrigation systems are presented with the challenge to provide cost effective methods to accurately measure and record water use in systems not initially designed with water measurement in mind. Districts need simple, low-cost, robust devices to measure and record water use to make effective water management decisions. This need has resulted in the development of a continuous flow meter and recorder (CFM). The CFM is designed to continuously measure flow rates passing through open channel measurement structures, such as flumes or weirs, by recording the water levels upstream. The water level measurements are then converted to flow rate using a simple weir power equation. The CFM consists of a CPU, that is easily programmed, an LCD, for displaying the flow rate and total amount of water that has passed the measurement structure, and a water level sensor.

Some of these devices are currently installed on irrigation systems in the field. Despite the harsh environments, the CFMs are functioning as designed. This manual discusses the Water Resources Research Laboratory's development, operation, testing and installation of the continuous flow meter (CFM) specifically designed for irrigation water management.

OBJECTIVE

Several goals were defined for the development of the CFM for irrigation use. A water measurement and recording device for open channel irrigation systems should:

- be easily used with farm head gates,
- be inexpensive,
- be reliable,
- pass debris and function with sediment-laden flow,
- have a built-in programmable data logger using a generalized form of the weir equation with simple button or keypad input,
- have a continuous display of flow rate and totalized flow volume,
- have an easily resettable totalizer,
- be easy to install, including set up, and programming,
- be easy to use and maintain by ditch riders and farmers.

CONCLUSIONS

The continuous flow meter was designed specifically for irrigation use and has broad application to thousands of water diversions that are currently made without accurate flow measurement. It can easily be used upstream of an open channel measurement device to continuously sense the water surface level and directly convert and display the volume of water diverted or used. This is a great advantage over staff gauges, existing generic data logging devices, and chart recorders. The CFM is also a cost effective device. Continuous measurement and totalized volumes of water delivered provides the best method of accounting for diverted water. The continuous measuring capability is really the only way for water resource managers, whether a governmental agency, irrigation district, private firm, or individual farmer to accurately measure and potentially conserve water.

INSTRUMENT DESCRIPTION AND DEVELOPMENT

The device developed is referred to as the continuous flow meter or CFM. It includes a water level sensor and a central processing unit (CPU) to continuously record water level, convert to flow rate and totalize the flow, and display flow rate and total volume of water delivered - all for a reasonable cost. Recent advances in technology have made inexpensive components available that can be combined in a compact single unit or can be easily configured to suit the needs of various water measurement applications.

Any water level sensor that outputs a voltage or current signal is compatible with the device CPU. Water level sensing devices include pressure transducers, bubblers, acoustic or ultrasonic devices, capacitance probes, and floats. A relatively low-cost, non-intrusive, LA15-50X1 ultrasonic water level sensor, supplied by Flowline Level Sensors, was chosen for the prototype device. In addition, this sensor has temperature compensation to reduce error that may occur from fluctuating air temperatures. The ultrasonic water level sensor does not require a stilling well and is easily mounted above the canal water surface. Mounting the sensor above the water surface greatly reduces the installation cost and maintenance because the sensor is not subjected to sediment, algae, or debris in the irrigation channel.

The initially developed CFM combines an ultrasonic transducer, data logger, and readout into a single compact system (figure 1). Because it is designed for agricultural usage, it is much simpler to use, easier to install, and more compact than other generic data logging systems.

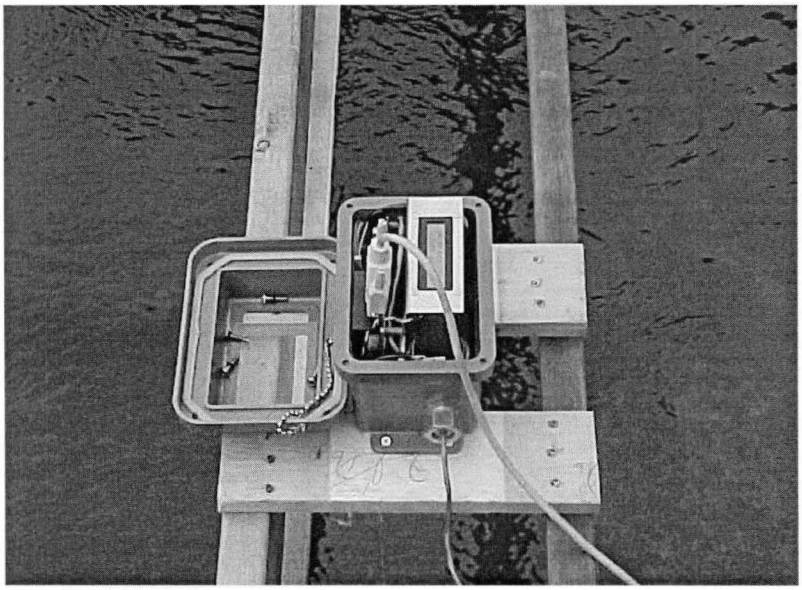


Figure 1. The single-unit CFM installed just upstream from a measurement structure. The sensor part of the meter extends out of the bottom of the enclosure.

If required, the CFM may be constructed so that the CPU and display are separate from the sensing unit (figure 2). This allows for applications where the sensor must be mounted over or in the canal or in a stilling well and it is more convenient to have the CPU and display mounted on the side of the canal.

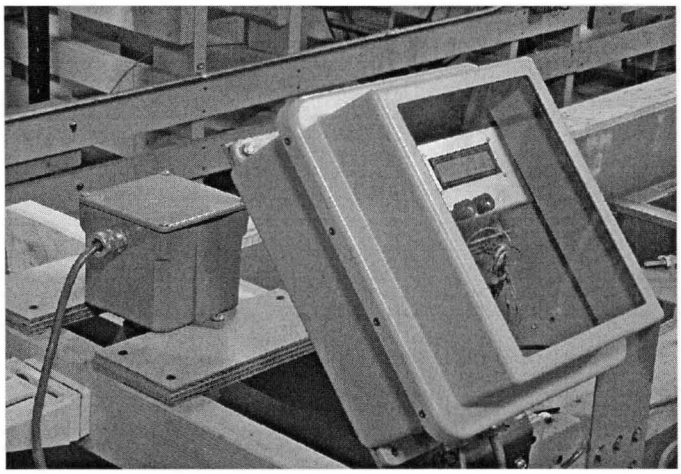


Figure 2. CFM mounted in Reclamation's Water Resources Research Laboratory. The ultrasonic sensor is located in the smaller enclosure to the left while the CPU and display are located in the enclosure to the right.

Several low-cost CPU's were considered for this project. The criteria used for selecting the CPU were availability, low cost, ease of programming, little or no fabrication requirement, an adequate number of input/output ports, and reliability. The BasicX-24 CPU supplied by NetMedia, Inc. was selected for use with the CFM. It has digital input/output ports, one of which is used to send the serial data to the liquid crystal display (LCD). The CPU also has an onboard analog to digital converter that is used to convert the analog signal from the sensor to a digital signal that is used by the CPU to determine the water depth and subsequent flow rate. A wiring diagram of the CFM circuit and power components is shown in figure 3.

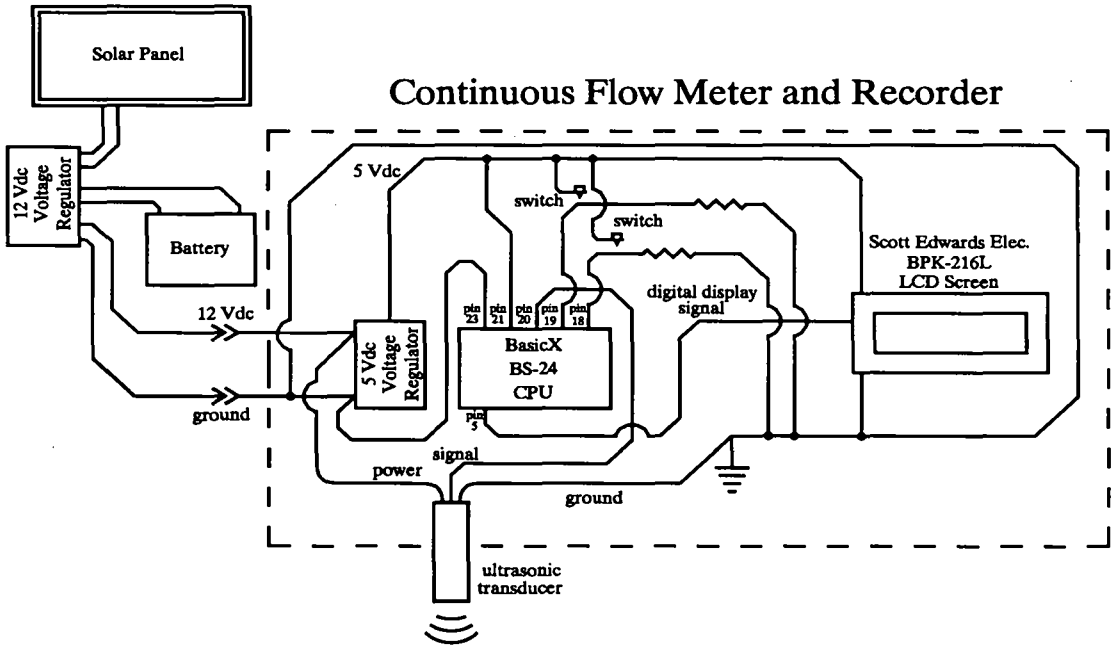


Figure 3. Wiring diagram of the components required for the CFM.

Program

The CPU can be programmed in Basic or assembly language. The prototype is programmed in Basic. The program for the CPU is easily downloaded via software provided by the CPU manufacturer. The program is downloaded with a laptop computer, a 9 pin serial cable, and the interface program. The program, given in Appendix A, is menu driven and user friendly. The code programmed into the CPU performs five tasks:

- Gathers multiple voltage readings from the sensor.
- Converts the voltage readings to a water level.
- Computes the flow rate from the water level using a generalized weir equation.

- Computes the total amount of water that has been diverted and stores it.
- Checks to see if the operator has accessed the CPU to make calibration changes to the meter.

Multiple voltage readings are recorded by the CPU in a short period of time and averaged to reduce variability that may occur in the sensor readings. The water level is computed from these readings using a standard calibration equation provided by the sensor manufacturer. This equation relates voltage to water depth in feet. Once the water depth is determined, the flow rate is computed by the CPU using a generalized form of the weir equation:

$$Q=C_dH_d^K \quad (1)$$

where Q is flow rate in ft^3/s, C_d is a discharge coefficient that includes the width of the control section, H_d is the head on the flume or weir in feet, and K is the discharge power. The initial values for the coefficients C_d and K are downloaded using the computer and are based upon the water measurement structure design. A coefficient for correction in the head measurement could have been included, but was omitted to simplify meter set up procedures and avoid possible confusion. The head correction coefficient has only a minor effect on the flow calculation. The reference head is entered during installation of the CFM on the canal and is the distance from the sensor to the control section or a known water surface. The CPU then computes the total amount of water that has been diverted. The LCD is updated with the flow rate and total amount of diverted water.

After the CPU has computed, displayed, and stored the total volume of water it checks to see if the operator wants to make changes to the meter configuration. Changes can be made if the initial parameters are not correct.

To access the meter configuration parameters, the operator simultaneously presses the two buttons (switches provided by Allied Electronics) that are on the case of the enclosure, figure 4. A series of prompts are then displayed. The prompts indicate the button that must be pressed to change values within the program.

When the buttons are pressed, the operator may access previous irrigations for display and hand recording, and zero the totalized water from the previous irrigation. At this point in the menu, the operator is prompted to input a number code that prevents tampering with critical data and parameters. The number code comes with the unit and must be entered correctly before access is allowed to the rest of the setup menu. If the right number is entered, the water level will be displayed and the operator will be prompted to change the water level offset. The discharge coefficient change prompt is then displayed, followed by the discharge power prompt. Finally, the operator is given the opportunity to zero the total water diverted. The totalized flow normally increases much like the odometer on an automobile. It is not recommended that this value be reset unless there is a valid reason. If no

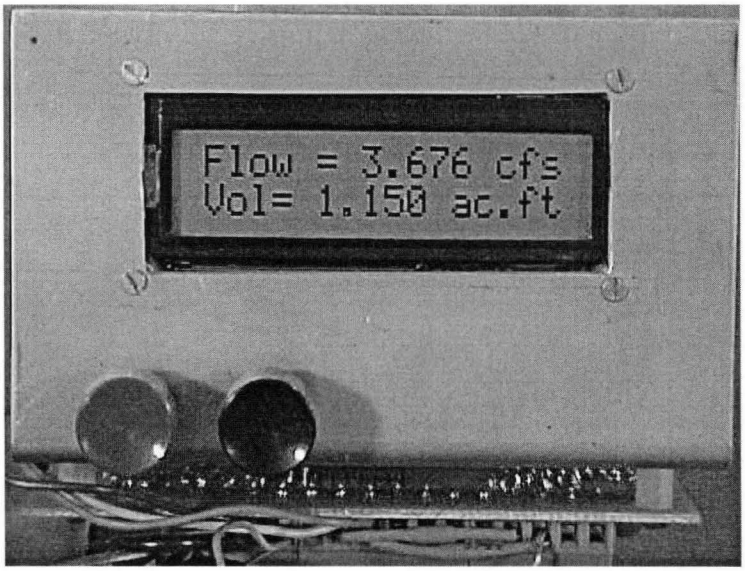


Figure 4. Typical meter display of the current flow rate and totalized flow volume.

changes are needed or the wrong number is entered (and no further buttons are pressed), the program will step through and return to the measurement and display routine. The procedure is given in detail in the Operation section of this manual.

The 2X16 Serial LCD was supplied by Scott Edwards Electronics, Inc. It is designed to take an RS 232 signal and display the data that is contained in the signal. The display operates on 5 Vdc and draws a low amount of current. The meter displays the flow rate data in cubic feet per second (cfs) and acre feet (ac-ft), but the data may be recorded or displayed in various formats such as gallons per minute, total gallons, etc. A schematic of the bracket used to mount the CFM is shown in Appendix C.

The CFM with the ultrasonic water level sensor has slightly greater power requirements than a device that would use a pressure transducer or a float and pulley transducer. A 15 watt solar panel, voltage regulator, and 20 amp hour battery were selected for the power requirements of this device. If AC power is available, an AC to DC converter can be substituted for a solar panel and voltage regulator.

A parts list and parts manufacturers information is given in Appendices B and D.

The CFM (case No. REC-3653) is U.S. patent pending under patent application serial No. 09/640,710.

TESTING

The CFM was developed and tested in Reclamation's Water Resources Research Laboratory (WRRL). The WRRL model canal facility was used extensively in the development and testing phases of the CFM. The model canal facility is 300-feet-long and is made from clear acrylic Plexiglas and aluminum. It has motorized control gates, turnouts, a long-throated flow measurement flume, and an inverted siphon. The model canal has many of the control and flow measurement features that are currently used on irrigation canals.

Extensive development and testing was conducted with the CFM installed on the canal just upstream from a long-throated flume. The test facility has been invaluable in identifying and correcting potential problems and ensuring that the CFM would operate properly in an open channel field application. In addition, the CFM has been successfully tested with a bubbler sensor and several submersible pressure transducers.

Field testing of the CFM is currently ongoing with both ultrasonic and bubbler sensors in Montana (Stringam and Frizell, 2000) and Arizona. Results show that the CFM and sensors are performing well.

INSTALLATION

The system can be field mounted directly over the conveyance channel or in a stilling well. The simple design of this water level sensor and recording device allows for quick and easy installations.

Required tools and equipment: Engineers level, survey equipment, staff gage, screw drivers, hammer, drill, 2x6 plank, 1x4 boards or suitable support to span the channel, battery enclosure, screws, and nails. An additional enclosure or stilling well may be required depending upon sensor selection or preferred data logging location.

The sensor needs to be installed at a level location that is upstream of the flume or weir as specified by the designer. It should be installed so that it is away from the sides of the flume or canal bank. Two 2x6 planks that are spaced about 1 foot apart function as a suitable platform for mounting this sensor. Nail or screw 1x4 boards onto the planks to preserve the plank spacing and function as a mounting platform for the sensor. A cover was fabricated and placed over the sensing unit to provide extra protection from the sun and weather. A typical field installation is shown on figure 5.

The CFM calculates flow based upon the formula in equation 1 and references head or water level to the control section or sill height. It is usually a good idea to obtain this reference distance from the control section to the sensor during installation.

Figure 5. The complete CFM and sensor setup, including solar power. The sensor is mounted on a Parshall Flume under a protective cover.

This can be accomplished by surveying the elevations of the sensor and the control section, regardless of the type of sensor being used. Or while there is no water in the canal, several boards or something that will **exactly** equal the height of the sill, can be placed under the ultrasonic sensor and the distance from the sensor to the control section recorded. Either method would produce a calibration level of 0.0 ft. If water is flowing over the measurement device, then the depth above the sill at the flow sensor location must be accurately known for entry.

It is good practice to bury the power cable from the power supply to the sensor unit. This will protect the cable from accidents and sunlight damage. Placing the battery in an enclosure that is painted white will help keep the battery cool.

OPERATION

Once the sensor has been properly installed and powered up, the screen will display flow rate and total amount of diverted water per irrigation as shown in figure 4. The red and black buttons must be pressed simultaneously to access the system menu. After this, a series of prompts will occur. The prompts will indicate the button that must be pressed to change values within the program. If a number must be changed, the red button may be used to decrease the number and the black button to increase the number. If no changes are needed (no further buttons pressed) the program will step through and return to the flow rate and totalized flow display. The

program also has a number code that prevents tampering with the unit. The number code comes with the unit and must be entered prior to changing protected data.

To begin the setup, the red and black buttons are pressed together, and the display should read:

"Zero Acre Feet?
Red Button"

If the red button is pushed the total amount of diverted water per irrigation is zeroed and stored in memory. If this routine is accessed, the present value for diverted water will always be stored in memory.

The display should then read:

"Prev. Irrigations
"Black Button"

If the black button is pushed, the amount of water that was used in the previous irrigations is displayed for each irrigation.

A number code must be known for access to the following routines. The display will read:

"Access Protected Data
Red Button"

If the red button is pressed, a number will be displayed on the LCD. Press either the red or black button to change the number to match the code number. Press both buttons together to resume. If the number is equal to the code, the program will proceed with the routines that provide calibration data for the flow equation.

The first routine needs the reference to the control section elevation that was recorded during installation. The display will alternate between the next two readouts:

"Water level is
###.## ft."

and

"Calb. Level?
Red Button"

If the water level needs to be adjusted, the red button must be pressed. The display will then read the water level and the black and/or red buttons must be pressed to adjust the level up or down. Once the level is at the desired value, both buttons must be pressed together to exit this routine.

The display will then read:

"Change Dis. Coe
Red Button"

If the red button is pressed, the discharge coefficient will be displayed on the LCD. This has been preprogrammed and should not need to be changed. If this value is changed, the C_d from the generalized weir equation is changed. Once the value is at the desired reading, both buttons must be pressed together to resume.

The display should then read:

"Change Dis. Pow
Black Button"

If the black button is pressed, the discharge power will be displayed on the LCD. This has been preprogrammed and should not need to be changed. This feature adjusts the K value in the generalized weir equation. Once the value is at the desired reading, both buttons must be pressed together to resume.

The display should then read:

"Zero Totalized
Red Button"

If the red button is pushed, the totalized flow is set to zero. Once this step is completed, the meter resumes its programmed functions and the flow rate and total flow will again be displayed.

TROUBLESHOOTING

1) No Display
☹ Check power wire connections. A wire may not be connected or may be broken.
☹ If there is still no display the CPU may have a problem and need servicing.

2) The display is showing 0.0 flow rate despite the fact that there is water in the canal.
☹ Check the power connection to the sensor. It may be disconnected or broken.
☹ Check the signal wire to the CPU. It may be disconnected or broken.
☹ If the wire connections are good, the sensor is likely malfunctioning and needs to be replaced.
☹ Access the water level calibration in setup menu. Look to see if the water level has a negative or zero value. If this is true the sensor in malfunctioning.

3) The flow rate is fluctuating dramatically.
☹ Check the power connection to the sensor. If may be corroded or poorly connected.
☹ Check the signal wire to the CPU. It may be corroded or poorly connected.

☹ If the wire connections are good, the sensor is likely malfunctioning and needs to be replaced.

4) The LCD is displaying the wrong flow rate.
☹ Check the power connection to the sensor. If may be corroded or poorly connected.
☹ Check the signal wire to the CPU. It may be corroded or poorly connected.
☹ Access the water level, discharge and power coefficients in the set up menu.

REFERENCES

US Bureau of Reclamation, (1997). "Water Measurement Manual", US Government Printing Office, Washington, DC.

Stringam, B.L, and Frizell, K.H. (2000). "Irrigation Flow Measurement - Instrumentation Development Part II." Operation and Maintenance Bulletin No. 193, US Department of the Interior, Bureau of Reclamation, Denver Colorado.

APPENDIX A
CFM Basic Program

```
'*****************************************************************************************************
'************************ CFM flume open channel flow meter program **********************
'*****************************************************************************************************

Dim Ocom3(1 to 40) As Byte                  'LCD serial com setup
Dim Icom3(1 to 40) As Byte                  'LCD serial com setup

Dim Toggle As Boolean                       'needed routine
Dim MainV As Single                         'needed routine
Dim LogicV As Single                        'needed routine
Dim V1 As Single                            'raw voltage input
Dim C1 As Single                            'flow power equation coefficient
Dim P1 As Single                            'flow power equation power
Dim R1 As Single                            'variable to compare to secret number
Dim L1 As Single                            'water level
Dim L As Single                             'water level sum variable
Dim Q As Single                             'flow rate
Dim c As Single                             'averaging counter
Dim Lsec As Single                          'last sec recorded
Dim sec As Single                           'last sec recorded
Dim dt As Single                            'difference in time
Dim vol As Single                           'total water volume
Dim tvol As Single                          'total water volume
Dim sc1 As Single                           'total floating point water volume
Dim d1 As Single                            'variable for accessing menu
Dim d2 As Single                            'variable for accessing menu
Dim irrg(1 To 12) As Single                 'variable for storing previous irrigations
Dim lev As Single                           'variable for water level calibration
Dim slope As Single                         'variable for water level slope/span
Dim off As Single                           'variable for water level offset
Dim off2 As Single                          'variable for water level offset

Dim a As Integer
Dim Qi As Integer
Dim Vi As Integer
Dim sc2 As Integer
Dim flag As Integer


Sub Main()

Call OpenQueue(Icom3,40)                    ' initialize input variable
Call OpenQueue(Ocom3,40)                    ' initialize output variable

Call DefineCom3(6,5,bx1000_1000)            ' initialize input and output port
```

```
Call OpenCom(3,2400,Icom3,Ocom3)          ' set baud rate to 2400

C1 = 15.87                              ' flow power equation coefficient
                                          '3.459  &  1.6 or 47.05 & 1.625
P1 = 1.798                                ' flow power equation power
slope =5.8530
                                          '2.8493 & -0.8854 or 3.7086 & -2.5092
off = -4.1639                             ' ultra offset -1.1155
off2 = 0.0                                ' initialize variable
Lsec = Timer                              ' raw time in secs

sc1 = 0.0                                 ' initialize variable
vol = 0.0                                 ' initialize variable
tvol = 0.0                                ' initialize variable
flag = 5                                  ' initialize variable
a=0                                       ' initialize variable

Do                                        ' loop for ever

c = 0.0                                   ' zero counter
L = 0.0                                   ' zero accumulator

Do While © < 101.0)                       ' read A/D 100 times

  c = c + 1.0                             ' increment count
  Call GetADC(20,V1)                      ' read A/D
  L = V1 + L                              ' sum
Loop

L=L/100.0                                 ' average reading
L1 = slope * L                          ' compute level (ultra gain 2.8169)
L1=L1 + off                               ' add offset
L1=L1 + off2                            ' add offset
If (L1 < 0.0001) Then
  L1 = 0.0
End If

Q = C1 * (Pow(L1,P1))                     ' compute flow rate
sec = Timer
'Call GetTime(hour, min, sec)             ' get time
dt = sec - Lsec                         ' compute time interval
If (dt < 0.0) Then                        ' check for negative value

  dt = dt + 86400.0
```

```
End If

sc1 = sc1 + (Q * dt)                          ' sum total water volume cubic feet
vol = sc1 / 43560.0                           ' compute acre feet
tvol = tvol + (Q * dt) / 43560.0              ' compute acre feet again

Lsec = sec                                    ' set last sec

' ******************  Print Flowrate to LCD  ************************

Call PutQueueStr(Ocom3,"Flow = " )
If (Q > 200.0) Then                           ' check large number code can't
                                              handle
  Qi = CInt(Q)                                ' convert to integer
  Call PutI(Qi)                               ' print flow rate to LCD
Else
  Call  PutS(Q)                          ' print flow rate to LCD
End If

Call PutQueueStr(Ocom3," cfs " )              ' print cfs to LCD
Call PutQueueStr(Ocom3,chr(254) & chr(192))

' ******************  Print total volume to LCD  ************************


Call PutQueueStr(Ocom3,"Vol= " )
If (vol > 200.0) Then                         ' check large number code can't
                                              handle
  Vi = CInt(vol)                              ' convert to integer
  Call PutI(Vi)                               ' print total volume (acre feet) to LCD
Else
  Call PutS(vol)                         ' print total volume (acre feet) to LCD
End If
Call PutQueueStr(Ocom3," ac.ft." )            ' print total volume (ac. ft.) to LCD
Call Delay (1.5)

' ***************************  Clear LCD  ******************************

Call PutQueueStr(ocom3,chr(254) & chr(1))

  Call GetADC(18,d1)                          ' read A/D to check switches
  Call GetADC(17,d2)                          ' read A/D to check switches

If (d1 > 0.1) And (d2 > 0.1) Then             ' check to see if switch pressed
```

```
d1 = 0.0
d2 = 0.0
c = 0.0
Do While © < 8.0)
  Call PutQueueStr(Ocom3," End Irrigation? " )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3,"   Red Button" )
  Call Delay (1.0)
  Call PutQueueStr(ocom3,chr(254) & chr(1))
  c = c + 1.0

  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches


  If (d1 < 0.1)  AND (d2 > 0.1) Then    ' red button pushed (but not black)

    a = a + 1
    If (a > 10) Then
      a = 1
    End If

    irrg(a) = sc1 / 43560.0
    sc1=0.0
    Call PutQueueStr(ocom3,chr(254) & chr(1))
    Call PutQueueStr(Ocom3," Ac. Ft. Zeroed " )

    Call Delay (2.0)
    c = 8.0                             ' force end of loop
  End If

 If (d1 > 0.1)  AND (d2 < 0.1) Then     ' black button pressed skip next option
    c = 8.0
  End If
Loop

c = 0.0
d1 = 0.0
d2 = 0.0

Do While © < 8.0)
  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3,"  Prev. Irrigs. " )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3,"  Black Button" )
```

```
  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches
  Call Delay (1.0)
  c = c + 1.0

  If (d1 > 0.1) and (d2 < 0.1) Then             'black button pushed only
    Dim i as Integer
    For i = 1 to a

      Call PutQueueStr(ocom3,chr(254) & chr(1))
      Call PutQueueStr(Ocom3," Irrigation  " )
      Call PutI(i)

      Call PutQueueStr(Ocom3,chr(254) & chr(192))
      Call PutS(irrg(i))
      Call PutQueueStr(Ocom3," ac.ft." )
      Call Delay (2.0)

    Next

    Call PutQueueStr(ocom3,chr(254) & chr(1))
    Call PutQueueStr(Ocom3," Total Irrig. Water" )
    Call PutQueueStr(Ocom3,chr(254) & chr(192))
    Call PutS(tvol)
    Call PutQueueStr(Ocom3," ac.ft." )
    Call Delay (2.0)
    c = 8.0

  End If

Loop
c = 0.0
lev = L1                                    ' save water level for cal. purposes
R1 = 83.0

Do While © < 8.0)

  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3," Protected Data?" )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3," Red Button" )

  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches
```

```
  Call Delay (1.0)
  c = c + 1.0

  If (d1 < 0.1) And (d2 > 0.1) Then              ' red button pushed only

    d1 = 0.0
    d2 = 0.0
    Call PutQueueStr(ocom3,chr(254) & chr(1))
    Call PutQueueStr(Ocom3," Pass Word val. is" )


    Do While (d1 < 0.1) Or (d2 < 0.1)            ' do until both buttons pushed

      d1 = 0.0
      d2 = 0.0
      Call GetADC(18,d1)                         ' read A/D to check switches
      Call GetADC(17,d2)                         ' read A/D to check switches

      If (d1 > 0.1) and (d2 < 0.1) Then
        R1 = R1 + 1.0
      End If

      If (d1 < 0.1) and (d2 > 0.1) Then
        R1 = R1 - 1.0
      End If

      Call PutQueueStr(Ocom3,chr(254) & chr(192))
      Call PutQueueStr(Ocom3,"  " )
      Call PutS(R1)
      Call PutQueueStr(Ocom3,"  " )
      Call Delay (1.0)

    Loop
    c = 8.0
  End If
Loop
c = 0.0

If (R1 = 79.0) Then                              ' if set correct secret #

   Do While © < 8.0)

    If (Toggle) Then
      Call PutQueueStr(ocom3,chr(254) & chr(1))
      Call PutQueueStr(Ocom3," Water Level is" )
```

```
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3,"  " )
  Call PutS(lev)
  Call PutQueueStr(Ocom3," feet " )
  Call Delay (1.5)

End If

If (Not Toggle) Then
  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3," Calb. Level?" )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3," Red Button" )
  Call Delay (1.5)

End If

Toggle = Not Toggle

Call GetADC(18,d1)                    ' read A/D to check switches
Call GetADC(17,d2)                    ' read A/D to check switches
c = c + 1.0


If (d1 < 0.1) and (d2 > 0.1) Then     'red pushed only

  Call Delay (0.6)
  d1 = 0.0
  d2 = 0.0

  Do While (d1 < 0.1) Or (d2 < 0.1)   'both buttons pushed

    d1 = 0.0
    d2 = 0.0
    Call PutQueueStr(ocom3,chr(254) & chr(1))
    Call PutQueueStr(Ocom3," Water Level" )

    Call GetADC(18,d1)                ' read A/D to check switches
    Call GetADC(17,d2)                ' read A/D to check switches

    Call PutQueueStr(Ocom3,chr(254) & chr(192))
    Call PutS(lev)
    Call PutQueueStr(Ocom3," feet " )
    Call Delay (1.0)
```

```
      If (d1 > 0.1) and (d2 < 0.1) Then
        lev = lev + 0.01
      End If

      If (d1 < 0.1) and (d2 > 0.1) Then
        lev = lev - 0.01
      End If

    Loop
    c = 4.0
  End If

Loop
c = 0.0

  If (lev <> L1) Then
    off2 = lev - L1
  End If

d1 = 0.0
d2 = 0.0
c = 0.0

Do While © < 8.0)

  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3," Change Coeff A?" )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3," Red Button" )

  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches

  Call Delay (1.0)
  c = c + 1.0

  If (d1 < 0.1) And (d2 > 0.1) Then    ' red pushed only

    Do While (d1 < 0.1) Or (d2 < 0.1)        'both buttons pushed


      d1 = 0.0
      d2 = 0.0
      Call PutQueueStr(ocom3,chr(254) & chr(1))
      Call PutQueueStr(Ocom3," Coeff. A =" )
```

```
      Call GetADC(18,d1)                    ' read A/D to check switches
      Call GetADC(17,d2)                    ' read A/D to check switches


      If (d1 > 0.1) and (d2 < 0.1) Then
        C1 = C1 + 0.01
      End If

      If (d1 < 0.1) and (d2 > 0.1) Then
        C1 = C1 - 0.01
      End If

      Call PutQueueStr(Ocom3,chr(254) & chr(192))
      Call PutQueueStr(Ocom3,"  " )
      Call PutS(C1)
      Call PutQueueStr(Ocom3,"  " )
      Call Delay (1.0)

    Loop

    c = 8.0
  End If
Loop

c = 0.0

Do While © < 8.0)

  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3," Change Exponent B?" )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3," Red Button" )

  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches

  Call Delay (1.0)
  c = c + 1.0

  If (d1 < 0.1) And (d2 > 0.1) Then

    d1 = 0.0
    d2 = 0.0

    Do While (d1 < 0.1) Or (d2 < 0.1)
```

```
      d1 = 0.0
      d2 = 0.0
      Call PutQueueStr(ocom3,chr(254) & chr(1))
      Call PutQueueStr(Ocom3,"  Exponent B =" )

      Call GetADC(18,d1)                    ' read A/D to check switches
      Call GetADC(17,d2)                    ' read A/D to check switches

      If (d1 > 0.1) and (d2 < 0.1) Then
        P1 = P1 + 0.01
      End If

      If (d1 < 0.1) and (d2 > 0.1) Then
        P1 = P1 - 0.01
      End If

      Call PutQueueStr(Ocom3,chr(254) & chr(192))
      Call PutQueueStr(Ocom3,"  " )
      Call PutS(P1)
      Call PutQueueStr(Ocom3,"    " )
      Call Delay (1.0)

    Loop
    c = 8.0
  End If
Loop

c = 0.0

Do While © < 8.0)

  Call PutQueueStr(ocom3,chr(254) & chr(1))
  Call PutQueueStr(Ocom3," Tot. Water 0?" )
  Call PutQueueStr(Ocom3,chr(254) & chr(192))
  Call PutQueueStr(Ocom3," Red Button" )
  Call Delay (1.0)

  Call GetADC(18,d1)                    ' read A/D to check switches
  Call GetADC(17,d2)                    ' read A/D to check switches

  Call Delay (1.0)
  c = c + 1.0

  If (d1 < 0.1)  AND (d2 > 0.1) Then
    tvol = 0.0
```

```
        Call PutQueueStr(ocom3,chr(254) & chr(1))
        Call PutQueueStr(Ocom3," Totalized Water" )
        Call PutQueueStr(Ocom3,chr(254) & chr(192))
        Call PutQueueStr(Ocom3," Zeroed" )
        Call Delay (2.0)
        c = 8.0
      End If

    Loop

  Else
    Call PutQueueStr(ocom3,chr(254) & chr(1))
    Call PutQueueStr(Ocom3," Incorrect value" )
    Call PutQueueStr(Ocom3,chr(254) & chr(192))
    Call PutQueueStr(Ocom3," Total NOT Zero" )
    Call Delay (1.0)

  End If

End If

Loop

End Sub

'*********************************************************************
'************** Factory code below this point ******************
'*********************************************************************

'---------------------------------------------------------------------------


Public Sub PutByte( _
  ByVal Value As Byte)

' Sends one byte of binary data to the serial port. The byte is sent
' directly without translating it to a string.

  Call PutQueue(ocom3, Value, 1)

End Sub
'---------------------------------------------------------------------------
Public Sub NewLine()

' Outputs a <CR> <LF> to the serial port.
```

```
    Call PutByte(13)
    Call PutByte(10)

End Sub
'-------------------------------------------------------------------------
Public Sub PutLine( _
    ByRef Tx As String)

' Outputs a String type, followed by <CR> <LF>. Output is to the serial
' port.

    Call PutStr(Tx)

    Call NewLine

End Sub
'-------------------------------------------------------------------------
Public Sub PutStr( _
    ByRef Tx As String)

' Outputs a String type to the serial port.

    Dim Length As Integer, Ch As String * 1, bCh As Byte
    Dim i As Integer

    Length = Len(Tx)

    For i = 1 To Length
        Ch = Mid(Tx, i, 1)
        bCh = Asc(Ch)
        Call PutByte(bCh)
    Next

End Sub
'-------------------------------------------------------------------------
Public Sub PutB( _
    ByVal Value As Byte)

' Outputs a Byte type to the serial port.

    Dim L As Long

    L = CLng(Value)
    Call PutL(L)
```

```
End Sub
'-------------------------------------------------------------------------
Public Sub PutI( _
   ByVal Value As Integer)

' Outputs an Integer type to the serial port.

   Dim L As Long

   L = CLng(Value)
   Call PutL(L)

End Sub
'-------------------------------------------------------------------------
Public Sub PutUI( _
   ByVal Value As UnsignedInteger)

' Outputs an UnsignedInteger type to the serial port.

   Dim L As Long, V As New UnsignedInteger

   V = Value

   ' Clear L.
   L = 0

   ' Copy Value into the lower two bytes of L.
   Call BlockMove(2, MemAddress(V), MemAddress(L))

   Call PutL(L)

End Sub
'-------------------------------------------------------------------------
Public Sub PutUL( _
   ByVal Value As UnsignedLong)

' Outputs an UnsignedLong type to the serial port.

   Dim UL As New UnsignedLong, L As Long, Digit As New UnsignedLong
   Dim i As Integer, Temp As New UnsignedLong

   ' If the top bit is clear, the number is ready to go.
   If ((Value And &H80000000) = 0) Then
      Call PutL(CLng(Value))
      Exit Sub
```

```
    End If

    ' Divide by 10 is done by a right shift followed by a divide by 5.
    ' First clear top bit so we can do a signed divide.
    UL = Value
    UL = UL And &H7FFFFFFF

    ' Shift to the right 1 bit.
    L = CLng(UL)
    L = L \ 2

    ' Put the top bit back, except shifted to the right 1 bit.
    UL = CuLng(L)
    UL = UL Or &H40000000

    ' The number now fits in a signed long.
    L = CLng(UL)

    ' Divide by 5.
    L = L \ 5

    Call PutL(L)

    ' Multiply by 10. Since multiply doesn't work yet for UnsignedLong, we
    ' have to do the equivalent addition.
    Temp = CuLng(L)
    UL = 0
    For i = 1 To 10
       UL = UL + Temp
    Next

    ' Find the rightmost digit.
    Digit = Value - UL
    Call PutL(CLng(Digit))

End Sub
'-------------------------------------------------------------------------
Public Sub PutL( _
    ByVal Value As Long)

' Outputs a Long type to the serial port.

    Dim Tx As String * 11 ' -2147483648 => 11 characters
    Dim i As Long, IsNegative As Boolean
    Dim Digit As Long, DigitsHaveStarted As Boolean
```

```
' Negative limit requires special processing.
If (Value = -2147483648) Then
   Tx = "-2147483648"
   Call PutStr(Tx)
   Exit Sub
End If

' Convert to positive value.
If (Value >= 0) Then
   IsNegative = False
   i = Value
Else
   IsNegative = True
   i = -Value
End If

If (IsNegative) Then
   Call PutByte(45)    ' Negative sign.
End If

' This is for suppressing leading zeros.
DigitsHaveStarted = False

Digit = i \ 1000000000
Call OutputDigit(Digit, DigitsHaveStarted)

i = i Mod 1000000000
Digit = i \ 100000000
Call OutputDigit(Digit, DigitsHaveStarted)

i = i Mod 100000000
Digit = i \ 10000000
Call OutputDigit(Digit, DigitsHaveStarted)

i = i Mod 10000000
Digit = i \ 1000000
Call OutputDigit(Digit, DigitsHaveStarted)

i = i Mod 1000000
Digit = i \ 100000
Call OutputDigit(Digit, DigitsHaveStarted)

i = i Mod 100000
Digit = i \ 10000
Call OutputDigit(Digit, DigitsHaveStarted)
```

```
    i = i Mod 10000
    Digit = i \ 1000
    Call OutputDigit(Digit, DigitsHaveStarted)

    i = i Mod 1000
    Digit = i \ 100
    Call OutputDigit(Digit, DigitsHaveStarted)

    i = i Mod 100
    Digit = i \ 10
    Call OutputDigit(Digit, DigitsHaveStarted)

    i = i Mod 10
    Digit = i
    Call OutputDigit(Digit, DigitsHaveStarted)

    ' If no digits have been output, this must be zero.
    If (Not DigitsHaveStarted) Then
       Call PutByte(48)
    End If

End Sub
'-------------------------------------------------------------------------
Private Sub OutputDigit( _
    ByVal Digit As Long, _
    ByRef DigitsHaveStarted As Boolean)

    ' Start the digits as soon as a non-zero digit has been found.
    If (Digit > 0) Then
       DigitsHaveStarted = True
    End If

    If (DigitsHaveStarted) Then
       Call PutByte(CByte(Digit + 48))
    End If

End Sub
'-------------------------------------------------------------------------
Public Sub PutS( _
    ByVal Value As Single)

' Outputs a floating point number to the serial port. If the number can be
' displayed without using scientific notation, it is. Otherwise scientific
' notation is used.
```

```
Dim X As Single, DecimalPlace As Integer, Mantissa As Single
Dim Exponent As Integer, DigitPosition As Integer, Factor As Long
Dim D As Integer, LMant As Long, DecimalHasDisplayed As Boolean

' Special case for zero.
If (Value = 0!) Then
   Call PutByte(48) ' Zero
   Call PutByte(46) ' Decimal
   Call PutByte(48) ' Zero
   Exit Sub
End If

X = Abs(Value)

' Use scientific notation for values too big or too small.
' If (X < 0.1) Or (X > 999999.9) Then
'    Call PutSci(Value)
'    Exit Sub
' End If

' What follows is non-exponent displays for 0.1000000 < Value < 999999.9

' Sign.
If (Value < 0!) Then
   Call PutByte(45)   ' Dash.
End If

If (X < 1!) Then
   Call PutByte(48)    ' Leading zero.
   Call PutByte(46)    ' Decimal point.
   DecimalPlace = 0

   ' Convert number to a 7-digit integer.
   LMant = FixL((X * 10000000#) + 0.5)
Else
   Call SplitFloat(X, Mantissa, Exponent)
   DecimalPlace = Exponent + 2

   ' Convert mantissa to a 7-digit integer.
   LMant = FixL((Abs(Mantissa) * 1000000!) + 0.5)

   ' Correct for roundoff error. Mantissa can't be > 9.999999
   If (LMant > 9999999) Then
      LMant = 9999999
   End If
```

```
    End If

    DecimalHasDisplayed = False
    Factor = 1000000

    For DigitPosition = 1 To 4

        If (DigitPosition = DecimalPlace) Then
            Call PutByte(46) ' Decimal
            DecimalHasDisplayed = True
        End If

        D = CInt(LMant \ Factor)
        Call PutByte(CByte(D + 48))

        LMant = LMant Mod Factor

        ' Stop trailing zeros, except for one immediately following the
        ' decimal place.
        If (LMant = 0) Then
            If (DecimalHasDisplayed) Then
                Exit Sub
            End If
        End If

        Factor = Factor \ 10
    Next

End Sub
'------------------------------------------------------------------------
Private Sub SplitFloat( _
    ByVal Value As Single, _
    ByRef Mantissa As Single, _
    ByRef Exponent As Integer)

' Splits a floating point number into mantissa and exponent. The mantissa
' range is such that 1.0 <= Abs(Mantissa) < 10.0 for nonzero numbers, and
' zero otherwise.

    Dim X As Single, Factor As Single

    ' Zero is a special case.
    If (Value = 0!) Then
        Mantissa = 0!
        Exponent = 0
```

```
    Exit Sub
  End If

  X = Abs(Value)

  Exponent = 0
  Factor = 1!

  ' Multiply or divide by ten to transform number to value between 1 and 10.
  Do
    If (X >= 10!) Then
      X = X / 10!
      Factor = Factor * 10!
      Exponent = Exponent + 1
    ElseIf (X < 1!) Then
      X = X * 10!
      Factor = Factor * 10!
      Exponent = Exponent - 1
    Else
      ' If we reach this point, then 1.0 <= mantissa < 10.0.
      Exit Do
    End If
  Loop

  ' Determine mantissa.
  If (Exponent = 0) Then
    Mantissa = Value
  ElseIf (Exponent > 0) Then
    Mantissa = Value / Factor
  Else
    Mantissa = Value * Factor
  End If

End Sub
'------------------------------------------------------------------------------
```

APPENDIX B
Parts List

One of the main goals of the continuous flow meter development was to have a device available to irrigation districts and farmers that would be relatively inexpensive. The sensor is the main factor that governs the cost of this device. Great effort was taken to find an ultrasonic sensor with temperature compensation that was accurate but inexpensive. In addition to the sensor, a CPU, an LCD, a solar power supply, voltage regulator, battery, instrumentation enclosure, and miscellaneous parts are required. A summary of the parts used in the CFM is shown in the following table with the supplier. A full listing of parts with manufactures specifications is given in Appendix C.

Part	Supplier
BasicX-24 CPU	NetMedia, Inc.
Circuit board	NetMedia, Inc
Two Pushbutton Switches	Allied Electronics
LCD Display	Scott Edwards Electronics, Inc.
LA15-50X1 Ultrasonic Sensor	Flowline Level Sensors
Instrument enclosure (NEMA 4) RJW1008HPL	Stahlin
Solar Panel 15 watt	Sanelco
Voltage Regulator	Sanelco
Battery 20 amp-hour	Allied Electric
Miscellaneous Parts (wire, post for solar panel)	N/A

APPENDIX C
CFM Bracket

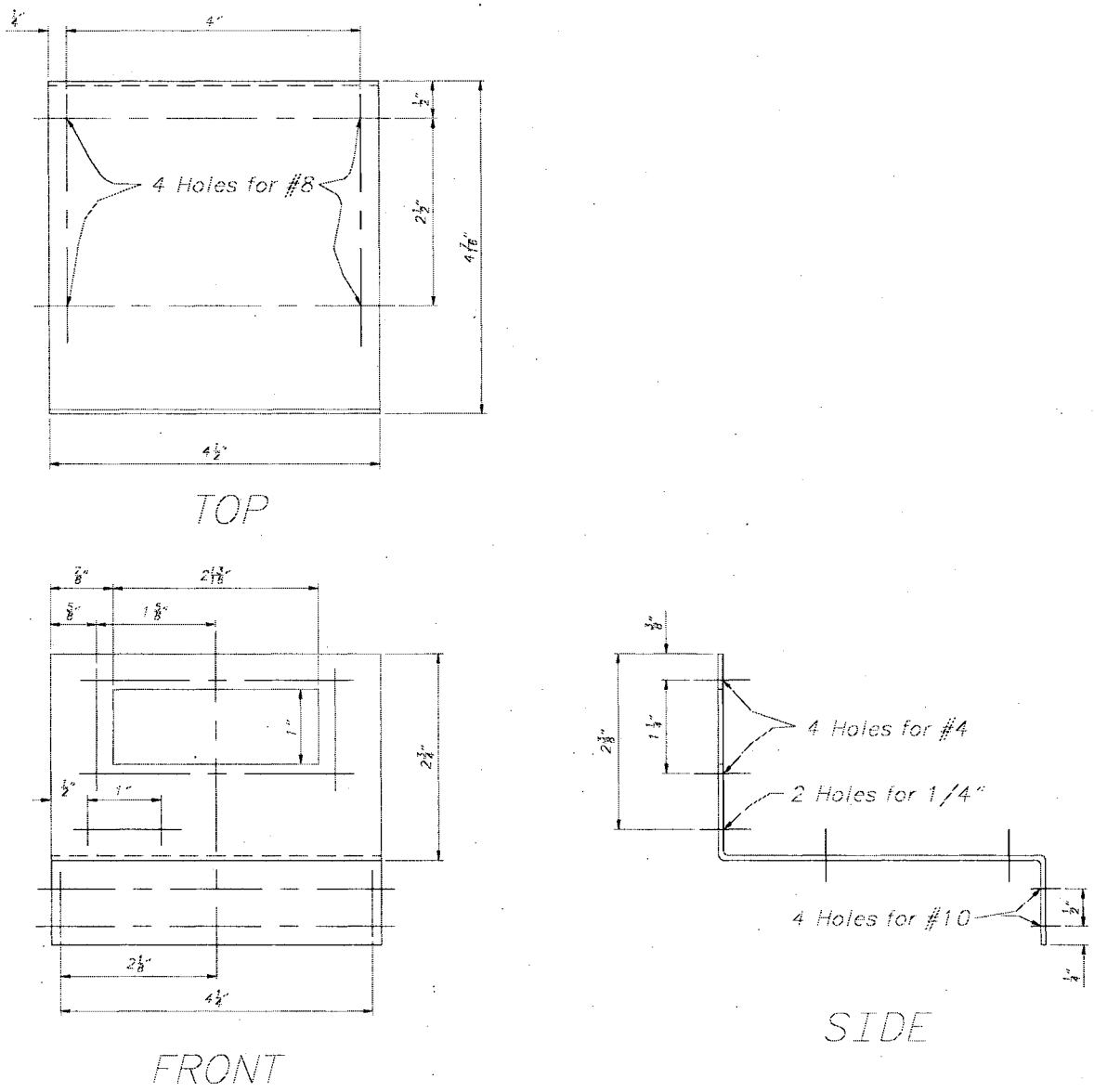


Figure 6. - Bracket for mounting the CFM enclosure.

APPENDIX D
CFM Parts Manufacturers

HOME Sunelco Directory
Sunsaver
Product 2 of 8

Sunsaver-6 Controller

The Sunsaver unit offers the advantages of the Prostar units for smaller 12 volt, 1 to 3 module systems at reduced costs. Morningstar controllers offer high reliablility with advanced battery charging technology.

Features:

- Constant voltage, PWM charge algorithm
- Temperature compensation standard
- Field selectable - flooded or sealed
- 100% solid state – no mechanical relays
- Charging and LVD LEDs
- Reverse polarity protected
- High efficiency - 3.4 mA to operate
- 5 year warranty

Specifications

Array Amperage: 6.5
Description: Standard
Low voltage disconnect max amperage: N/A

ID #: 34962
Price: **$55.00**
Retail: $55.00

Quantity: 1 Add to basket

Sunelco Home Page Go

Checkout
Contents of shopping basket

BasicX-24 Overview

NetMedia's new BX-24 is a single chip Basic-programmable Microcontroller that has all the features you've been looking for!

Onboard features include:

8 independent 10-bit Analog to Digital Converters (ADCs),
(Note: ADC pins also function as standard TTL I/Os)
16 total I/O lines (8 TTL plus 8 ADCs and/or TTL)
Pin-for-pin compatible with the BS2 and BS2SX

1200 to 19200 Baud buffered serial in or out any I/O pin
1 buffered high speed serial port (2400 Baud to 460.8 KBaud)
SPI interface

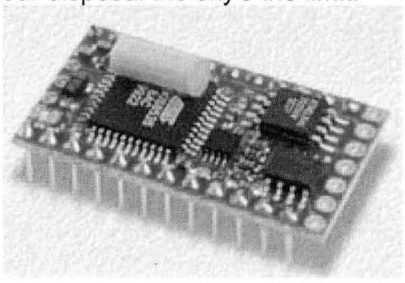
400 bytes of RAM
32 KB EEPROM for user program storage
Parallel or serial downloadable

On-chip voltage regulator
2 user controllable on-chip surface mount LEDs, red/green
System clock/calendar

Multitasking
Full IEEE floating point math
Plus much, much more!

Price: $49.95 (quantity 1)

Now with just one chip you can build a multitude of complex devices like temperature data loggers, analog joystick interfaces, real time weather stations, data terminals, virtual reality gear or smart car systems. With the power of a BX-24 at your disposal the sky's the limit!



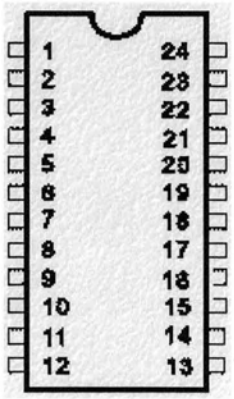
BasicX-24 Chip

BasicX-24 Specifications

I/O Lines	16 total. 8 digital and 8 10 Bit ADCs/digital I/Os
EEPROM for program and data storage	On board 32 KB SPI EEPROM Largest executable user program size = 32K
RAM	400 bytes
Analog To Digital Converter	Port A consists of 8 10Bit ADCs that can also be used as regular TTL level I/Os
ADC Sample Rate	6000 samples per second maximum
On Chip LEDs	The BX-24 contains one 2 color surface mount LED (Red/Green) that is fully user user programmable. (Not counted as an I/O line)
Program Execution Speed	65,000 lines of code per second Based on our speedtest.bas file
Serial I/O Speed	2400 to 460.8 Kbaud on Com1 300 to 19,200 baud on any I/O pin using Com3
Operating Voltage Min/Max	4.8 VDC to 15.0 VDC
Current Requirements	20 mA plus I/O loads, if any
I/O Output Source Current	10 mA @ 5 V (I/O pin driven high)
I/O Output Sink Current	20 mA @ 5 V (I/O pin pulled low)
Combined Maximum Current Load Allowed Across All I/Os	80 mA sink or source
I/O Internal Pull-up Resisters	120 k-Ohm maximum
Floating Point Math	Yes
On Chip Multitasking	Yes
On Chip Time Clock	Yes
Built In SPI Interface	Yes
PC Programming Interface	Parallel or Serial Down-loadable
Package Type	24 Pin PDIP carrier board
Environmental Specifications Absolute Maximum Ratings	Operating temperature: 0 C to +70 C Storage temperature: -65 C to +150 C

BasicX-24 package

24 Pin PDIP (Standard Package)



Pin Definitions

OVERVIEW DEVELOPMENT KIT FEATURES BASICX FAQ SPECIFICATIONS
USER'S GUIDE SCHEMATICS

BasicX CONTACT

NetMedia Inc
10940 N. Stallard Pl.
Tucson, Arizona 85737

Tel. 520-544-4567
Fax 520-544-0800

email sales@basicx.com
support support@basicx.com

MPA6 Series *"6 Amp" Panel Mount Pushbutton Wire-Lug Termination*

GREEN SERIES

MATERIAL SPECIFICATIONS:

Contacts ..... Silver clad copper with gold flash
Case Material ..... Thermoset
Actuator Material ..... Nickel plated copper alloy
Terminals ..... Copper with gold flash
Terminal Seal ..... Molded in

ENVIRONMENTAL SPECIFICATIONS:

Operating Temperature ..... -4°F to +176°F (-20°C to +80°C)
Storage Temperature ..... -40F to +176°F (-40°C to +80°C)
Solder Heat Resistance ..... See page M6-7

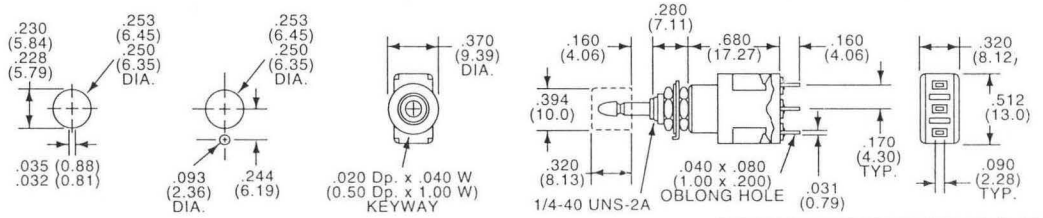
TYPICAL PERFORMANCE CHARACTERISTICS:

Contact Rating ..... 6 A @ 125 VAC, 3 A @ 250 VAC
Initial Contact Resistance ..... 10 Milliohms max.
Contact Timing ..... Break-before-make
Insulation Resistance ..... 1,000 Megohms min.
Dielectric Strength ..... 1,500 Volts RMS @ sea level
Actuation Force ..... 1.3 to 2.7 lbs.
Actuator Travel ..... .140" (3.56)
Life Expectancy ..... 50,000 Actuations

D

SPDT

MPA106D

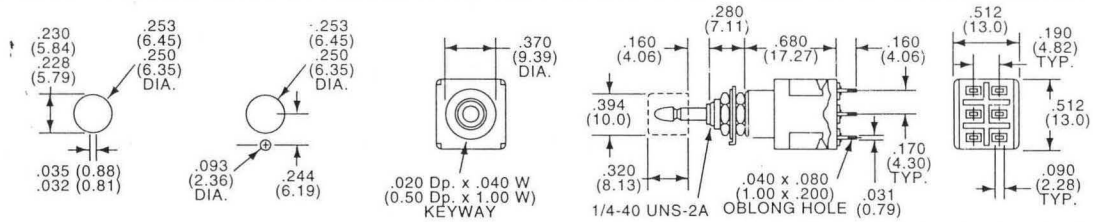


Model	Type	Act. Code P. M9	Action
MPA106D	SPDT	23	Push-on/Push-off
MPA106F	SPDT	19	Momentary

Cap not supplied, order separately (See Cap Model C22 and C23 on page D45.)

DPDT

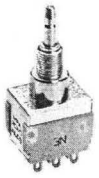
MPA206N



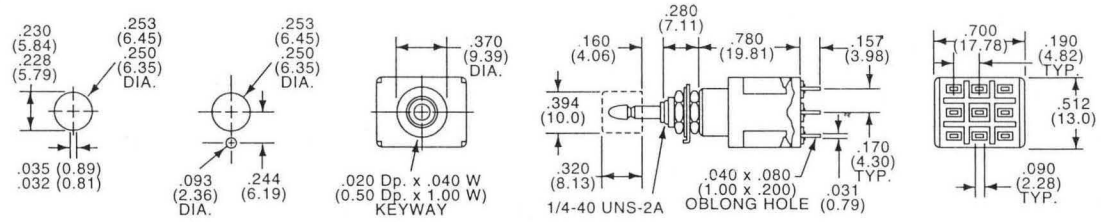
Model	Type	Act. Code P. M9	Action
MPA206N	DPDT	24	Push-on/Push-off
MPA206R	SPDT	20	Momentary
MPA206NPC	DPDT	24	Push-on/Push-off
MPA206RPC	DPDT	20	Momentary

Cap not supplied, order separately (See Cap Model C22 and C23 on page D45.)

3PDT



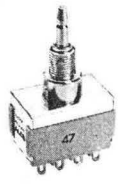
MPA306D



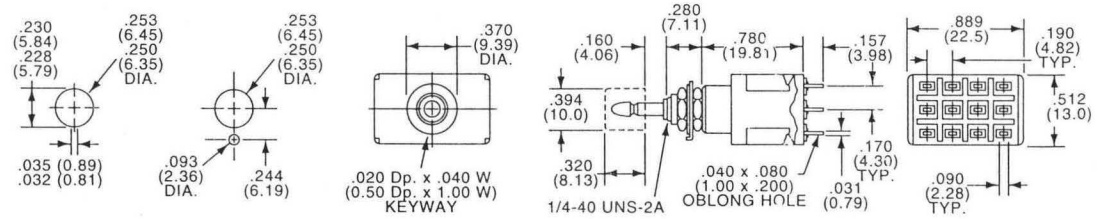
Model	Type	Act. Code P. M9	Action
MPA306D	3PDT	25	Push-on/Push-off
MPA306F	3PDT	21	Momentary

Cap not supplied, order separately (See Cap Model C22 and C23 on page D45.)

4PDT



MPA406N

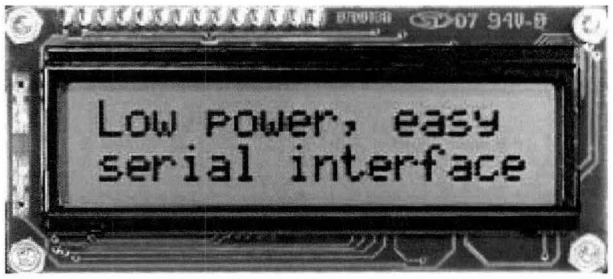


Model	Type	Act. Code P. M9	Action
MPA406N	4PDT	26	Push-on/Push-off
MPA406R	4PDT	22	Momentary

Cap not supplied, order separately (See Cap Model C22 and C23 on page D45.)

AUGAT Inc.
452 John L. Dietsch Blvd.
Attleboro Falls, MA 02763 USA
(508) 699-9800 FAX (800) 533-2526

2x16 Serial LCD Modules



BPI-216s consist of a supertwist 2x16 LCD with a serial interface factory installed. For new applications, consider our ILM-216 for the best mix of price and features. But the BPI-216 is the right choice if you require the smallest footprint, lowest current draw, or compatibility with existing Backpack® applications.

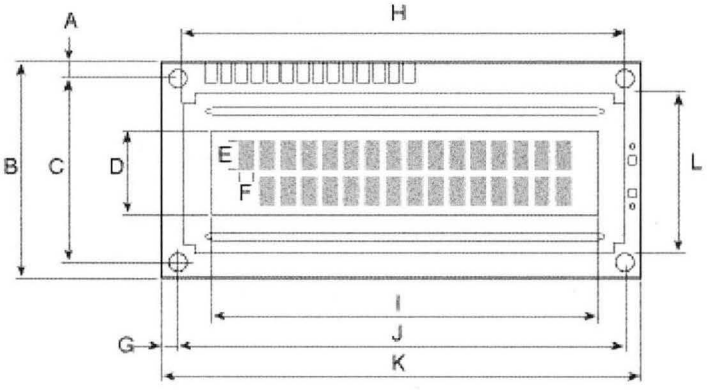
- 2400/9600 baud serial input
- Lowest current draw: 2 - 3mA
- Simple protocol prints text, passes instructions to LCD
- Display of choice for BASIC Stamp® applications
- 10s of thousands sold!

***NOTE:** As of May 1999, we have changed BPK-216 models to a new series, BPI-216. The new model is functionally identical, but incorporates some tweaks to the layout of the circuit board. See the comparison page for further information.

Dimensional Data | Basic Specs | LCD Instructions | Prices, More Info

---

Dimensional Data



A	y offset edge to hole center (top & bottom)	2.50
B	y pcb height	36.00
C	y hole spacing	31.00
D	y screen opening	16.20
E	y character size	5.94
F	x character size	2.95
G	x offset pcb edge to hole center	2.50
H	x screen frame	71.00
I	x screen opening	66.00
J	x hole spacing	75.00
K	x pcb width	80.00
L	y frame height	25.00
-	mounting hole diameter	2.50
-	frame depth, non-backlit	5.00
-	frame depth, LED backlit	8.50

- All dimensions in millimeters
- Tolerance is +/- 0.50mm
- Maximum depth (front of screen to tips of interface header posts) is 22mm (BPI-216N) or 26mm (BPI-216L).

back to top

Basic Specifications

Power requirements	4.8 to 5.5Vdc @ 3mA
User connector	5-pin header; 0.025" posts on 0.10" centers
Connector pinout	+5V GND SERIAL GND +5V
Serial Input	RS-232 or inverted TTL, 1200-9600, N81
Operating Temperature	0° to 50° C
Initialization	switches LCD power; performs soft init
Instruction prefix	ASCII 254 (0FE hex)
LCD type	Supertwist (STN), yellow-green
Optimum viewing direction	6 o'clock

back to top

LCD Instructions by Function

The BPI interface is based on our LCD Serial Backpack®, which functions as an intelligent serial-to-parallel converter. It passes data to the LCD module, which prints it to the screen. To distinguish between text and instructions, the Backpack recognizes an instruction prefix, ASCII 254. The byte following ASCII 254 will be sent to the LCD as an instruction. For example, to clear the screen, send the instruction prefix (254) followed by the LCD clear-screen code (1).

This is different from our other serial LCDs, which use a protocol that's similar to a text terminal. The Backpack protocol's simplicity means that it can run at a very low clock rate (480kHz) for the lowest possible current draw.

Function	ASCII Value
Clear screen	1
Home cursor	2
Blank display (retaining data)	8
Hide cursor	12
Show underline cursor	14
Move cursor 1 character left	16
Move cursor 1 character right	20
Scroll 1 character left	24
Scroll 1 character right	28
Set display address (position the cursor)	128 + location
Move to 1st character of 1st line	128
Move to *nth* character of 1st line	128 + *n*
Move to 1st character of 2nd line	192
Move to *nth* character of 2nd line	192 + *n*
Set character-generator address	64 + address

back to top

Links for Additional Information

- Check pricing
- Frequently asked questions (FAQ)
- Brief data sheet (Acrobat PDF format, ~43kB)
- BPK- series user manual (Acrobat PDF format, ~386kB)
- Application notes

Scott Edwards Electronics Inc.
1939 S. Frontage Rd. #F, Sierra Vista, AZ 85635
phone 520-459-4802; fax 520-459-0623
e-mail info@seetron.com

Application & Specs | Derating Charts | Dimensions | Features | Technology

Wiring Diagram | CLICK TO ADD PRODUCT TO SPEC-TOOL | Manuals

Ricochet Small Tank Alphasonic Level Transmitter LA15-50_1

Tech Tip

Ricochet Small Tank
Alphasonic Level Transmitter
LA15-50X1

The alphasonic transmitter is loaded with innovation and represents a breakthrough in ultrasonic size and performance. Once installed, the device stands only 3.75 inches above the tank top and features a tight 2 inches dead band to maximize filling tank capacity.

10500 Humbolt Street, Los Alamitos, CA 90720
Phone:(562) 598-3015 • Fax:(562) 431-8507
www.flowline.com

Derating Charts | Dimensions | Features | Technology | TechTip

Wiring Diagram | CLICK TO ADD PRODUCT TO SPEC-TOOL | Manuals

Ricochet Small Tank Alphasonic Level Transmitter LA15-50_1

Application

Ricochet Small Tank Alphasonic Level Transmitter LA15-50_1

The two-wire, small tank alphasonic level transmitter is mounted through the top wall of the tank and provides non-contact measurement up to 6 feet. This device is ideal for use with general purpose intermediate bulk containers, process vessels and plating lines. With non-contact technology, the transmitter is an excellent choice for applications with dirty, coating or scaling type media such as acid waste. The compact design is the perfect size for small tank applications.

Specifications

LA15 Ricochet Alphasonic Transmitter	
Range:	3.6" to 6' (9 cm to 1.8 m)
Accuracy:	± .25% of span in air
Resolution:	0.125" (3 mm)
Frequency:	83 kHz (nominal)
Pulse rate:	2 pulses per second
Beam width:	8¡ conical
Dead band:	3.6" (9 cm)
Supply voltage:	12-36 VDC
Max loop resistance:	600 Ohms @ 36 VDC
Signal output:	4-20 mA, 12-36 VDC
Fail-safe diagnostics:	Reverts to 22 mA LED flashing
Temperature rating:	F: -40 degrees to 140 degrees C: -40 degrees to 60 degrees
Temp. compensation:	Automatic over entire range
Pressure rating:	30 psi (2 bar) @ 25 degrees C., derated @ 1.667 psi (0.113 bar) per degree C. above 25 degrees C.
Enclosure rating:	NEMA 4X / IP65
Enclosure material:	Polypropylene, U.L. 94VO
Transducer materials:	PVDF

Mounting threads:	3/4" NPT (3/4" G)
Mounting gasket:	Viton (3/4" G) metric only
Conduit connection:	1/2" NPT
CE compliance:	EN 50082-2 immunity EN 55011 emission (pending)

Click here to Download Specifications
(PDF Format)

Click here to review recommended engineering specifications
for the Ricochet Small Tank Alphasonic Level Transmitter

Derating Charts | Dimensions | Features | Technology | TechTip

Wiring Diagram | CLICK TO ADD PRODUCT TO SPEC-TOOL | Manuals

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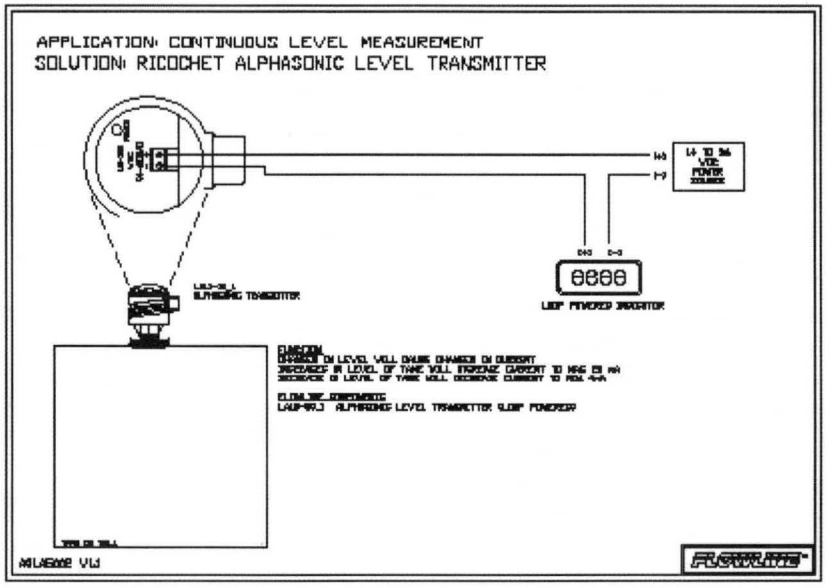
Application & Specs | Derating Charts | Dimensions | Features | Technology | TechTip
Wiring Diagram | CLICK TO ADD PRODUCT TO SPEC-TOOL | Manuals

Ricochet Small Tank Alphasonic Level Transmitter LA15-50_1

Wiring Diagram

Ricochet Small Tank
Alphasonic Level Transmitter
LA15-50_1



Download PDF LA15 Transmitter to Loop Powered Display

Application & Specs | Derating Charts | Dimensions | Features | Technology | TechTip
Wiring Diagram | CLICK TO ADD PRODUCT TO SPEC-TOOL | Manuals

Warranty, Service & Repair

To register your product with the manufacturer, fill out the enclosed warranty card and return it immediately to:

Flowline Inc.
10500 Humbolt Street
Los Alamitos, CA 90720.

If for some reason your product must be returned for factory service, contact Flowline Inc. to receive a Material Return Authorization number (MRA) first, providing the following information:

1. Part Number, Serial Number
2. Name and telephone number of someone who can answer technical questions related to the product and its application.
3. Return Shipping Address
4. Brief Description of the Symptom
5. Brief Description of the Application

Once you have received a Material Return Authorization number, ship the product prepaid in its original packing to:

Flowline Factory Service
MRA _____
10500 Humbolt Street
Los Alamitos, CA 90720

To avoid delays in processing your repair, write the MRA on the shipping label. Please include the information about the malfunction with your product. This information enables our service technicians to process your repair order as quickly as possible.

FLOWLINE®

Ricochet™ Alphasonic Level Transmitter Model LA15 Owner's Manual

Version 1.2A

Manual # LA900002 5/99

WARRANTY

Flowline warrants to the original purchaser of its products that such products will be free from defects in material and workmanship under normal use and service for a period which is equal to the shorter of one year from the date of purchase of such products or two years from the date of manufacture of such products.

This warranty covers only those components of the products which are non-moving and not subject to normal wear. Moreover, products which are modified or altered, and electrical cables which are cut to length during installation are not covered by this warranty.

Flowline's obligation under this warranty is solely and exclusively limited to the repair or replacement, at Flowline's option, of the products (or components thereof) which Flowline's examination proves to its satisfaction to be defective. FLOWLINE SHALL HAVE NO OBLIGATION FOR CONSEQUENTIAL DAMAGES TO PERSONAL OR REAL PROPERTY, OR FOR INJURY TO ANY PERSON.

This warranty does not apply to products which have been subject to electrical or chemical damage due to improper use, accident, negligence, abuse or misuse. Abuse shall be assumed when indicated by electrical damage to relays, reed switches or other components. The warranty does not apply to products which are damaged during shipment back to Flowline's factory or designated service center or are returned without the original casing on the products. Moreover, this warranty becomes immediately null and void if anyone other than service personnel authorized by Flowline attempts to repair the defective products.

Products which are thought to be defective must be shipped prepaid and insured to Flowline's factory or a designated service center (the identity and address of which will be provided upon request) within 30 days of the discovery of the defect. Such defective products must be accompanied by proof of the date of purchase.

Flowline further reserves the right to unilaterally wave this warranty and to dispose of any product returned to Flowline where:

a. There is evidence of a potentially hazardous material present with product.
b. The product has remained unclaimed at Flowline for longer than 30 days after dutifully requesting disposition of the product.

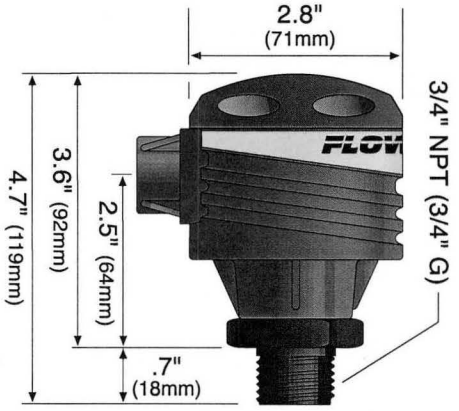
THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE OF THIS WARRANTY. This warranty and the obligations and liabilities of Flowline under it are exclusive and instead of, and the original purchaser hereby waives, all other remedies, warranties, guarantees or liabilities, express or implied. EXCLUDED FROM THIS WARRANTY IS THE IMPLIED WARRANTY OF FITNESS OF THE PRODUCTS FOR A PARTICULAR PURPOSE OR USE AND THE IMPLIED WARRANTY OF MERCHANT ABILITY OF THE PRODUCTS.

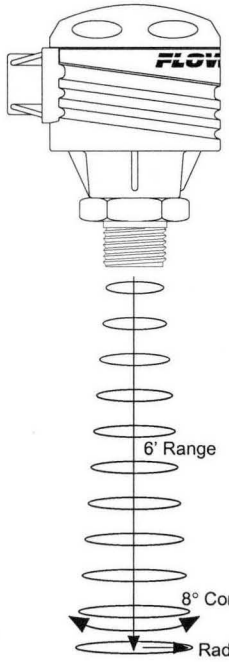
This warranty may not be extended, altered or varied except by a written instrument signed by a duly-authorized officer of Flowline, Inc.

SPECIFICATIONS

Step One

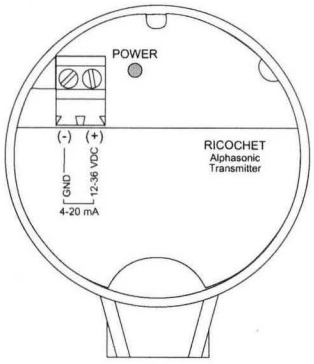
Range:	3.6" to 6' (9 cm to 1.8 m)
Accuracy:	± .25% of span in air
Resolution:	0.125" (3 mm)
Frequency:	83 kHz (nominal)
Pulse rate:	2 pulses per second
Beam width:	8° conical
Dead band:	3.6" (9 cm)
Supply voltage:	12-36 VDC
Max loop resistance:	600 Ohms @ 36 VDC
Signal output:	4-20 mA, 12-36 VDC
Fail-safe diagnostics:	Reverts to 22 mA LED flashing
Temperature rating:	F: -40° to 140° C: -40° to 60°
Temp. compensation:	Automatic over entire range
Pressure rating:	30 psi (2 bar) @ 25 °C., derated @ 1.667 psi (0.113 bar) per °C. above 25 °C.
Enclosure rating:	NEMA 4X / IP65
Enclosure material:	Polypropylene, U.L. 94VO
Transducer materials:	PVDF
Mounting threads:	3/4" NPT (3/4" G)
Mounting gasket:	Viton (3/4" G) metric only
Conduit connection:	1/2" NPT
CE compliance:	EN 50082-2 immunity EN 55011 emission (pending)



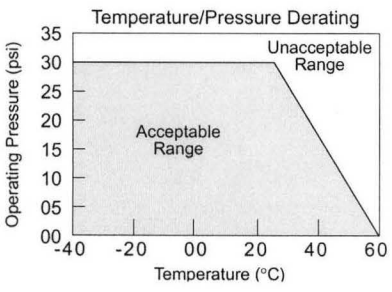


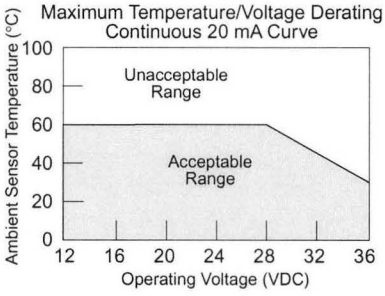
About Alphasonic Technology:

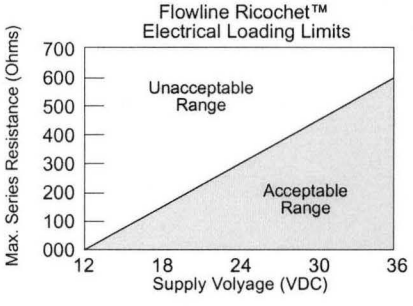
An ultrasonic sound wave is pulsed five times per second from the base of the transducer. The sound wave reflects against the process medium below and returns to the transducer. The microprocessor based electronics measures the time of flight between the sound generation and receipt, and translates this figure into the distance between the transmitter and process medium below.



Range Feet	Radius Inches	Radius cm
1	1.2	3.1
2	2.1	5.2
3	2.9	7.3
4	3.7	9.5
5	4.9	11.6
6	5.4	13.7







SAFETY PRECAUTIONS

Step Two

⚠ About this Manual:

PLEASE READ THE ENTIRE MANUAL PRIOR TO INSTALLING OR USING THIS PRODUCT. This manual includes information on the Ricochet™ Alphasonic continuous non-contact level transmitter from FLOWLINE: LA15-5001 and LA15-5061. Please refer to the part number located on the sensor label to verify the exact model which you have purchased.

⚠ User's Responsibility for Safety:

FLOWLINE manufactures a wide range of liquid level sensors and technologies. While each of these sensors is designed to operate in a wide variety of applications, it is the user's responsibility to select a sensor model that is appropriate for the application, install it properly, perform tests of the installed system, and maintain all components. The failure to do so could result in property damage or serious injury.

⚠ Proper Installation and Handling:

Because this is an electrically operated device, only properly-trained staff should install and/or repair this product. Use a proper sealant with all installations. Note: *Always install the 3/4" Viton gasket with the LA15-5061. The G threaded version of the Echotouch will not seal unless the gasket is installed properly.* Never overtighten the transmitter within the fitting. Always check for leaks prior to system start-up.

⚠ Wiring and Electrical:

A supply voltage of 12-36 VDC is used to power the LA15 transmitter. The sensor systems should never exceed a maximum of 36 volts DC. Electrical wiring of the sensor should be performed in accordance with all applicable national, state, and local codes.

⚠ Material Compatibility:

The Ricochet™ enclosure is made of Polypropylene (PP). The transducer is made of Polyvinylidene Fluoride (PVDF). Make sure that the model which you have selected is chemically compatible with the application liquids it will contact.

⚠ Enclosure:

While the transmitter housing is liquid-resistant when installed properly, it is not designed to be immersed. It should be mounted in such a way that the enclosure and diaphragm do not come into contact with fluid.

⚠ Make a Fail-Safe System:

Design a fail-safe system that accommodates the possibility of transmitter or power failure. In critical applications, FLOWLINE recommends the use of redundant backup systems and alarms in addition to the primary system.

⚠ Flammable, Explosive and Hazardous Applications:

The LA15 transmitter systems should not be used within flammable or explosive applications.

⚠ Warning ⚠

Always install the 3/4" Viton gasket with all versions of the LA15-5061. The G threaded version of the Ricochet will not seal unless the gasket is installed properly.

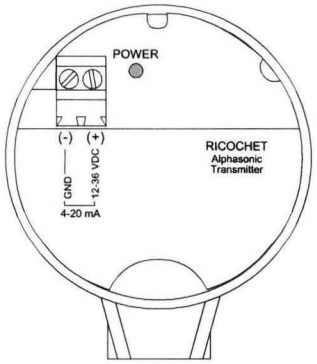
WIRING

Step Three

Wiring to Terminal:

The Ricochet™ arrives from the factory pre-calibrated and pre-assembled. Use the following instructions below for wiring to the LA15.

1. First, remove the cap of the transmitter:



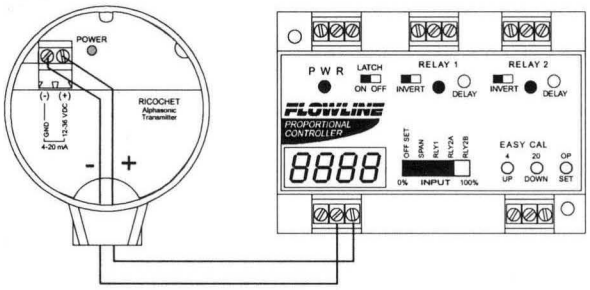
2. Look for the terminal block with two terminals.
3. Remove the terminal block to wire the LA15. The terminal to the right is positive and the terminal to the left is negative.
4. When finished attaching the wires, assemble the LA15 using steps 1 - 3 in reverse.

WIRING

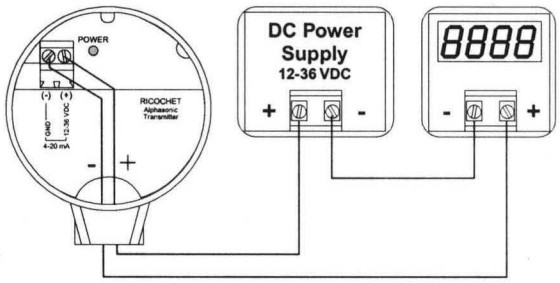
Step Four

Follow the instructions in Step 3 for wiring to the Ricochet™.

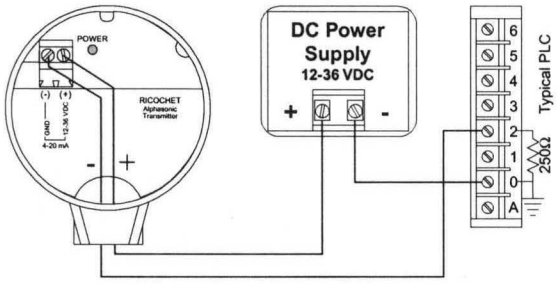
1. **Wiring to a FLOWLINE Continuous Controller (LC52):**
   Connect the (+) terminal to the positive 24 VDC, 25 mA terminal on the LC52 controller. Connect the (-) terminal to the GND terminal on the LC52 continuous controller (See illustration below). Check LC52 instruction manual for setting the LC52 for loop powered operation.



2. **Wiring to a Two-Wire Loop Powered Indicator:**
   The LA15 requires 12-36 VDC power and an indicator which receives a 4-20 mA current input. Connect the (+) terminal of the LA15 transmitter to the positive VDC terminal on the power supply. Connect the (-) terminal on the LA15 to the (+) terminal on the loop indicator. Connect the (-) of the loop indicator to the (-) of the power supply (See illustration below).



3. **Wiring to a Typical PLC:**
   The LA15 requires a PLC which provides a 12-36 VDC excitation and receives a 4-20 mA current input. Connect the (+) terminal of the LA15 transmitter to the positive VDC power terminal. Connect the (-) terminal on the LA15 to the (+) channel on the PLC. Connect the (-) of the PLC to the (-) of the power terminal (See illustration below).



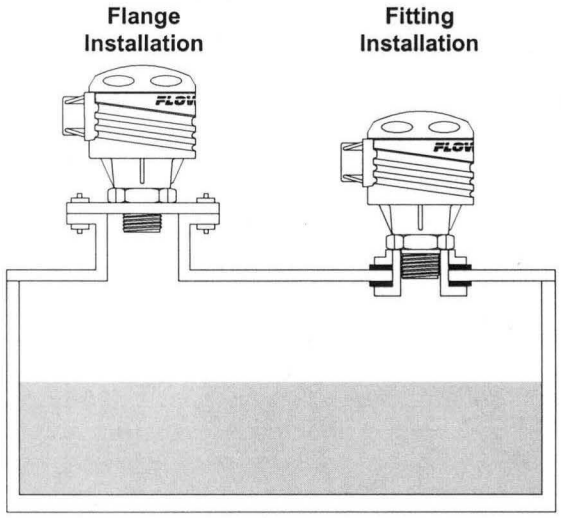
* 250 Ω resistor typically internal to PLC

INSTALLATION

Step Five

FLOWLINE's LA15 transmitter may be installed through the top wall of a tank. Installation requires a 3/4" NPT fitting or blind flange.

1. Install the appropriate 3/4" fitting in the top wall of the tank. Prior to installation, make sure that the fitting has been installed properly and checked for leaks. Use a proper sealant at the time of installation to ensure a liquid-tight seal. Secondly, make sure that the fitting's threads are not damaged or worn.
2. Insert the Transmitter into the fitting and tighten to hand tight.
3. Always check for leaks prior to system start-up. To ensure proper installation, a complete leak test and simulation of actual process conditions should be preformed.

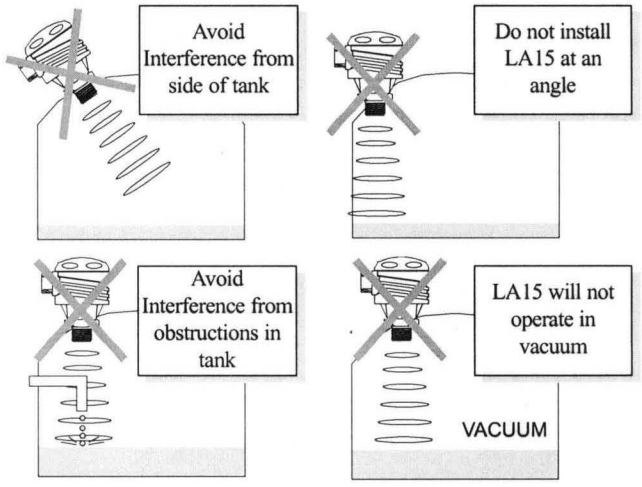


⚠ Warning ⚠

Do not install the Ricochet™ in pressurized applications above 30 psi.

Always install the 3/4" Viton gasket with all versions of the LA15-5061. The G threaded version of the Ricochet will not seal unless the gasket is installed properly.erly and checked for leaks.

Use a proper sealant at the time of installation to ensure a liquid-tight seal. Secondly, make sure that the fitting's threads are not damaged or worn.

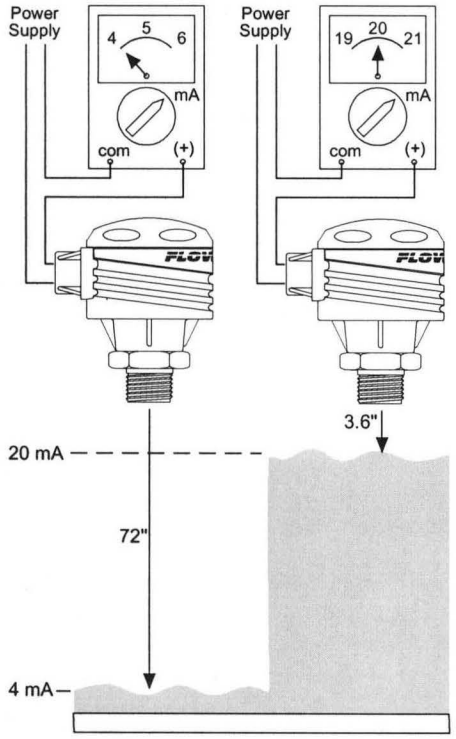


CALIBRATION

Step Six

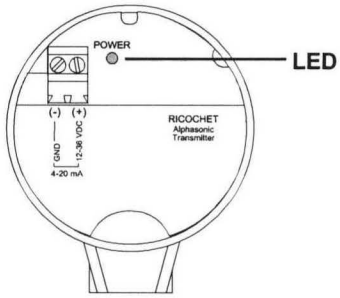
The Ricochet™ is factory calibrated with a fixed measurement span of 6 feet. The 4 mA position is located 72" from the transducer face of the LA15. The 20 mA position is located 3.6 inches from the transducer face. Refer to the current to distance and distance to current conversion charts in step seven for reading the current output.

1. Connect a multimeter in series to read the current output.
2. Verify that as the distance from the liquid to the LA15 increases, the current signal decreases.
3. Verify that as the distance from the liquid to the LA15 decreases, the current signal increases.



LED Indication

The Ricochet™ features a single LED indicator which is used for power and fail-safe indication. During normal operation, the LED will be ON continuously to indicate that the transmitter has power and a strong echo signal return strength. Should the LED begin to FLASH, it indicates that the transmitter has no signal return strength and the device has gone into a fail-safe condition. During the fail-safe condition, the current will increase up to 22 mA and hold until the acoustic signal is reacquired. Once reacquired, the LED will turn back ON continuously and the current will indicate the appropriate measured value.



CALIBRATION

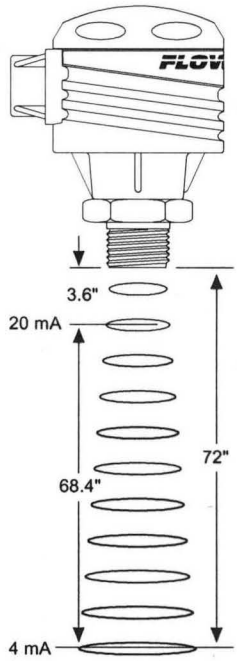
Step Seven

Current to Distance Conversion Chart (Nominal)

Current mA	Distance inches	Current mA	Distance inches	Current mA	Distance inches
20	03.6	14	29.2	08	54.9
19	07.9	13	33.5	07	59.2
18	12.1	12	37.8	06	63.5
17	16.4	11	42.1	05	67.7
16	20.7	10	46.3	04	72.0
15	25.0	09	50.6		

Distance to Current Conversion Chart (Nominal)

Distance inches	Current mA	Distance inches	Current mA	Distance inches	Current mA
3.6	20.0	30	13.8	60	06.8
06	19.4	36	12.4	66	05.4
12	18.0	42	11.0	72	04.0
18	16.6	48	09.6		
24	15.2	54	08.2		



MAINTENANCE

Step Eight

General:

The LA15 series level transmitter itself requires no periodic maintenance except cleaning as required. It is the responsibility of the user to determine the appropriate maintenance schedule, based on the specific characteristics of the application liquids.

Cleaning Procedure:

1. Power: Make Sure that all power to the transmitter, controller and/or power supply is completely disconnected.
2. Sensor Removal: In all through-wall installations, make sure that the tank is drained well below the sensor prior to removal. Carefully, remove the sensor from the installation.
3. Cleaning the Sensor: Use a soft bristle brush and mild detergent, carefully wash the transducer of the LA15. Do not use harsh abrasives such as steel wool or sandpaper, which might damage the transmitter's surface. Do not use incompatible solvents which may damage the PVDF transducer or the transmitters PP body.
4. Sensor Installation: Follow the appropriate steps of installation as outlined in the installation section of this manual.

Step Nine

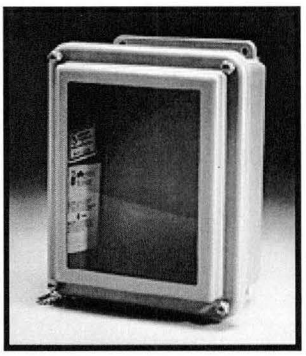
STAHLIN
NON-METALLIC
ENCLOSURES

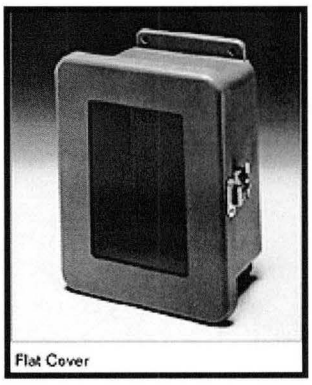
COLORADO
Sales Representatives

ACE ELECTRICAL SALES
2025 West Evans
Denver, CO 80223
Phone: 303/ 934-6211
Fax: 303/ 934-6212
ACEELECTRICALSALES@prodigy.net

Junction Enclosures

Flush Mounted Window Units





Flat Cover

FLUSH MOUNTED WINDOW
Construction

- scratch resistant UVA acrylic material
- routed for a precision fit
- bonded into the enclosure with acrylic adhesive
- special preparations to substrate ensures a tight bond and adhesive coverage
- standard as well as custom window sizing available, consult factory when ordering custom windows
- submersible

Panels

- Panels must be ordered separately.

Accessories

- See Junction Enclosure Section

FLAT COVER DIMENSIONS		
PART NUMBER	CC	WINDOW AREA (MAXIMUM)
JW 604	3.88 (99)	4.25 x 2.25 (108 x 57)
JW 606	3.88 (99)	4.25 x 4.25 (108 x 108)
JW 806	3.88 (99)	6.25 x 4.25 (159 x108)
JW 1008	3.42 (87)	8.25 x 6.25 (210 x 159)
JW 1210	4.38 (111)	10.25 x 8.25 (260 x210)
JW 1407	5.98 (152)	12.75 x 5.75 (324 x 146)
JW 1412	5.25 (133)	12.25 x 10.25 (311 x 260)
JW 1614	5.27 (134)	14.25 x 12.25 (362 x 311)
JW 1816*	7.93 (201)	16.25 x 14.25 (413 x 362)

Caution: Metric units are for reference;do not convert.

All measures are in inches, items in parentheses are in millimeters.

*STD part is not 6P rated, Modified 1816 6P rated with window up to 14 1/4 x 12 1/4.

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SCREW COVER			LINK LOCK LATCH		PADLOCK LATCH		FRP LATCH
LIFT-OFF W	STAINLESS STEEL HINGE HW	FIBERGLASS HINGE FHW†	STAINLESS STEEL HINGE HLL	FIBERGLASS HINGE FHLL*†	STAINLESS STEEL HINGE HPL	FIBERGLASS HINGE FHPL*†	FIBERGLASS HINGE FHL*
JW604W	JW604HW		JW604HLL		JW604HPL		
JW606W	JW606HW		JW606HLL		JW606HPL		
JW806W	JW806HW	JW806FHW	JW806HLL	JW806FHLL	JW806HPL	JW806FHPL	JW806FHL
JW1008W	JW1008HW	JW1008FHW	JW1008HLL	JW1008FHLL	JW1008HPL	JW1008FHPL	JW1008FHL
JW1008WA	JW1008HWA	JW1008FHWA	JW1008HALL	JW1008FHALL	JW1008HAPL	JW1008FHAPL	JW1008FHAL
JW1210W	JW1210HW	JW1210FHW	JW1210HLL	JW1210FHLL	JW1210HPL	JW1210FHPL	JW1210FHL
JW1407W	JW1407HW		JW1407HLL		JW1407HPL		
JW1412W	JW1412HW	JW1412FHW	JW1412HLL	JW1412FHLL	JW1412HPL	JW1412FHPL	JW1412FHL
JW1614W	JW1614HW	JW1614FHW	JW1614HLL	JW1614FHLL	JW1614HPL	JW1614FHPL	JW1614FHL
JW1816W	JW1816HW	JW1816FHW	JW1816HLL	JW1816FHLL	JW1816HPL	JW1816FHPL	JW1816FHL
RJW604W	RJW604HW		RJW604HLL		RJW604HPL		
RJW606W	RJW606HW		RJW606HLL		RJW606HPL		
RJW806W	RJW806HW	RJW806FHW	RJW806HLL	RJW806FHLL	RJW806HPL	RJW806FHPL	RJW806FHL
RJW1008W	RJW1008HW	RJW1008FHW	RJW1008HLL	RJW1008FHLL	RJW1008HPL	RJW1008FHPL	RJW1008FHL
RJW1210W	RJW1210HW	RJW1210FHW	RJW1210HLL	RJW1210FHLL	RJW1210HPL	RJW1210FHPL	RJW1210 FHL
RJW1412W	RJW1412HW	RJW1412FHW	RJW1412HLL	RJW1412FHLL	RJW1412HPL	RJW1412FHPL	RJW1412FHL
RJW1614W	RJW1614HW	RJW1614FHW	RJW1614HLL	RJW1614FHLL	RJW1614HPL	RJW1614FHPL	RJW1614FHL
RJW1816W	RJW1816HW	RJW1816FHW	RJW1816HLL	RJW1816FHLL	RJW1816HPL	RJW1816FHPL	RJW1816FHL

* Do not meet NEMA 4X requirements

† Do not meet 6P requirements

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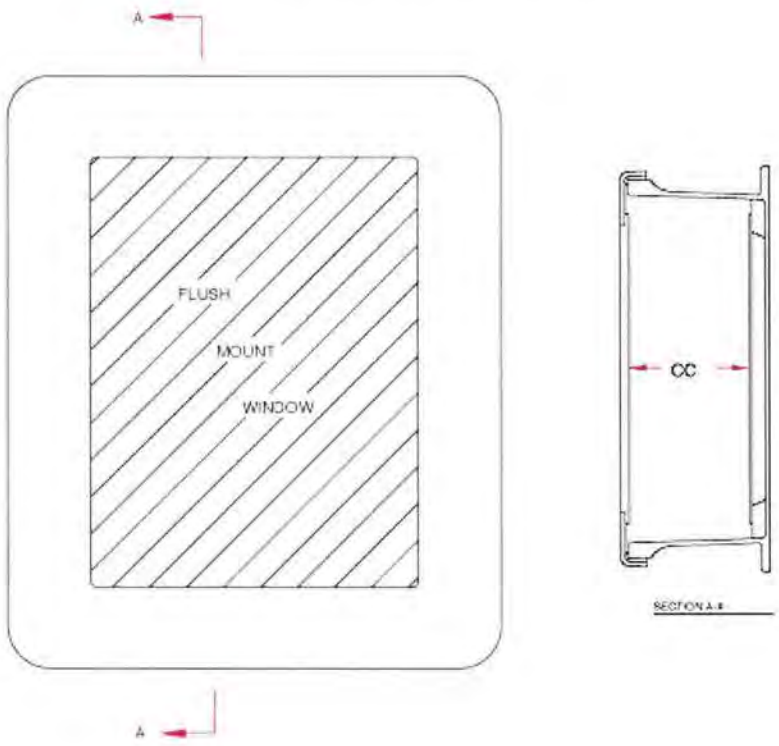

CROWNED COVER DIMENSIONS				
CATALOG NUMBER	CA	CB	CC	WINDOW AREA
JWA 1008A	9.39 (239)	7.38 (188)	4.25 (108)	8.25 X 6.25 (210 x 159)

RAISED COVER DIMENSIONS				
CATALOG NUMBER	CA	CB	CC	WINDOW AREA (MAXIMUM)
RJW 604	5.31 (135)	3.34 (85)	5.39 (137)	4.25 x 2.25 (108 x 57)
RJW606	5.34 (136)	5.31 (135)	5.39 (137)	4.25 x 4.25 (108 x 108)
RJW806	7.27 (185)	5.28 (134)	5.38 (137)	6.25 x 4.25 (159 x 108)
RJW 1008	9.29 (236)	7.38 (188)	5.78 (147)	8.25 x 6.25 (210 x 159)
RJW 1210	11.2 (284)	9.23 (234)	5.73 (146)	10.25 x 8.25 (260 x 210)
RJW 1412	13.2 (335)	11.16 (284)	6.74 (171)	12.25 x 10.25 (311 x 260)
RJW 1614	15.2 (386)	13.23 (336)	6.74 (171)	14.25 x 12.25 (362 x 311)
RJW 1816*	17.25 (438)	15.25 (387)	9.73 (247)	16.25 x 14.25 (413 x 362)

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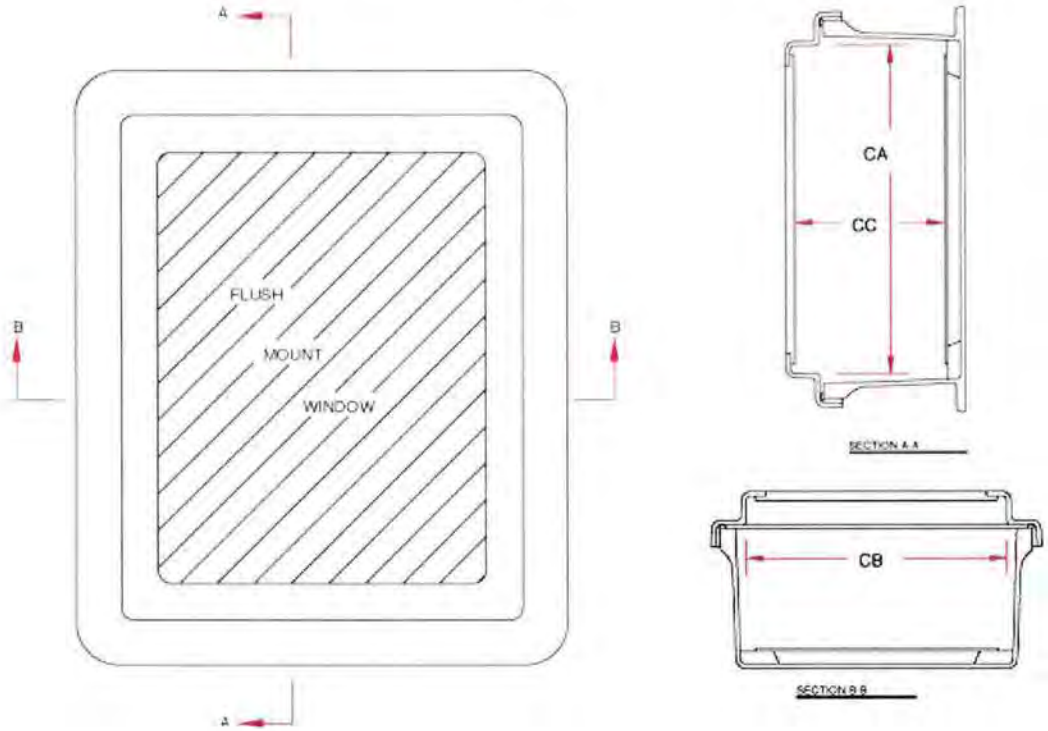

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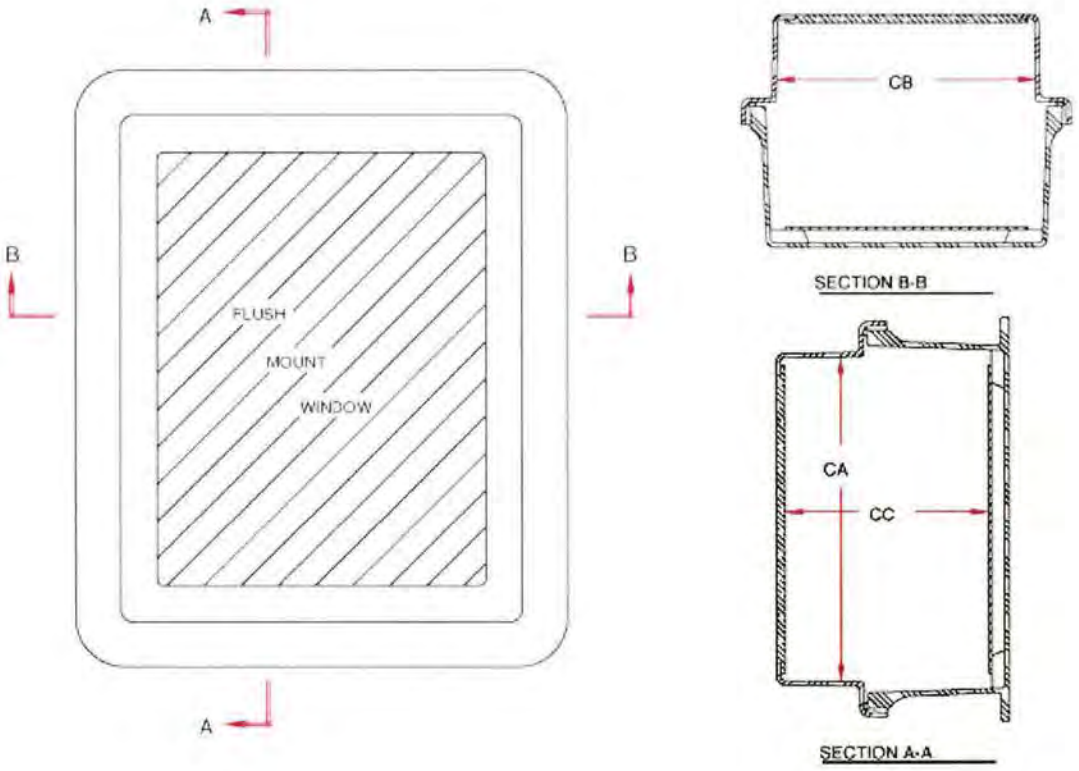

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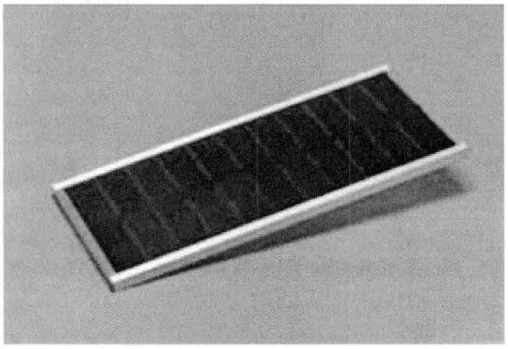
Unisolar US21



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Short Circuit Current 1.59 amps
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Size in inches 15 x 36.5

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