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# ***DRAFT REPORT***

## **Low Cost RTU for Water Level Measurement**

Prepared for the

**Harlingen Irrigation District**



**Under a Texas Water Development Board Grant**

Innovative Technologies for  
Agricultural Water Management  
and Flow Measurement

September 27, 2010

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## 1. Introduction and Overview

Measurements are crucial to the good management of canal systems. However, making measurements, and recording, delivering and analysing the data can be very time consuming and expensive. There is a need for a low cost but reliable system that can make and transmit frequent measurements of values such as the depth of water in a canal. This project has resulted in the design of such a low-cost remote telemetry unit (LCRTU).

Key features include solar-powered operation, the ability to measure analog voltage/current and digital SDI-12 signals, and good radio range.

The major components of the LCRTU are:

1. The enclosure/housing.
2. The power supply system
3. The electronic circuits to read signals and transmit data.

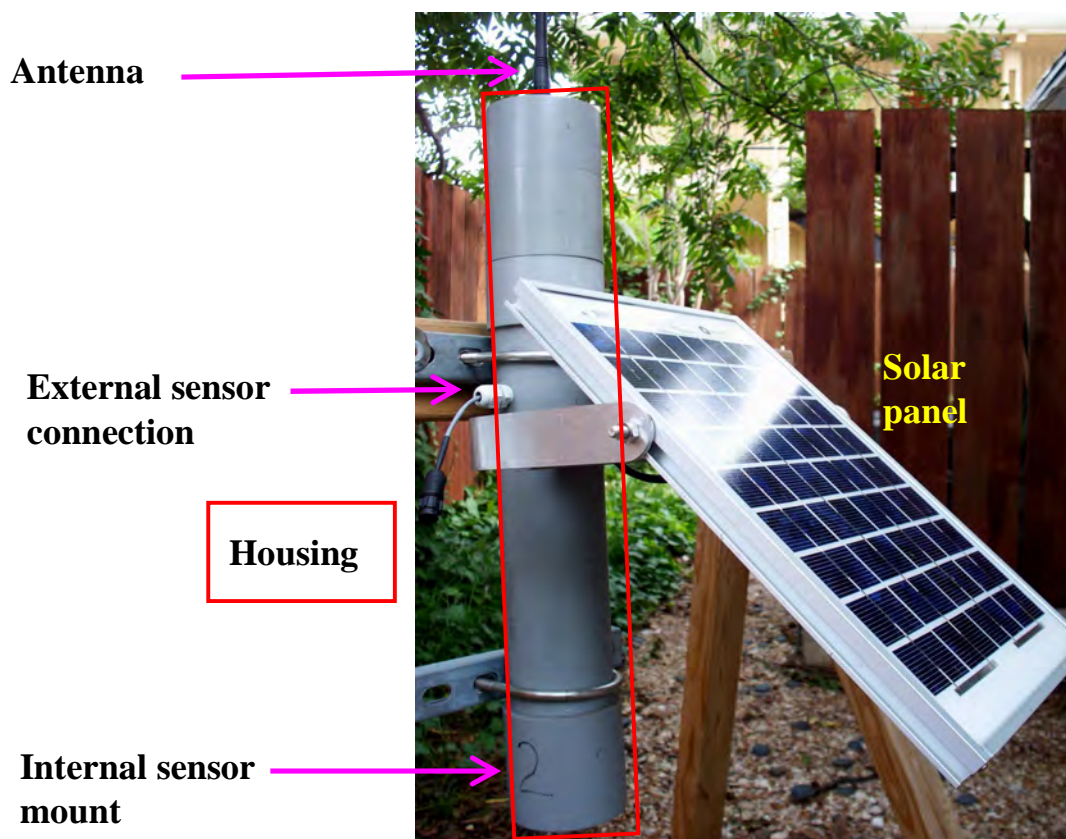


Figure 1. External view of typical LCRTU showing solar panel, antenna, and external sensor connection.

## 2. Housing/Enclosure

The housing/enclosure contains the electronic components and the power supply (in the form of a rechargeable lead/acid battery). The enclosure should be inexpensive and robust, and not subject to deterioration from sunlight, rainfall and temperature variation. The material used to meet these requirements is UV resistant schedule 40 PVC electrical conduit pipe and fittings, and various non UV resistant PVC plumbing fittings if they are not exposed to sunlight. The fittings take various forms, including male or female threaded connectors. Where appropriate, fittings are permanently joined with solvent welded “slip” joints.

### 2.1 Pipe

The main body of the enclosure is constructed from 3 inch (internal diameter) conduit pipe, as this size is large enough to contain the electrical components. The pipe is available in 10 ft lengths with one end flared to enable them to be joined together. This flared end section is not used. The pipe can be cut into appropriate lengths using a saw. Figure 2 shows the pipe, which can be purchased from electrical supplies dealers.

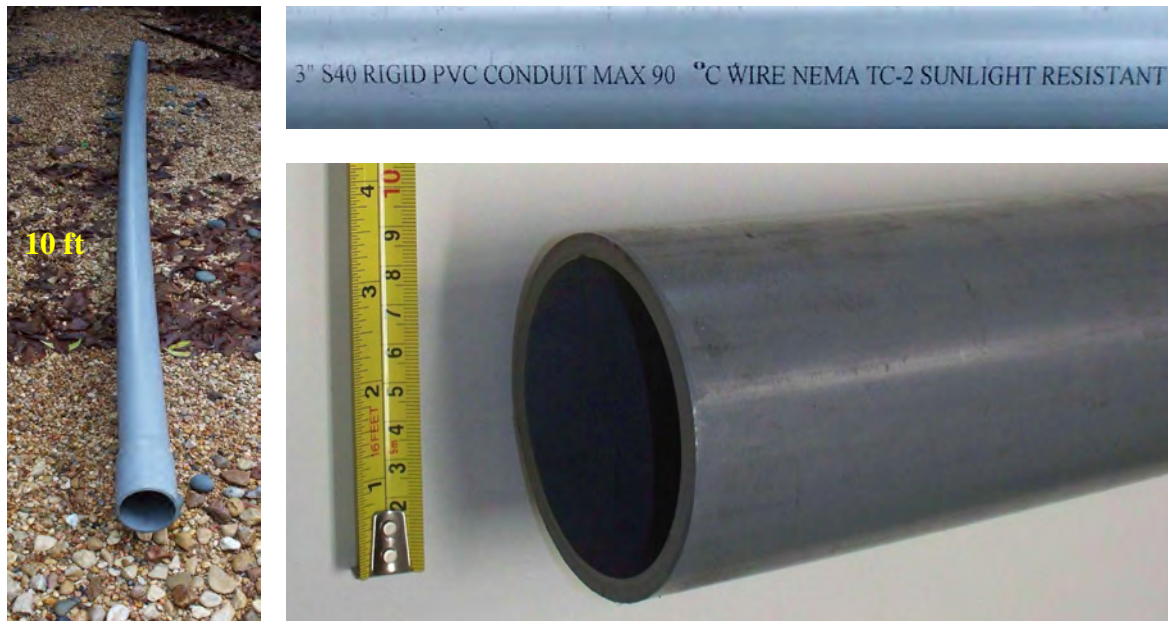


Figure 2. Three inch electrical conduit used for enclosure. A pipe length (top), specifications (middle) and flared end (bottom).



## 2.2 Pipe fittings

Various standard fittings are used with the pipe to fabricate the top and bottom of the housing/enclosure. The top, to which the antenna is mounted, must be removable so that the electrical components inside can be accessed. The bottom may not need to be removed, and so can be permanently joined to the pipe and configured according to the sensor or other function required. The example used in this manual is for an acoustic distance sensor that has a threaded mounting. Figure 3 shows the top and bottom of the enclosure. Threaded components are used to enable the top to be removed.



Figure 3. LCRTU showing top with antenna (left), top with screw-on cap removed (center) and bottom with downward facing acoustic water level sensor (right).

### 2.2.1 TOP FITTINGS

The top cap, which is removable, is constructed using a 3 inch slip end cap joined to a 3 inch female threaded/slip connector, both components being UV resistant PVC (figure 4). Figure 5 shows the end cap, through which a hole must be drilled for the antenna mounting hardware. Figure 6 shows the female threaded/slip connector.

The end cap is permanently joined to the female threaded slip/connector using a short length of pipe solvent welded to each piece, as shown in figure 7. The length of this pipe is such that it enables the end cap and the threaded/slip connector to be pushed together after applying solvent to the inside surface of the two pieces.

The end cap can be drilled for the antenna and the antenna screw mount tightened before joining the two pieces (figure 8), but care must be taken that the antenna lead wire does not interfere when they are pushed together. The antenna can also be mounted after joining the two pieces together, but then it is more difficult to reach inside to tighten the antenna mounting screws.

The top of the end cap should be flattened where the antenna mounts so that the mount screw can fit flush. This can be done with a counterbore type wood drill.



Figure 4. Top cap

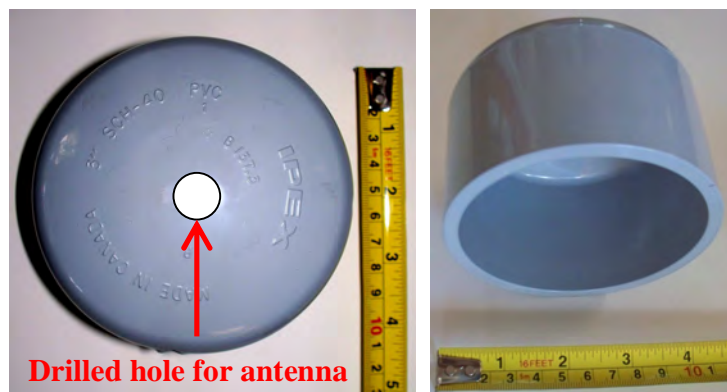


Figure 5. Three inch end cap viewed from the top (left), and from the bottom (right)

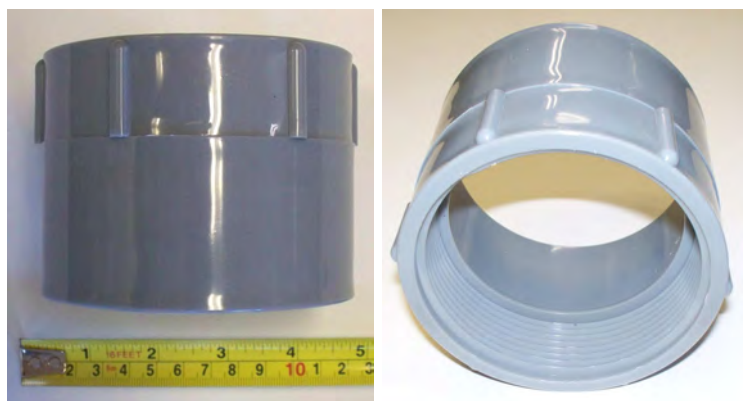


Figure 6. Female threaded/slip connector from the side (left) and from the threaded end (right).

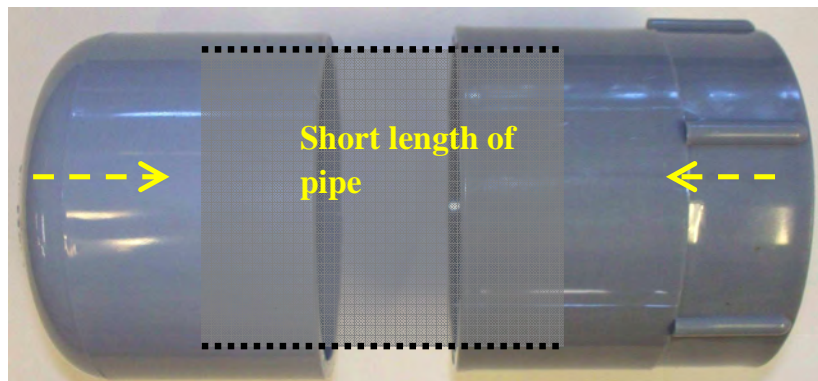


Figure 7. End cap and threaded/slip connector connected with solvent to a short length of pipe.



Figure 8. Antenna and mount on end cap (left), with close up view of mount (top right), and view looking inside the top (bottom right) with the antenna lead.



## 2.2.2 MAIN BODY OF ENCLOSURE

The main body of the enclosure consists of a length of pipe to which the top and bottom fittings attach (figure 9).

The length of pipe required is determined by the electrical components it encloses, primarily the battery pack. Both the male threaded/slip connector used for the screw-on top and the female slip/slip connector for the bottom are solvent welded to the pipe.

Two internal slots are cut into opposite sides of the pipe and connector to hold the circuit board is held (figure 10).

One or more ports are also installed in the pipe for weatherproof cable connections between internal and external components (figure 11). One port is required for the cable between the external solar panel

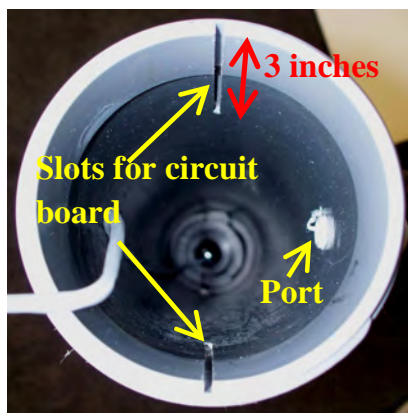


Figure 10. View into top of enclosure



Figure 9. Main body of enclosure showing the male threaded/slip connector for the top cap (top right) and the female slip/slip connector for the bottom sensor (bottom right)



Figure 11. Cable port located near top of enclosure (left) and detail (right).

and the internal battery pack. Other ports can be installed for external sensors such as for soil water content.

### **2.2.3 BOTTOM SENSOR MOUNT**

The bottom sensor mount, such as for the acoustic water level sensor, is constructed from off-the-shelf plumbing/electrical fittings that fit into the bottom female slip/slip connector attached to the pipe (figure 12). These fittings do not need to be resistant to sunlight as they are contained inside the connector.

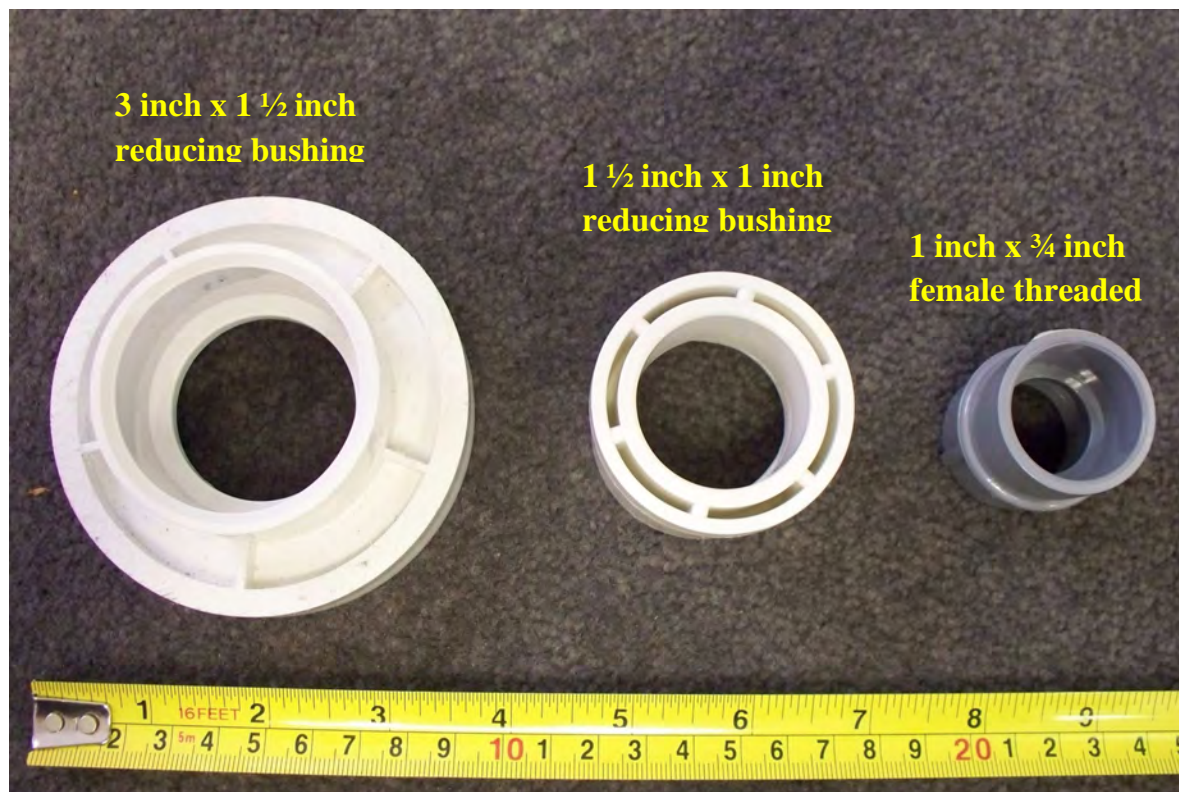


Figure 12. Primary fittings used in making bottom sensor mount.

The 3 inch x 1 1/2 inch reducing bushing has to be modified by cutting off approximately half of the outer ring and supports. This reduces the height and enables both it and the enclosure pipe to be solvent welded into one side of the female/female slip connector. Figure 13 shows the part of the bushing that is removed during the modification. A saw can be used to cut through the outer wall without cutting through the inner wall. A chisel can then be used to remove the “fins” between the two walls.

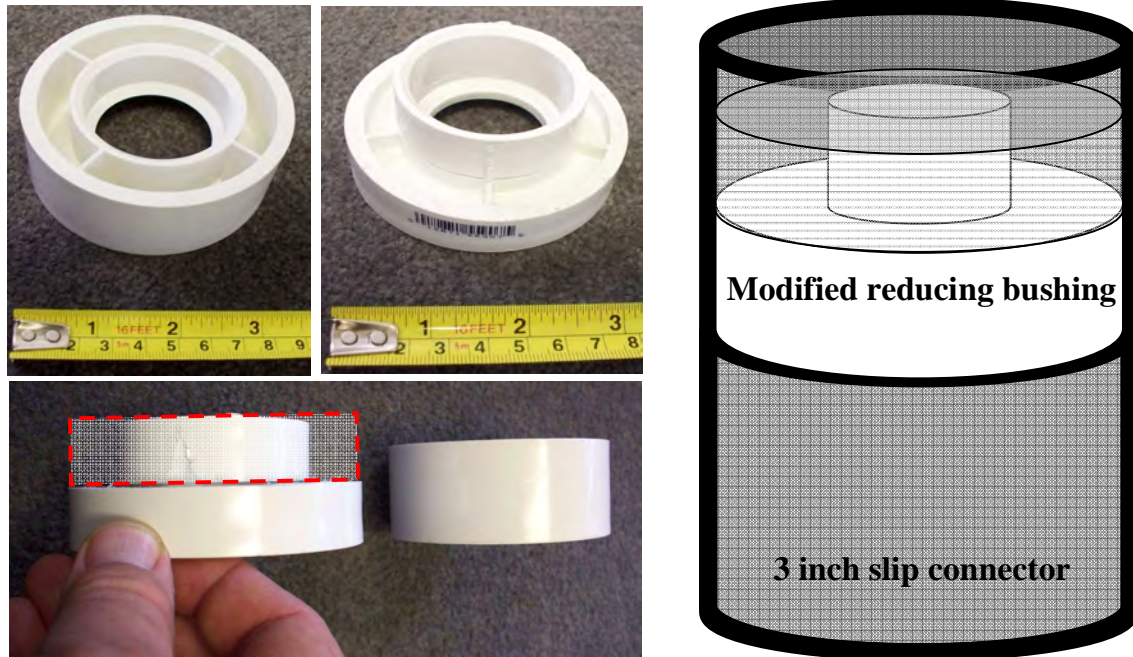


Figure 13. Three inch x 1 ½ inch reducing bushing (top left), and after modification (top center and bottom left). The modified bushing fits into the 3 inch slip connector as illustrated (right).

The 1 ½ inch by 1 inch bushing also has to be modified because it has an internal lip that prevents the 1 inch to ¾ inch adapter from fitting correctly inside it. A small grinding tool (such as a Dremel) can be used to grind off the lip. Figure 14 shows the fitting and where the lip has been ground off.

The final piece is the 1 inch x ¾ inch female threaded adapter into which the water level sensor screws (figure 15). This fitting is solvent welded into the modified 1 ½ inch x 1 inch bushing, as shown in figure 16. Finally, this assembly is solvent welded to the modified 3 inch x 1 ½ inch bushing shown in 13, to create a screw-in mount for the sensor that can be solvent welded into the 3 inch female connector at the bottom of the enclosure (figure 17).

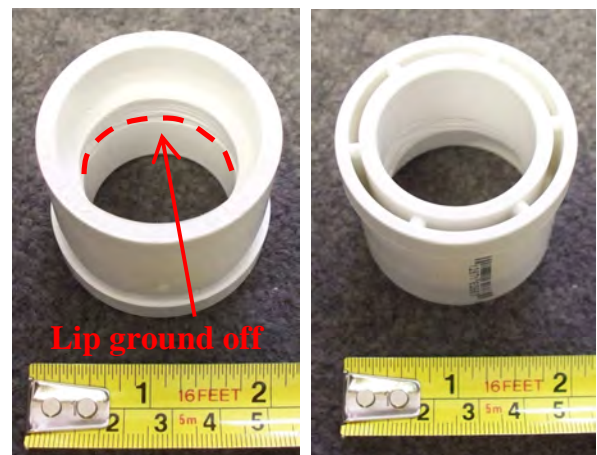


Figure 14. 1 ½ inch to 1 inch reducing bushing, showing where lip has been ground off.





Figure 15. Views of threaded (left) and slip (right) ends of 1 inch slip to  $\frac{3}{4}$  inch female threaded adapter.

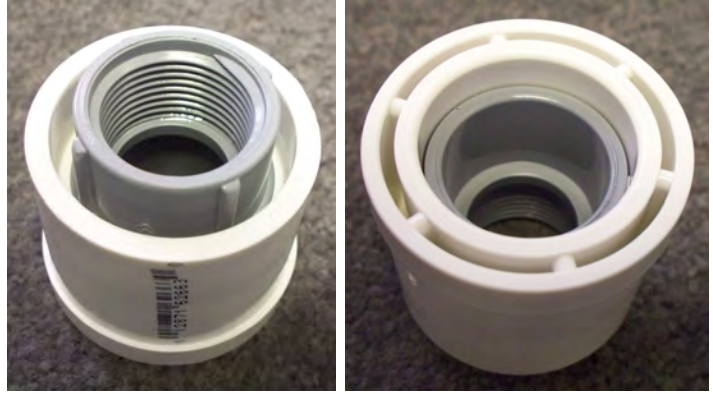


Figure 16. 1 inch slip to  $\frac{3}{4}$  inch female threaded adapter solvent welded to modified 1  $\frac{1}{2}$  inch to 1 inch reducing bushing,

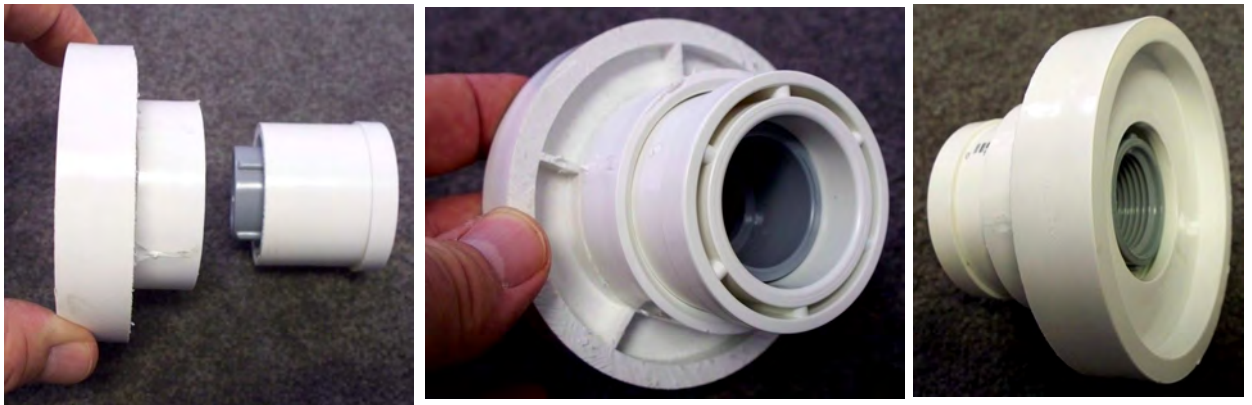


Figure 17. The assembly shown in figure 16 solvent welded to the modified 3 inch to 1  $\frac{1}{2}$  inch reducing bushing shown in figure 13 to create the sensor mount.

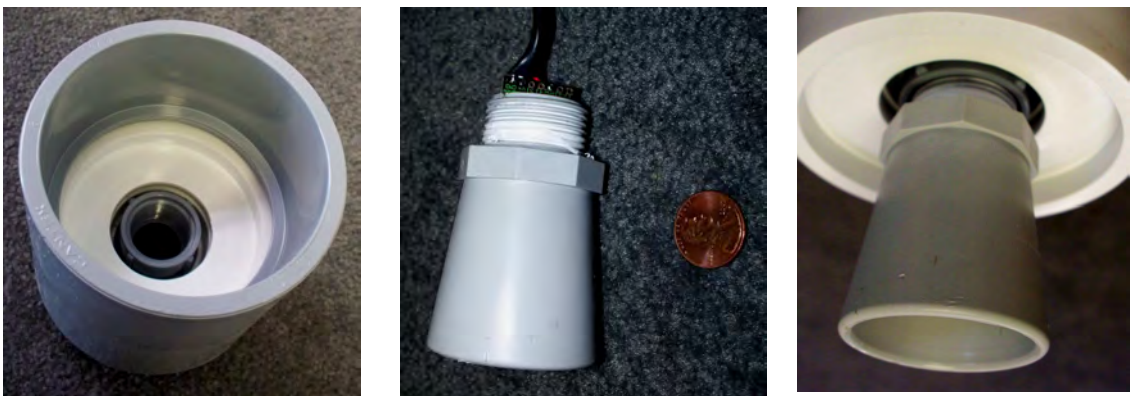


Figure 18. The assembly in figure 17 mounted in the 3 inch female/female connector (left), showing the  $\frac{3}{4}$  inch threaded socket into which the sensor (middle) screws, as shown (right).

Another type of 3 inch x 1 ½ reducing bushing is used as a ring surrounding the sensor. Rather than the modified flat face bushing shown in figure 13, this bushing has an inwardly sloping face enabling the sensor to be recessed. Figure 19 shows the bushing and its use as a surround ring around the sensor, while figure 20 shows the final assembly at the bottom of the enclosure.



Figure 19. Sensor surround ring (left) with sensor (right)



Figure 20. Final assembly of water level sensor with surround ring (left and middle) into the 3 inch female slip connector (right).



### **3. Power supply system**

The LCRTU requires a 12V dc power supply. This is accomplished using an external solar panel to recharge a battery system located inside the enclosure.

#### **3.1 Solar panel**

The solar panel (figure 21) is rated at 10 Watts, and is held by an aluminum bracket using bolts that fit into an aluminum channel on each side of the frame. The angle at which the solar panel should be held depends on latitude, and can be adjusted using the bolts. A cable passing through an access port connects the panel to the battery pack inside the enclosure.

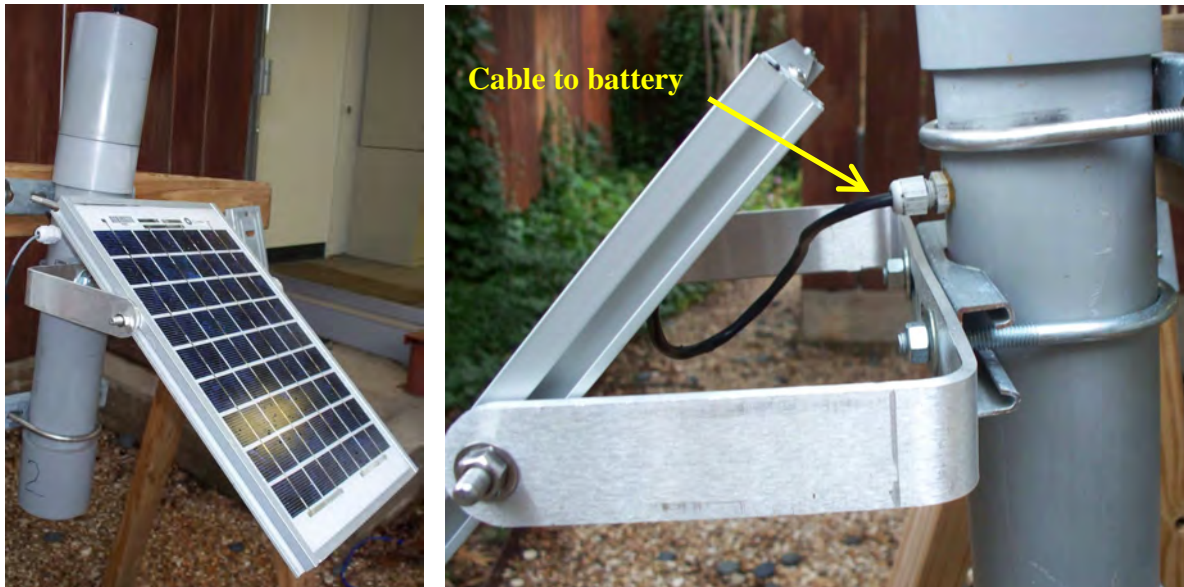


Figure 21. Solar panel (left), with connection to battery and mounting hardware (right)

#### **3.2 Battery pack**

The battery pack (figure 22) is a 12V rechargeable lead-acid system that is contained inside the enclosure. Two 6V batteries connected in series and physically joined together using large diameter heat shrink tubing are used in this example. A single 12V battery could also be used. An off-the-shelf voltage regulator circuit board is used between the solar panel and the battery pack.

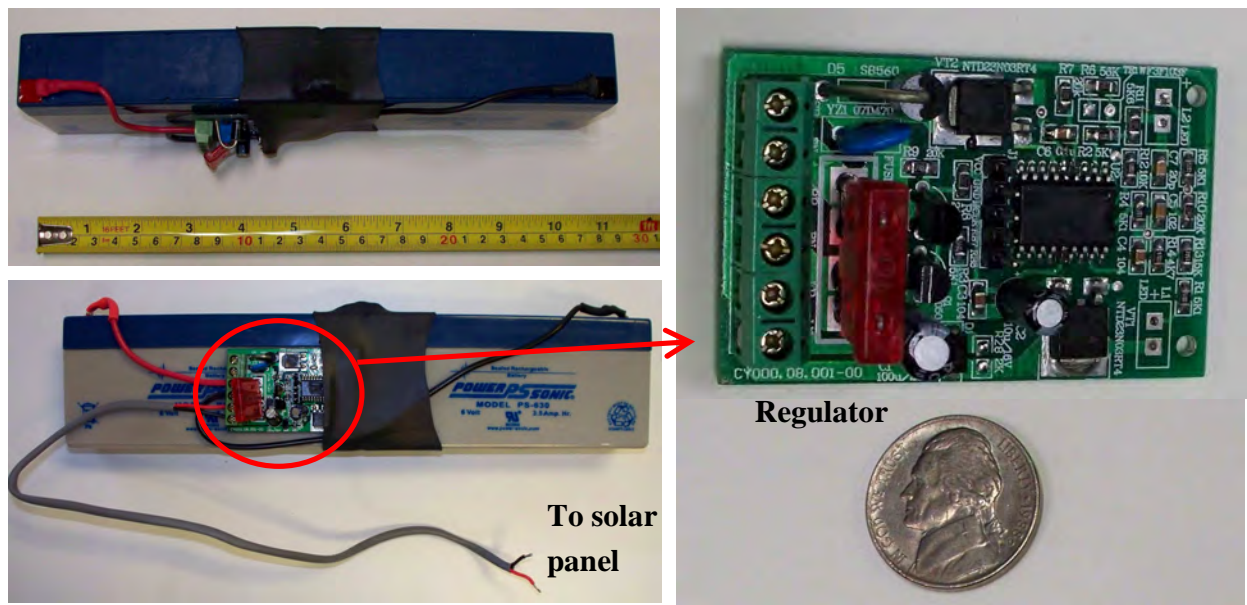


Figure 22. Top and side views of battery pack (top left and bottom left) with detail of regulator (right)

#### 4. Electronics

A custom designed circuit board is used in combination with a radio. The circuit board is a “piggy back” design with one side of the board used for mounting the radio and the other side for mounting the Single Board Computer (SBC) measurement and control circuit. The board fits into the two machined slots in the enclosure (figure 23).

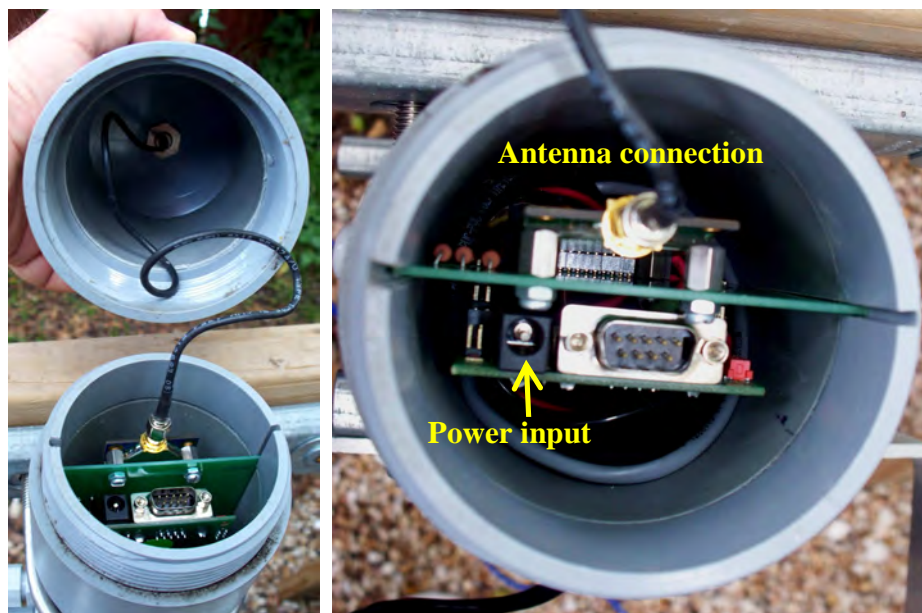


Figure 23. Circuit board in enclosure, with antenna connected through cap (left) and detail (right)

Figure 24 shows a top view of the board with the radio mounted. Four screws secure the radio to the board. Connections to the board are made through a terminal strip. Power from the battery pack is connected to the SBC side of the board. The SBC board is initially programmed using the serial connector and a hardware/software interface.

Figure 25 shows both sides of the circuit board with their respective components unplugged. Connections are made using pin and socket connectors.

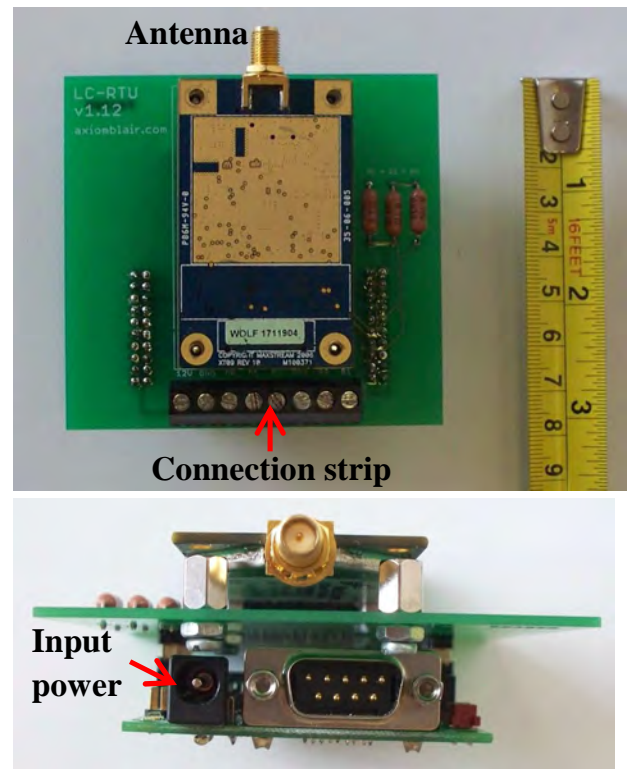


Figure 24. Top view of board showing radio (top), and edge view of board showing radio and measurement circuit sides (bottom).

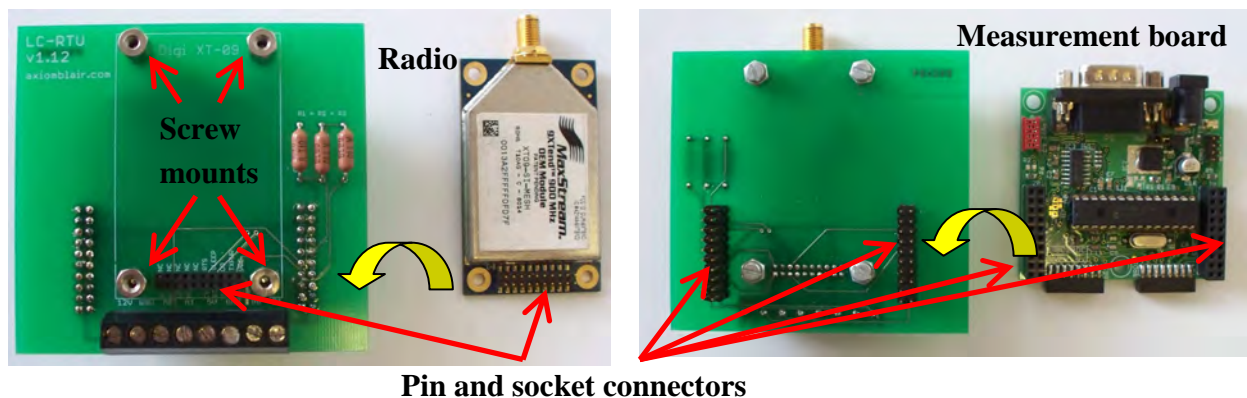


Figure 25. Radio and radio side of board (left) and measurement circuit side of board (right)

## **APPENDIX A**

### **LCRTU Enclosure Assembly Details**

Front and side view

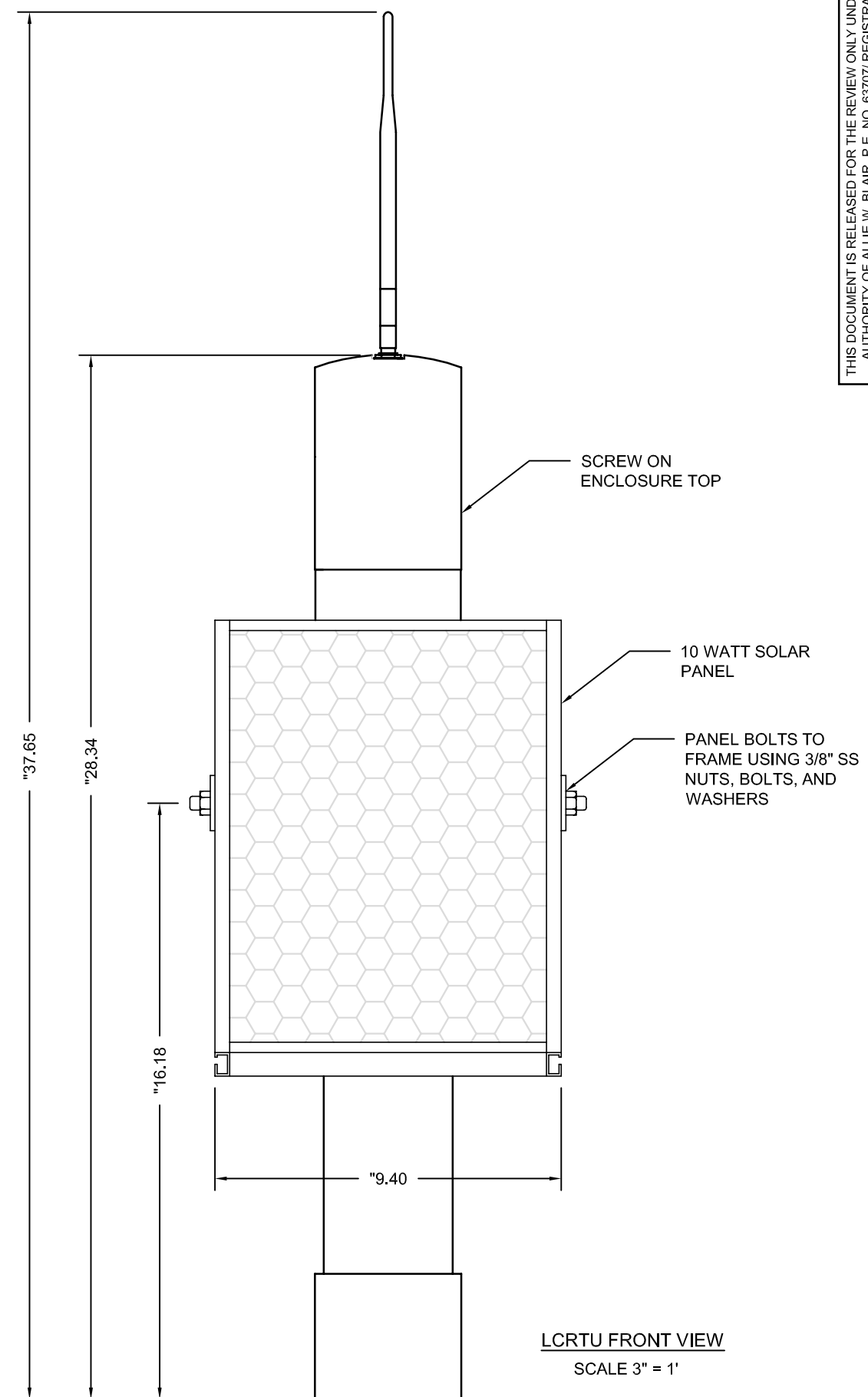
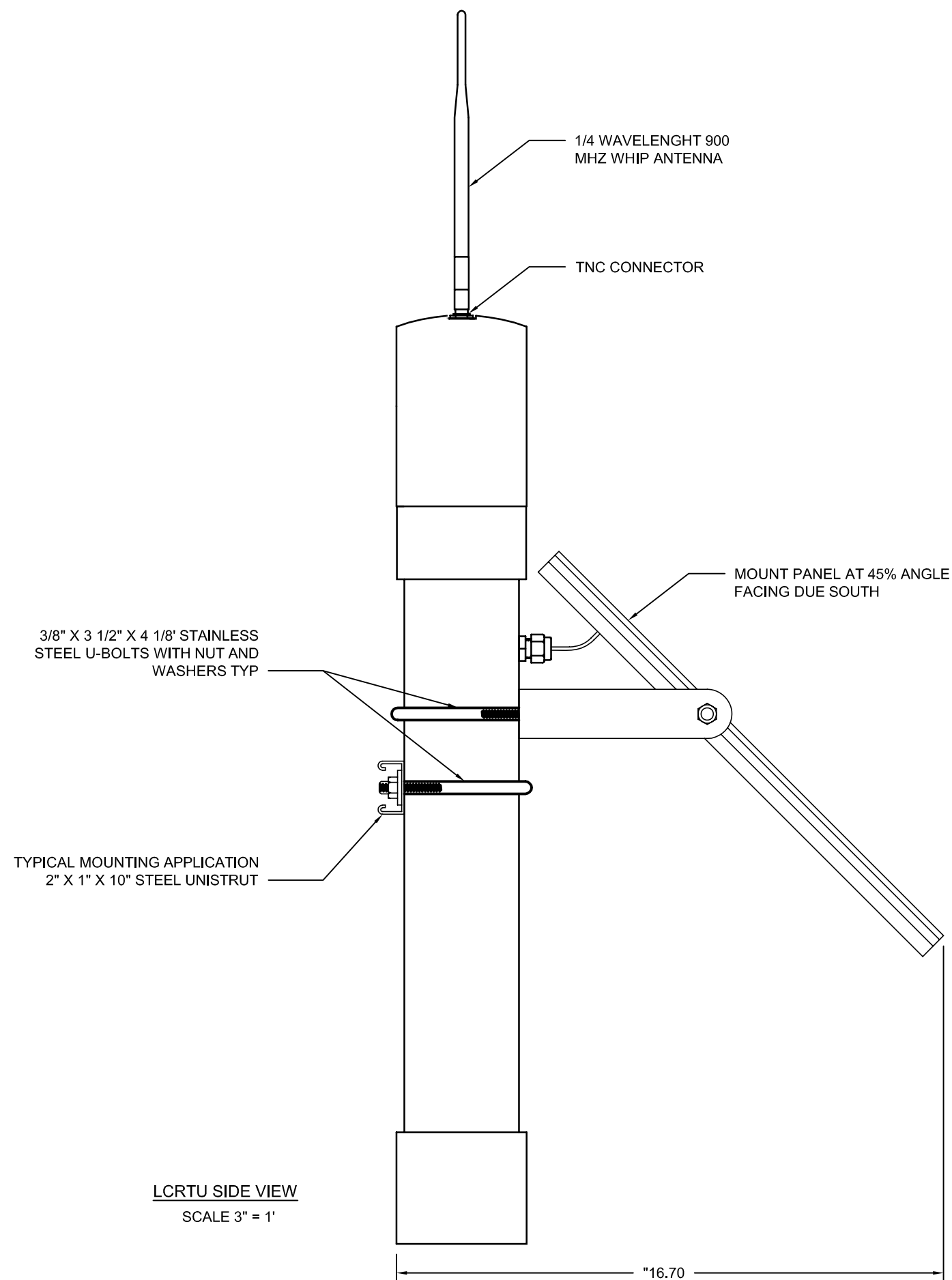
Enclosure section

Exploded views

Enclosure details

Sensor assembly details

Electrical schematic



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LCRTU Enclosure  
HARLINGEN IRRIGATION DISTRICT  
Assembly Details  
FRONT & SIDE VIEW

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FILE:
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APPENDIX D



Low Cost Remote Telemetry Unit Materials List					
Item #	Qty. per Unit	Item	Manufacturer	Model No.	Description
1	1	Enclosure Body	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" X 16"
2	1	Enclosure Bottom Cap	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Standard Coupling
3	1	Enclosure Top Cap (Part A)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" End Cap
4	1	Enclosure Top Cap (Part B)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" X 4"
5	1	Enclosure Top Cap (Part C)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Female Adapter
6	1	Enclosure Top Fitting	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Male Terminal Adapter
7	1	Sensor Assembly (Part A)	Local Plumbing	PVC	Schedule 40 PVC DWV 3" to 2" Adapter Bushing
8	1	Sensor Assembly (Part B)	Local Plumbing	PVC	Schedule 40 PVC 2" to 1" Reducer Bushing
9	1	Sensor Assembly (Part C)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3/4" Threaded Adapter
10	1	Sensor Guard	Local Plumbing		Schedule 40 PVC DWV 3" to 2" Adapter Bushing Sewer
11	1	RF bulkhead Jack	Amphenol	122192	RF Coaxial, TNC Bulkhead crimp Jack
12	2	Lead Acid Battery; 6 VDC	Power-Sonic	PS-630	6 VDC; 3.5 AmpHr Rechargeable Lead Acid Battery
13	1	Solar Power Controller	CES	SS1203A	3A Solar Power Controller
14	2	Stainless Steel U Bolts	Local Hardware	3/8" SS	3/8" x 3 1/2" x 4 1/8" U Bolt; Stainless Steel
15	4	Stainless Steel Hex Nut	Local Hardware	3/8" SS	3/8" - 16 Hex Finish Nut; Stainless Steel
16	4	Stainless Steel Flat Washer	Local Hardware	3/8" SS	3/8" Flat Washer; Stainless Steel
17	4	Stainless Steel Lockwasher	Local Hardware	3/8" SS	3/8" Split Lockwasher; Stainless Steel
18	1	ABE-LCRTU Board		V1.12	
19	1	Single Board Computer for PIC	Modtronix	SB28DC	Single Board Computer for 28 pin PIC microcontroller with RS232 interface
20	1	28 pin DIP PIC chip	Microchip	PIC18F258-I-SP	Dual Inline Package Programmable Interface Controller
21	1	MaxStream 9XTend 900 MHz	MaxStream	XT09-SI-MESH	900 MHz OEM Radio
22	1	Whip Antenna	Larson	SPDA17918	872-964 MHz, Unity Gain, 1/4 Wavelength, TNC (M) Portable Antenna
23	1	Solar Panel	BP Solar	SX 310M	10 Watt; 12 Volt; Photovoltaic Charge Panel
24	1	Solar Panel Mount Bracket	Ameresco	HPM 5-10	Solar Panel Mount Bracket
25	1	Ultrasonic Sensor	Maxbotix	MB7070	XL-MaxSonar-WRA1 (MB7070) Ultrasonic Sonar Sensor
26	1	Coax Cable	Belden	RG 174	RG 174 type 24.5 AWG solid .020" Coax Cable



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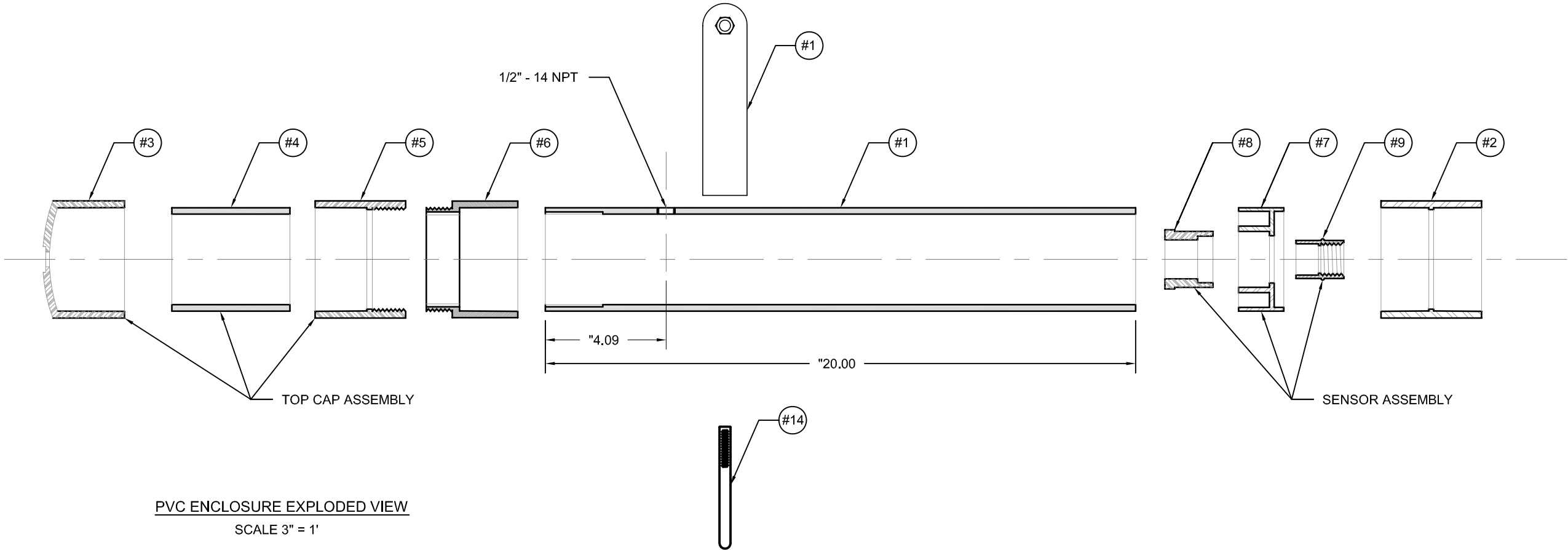
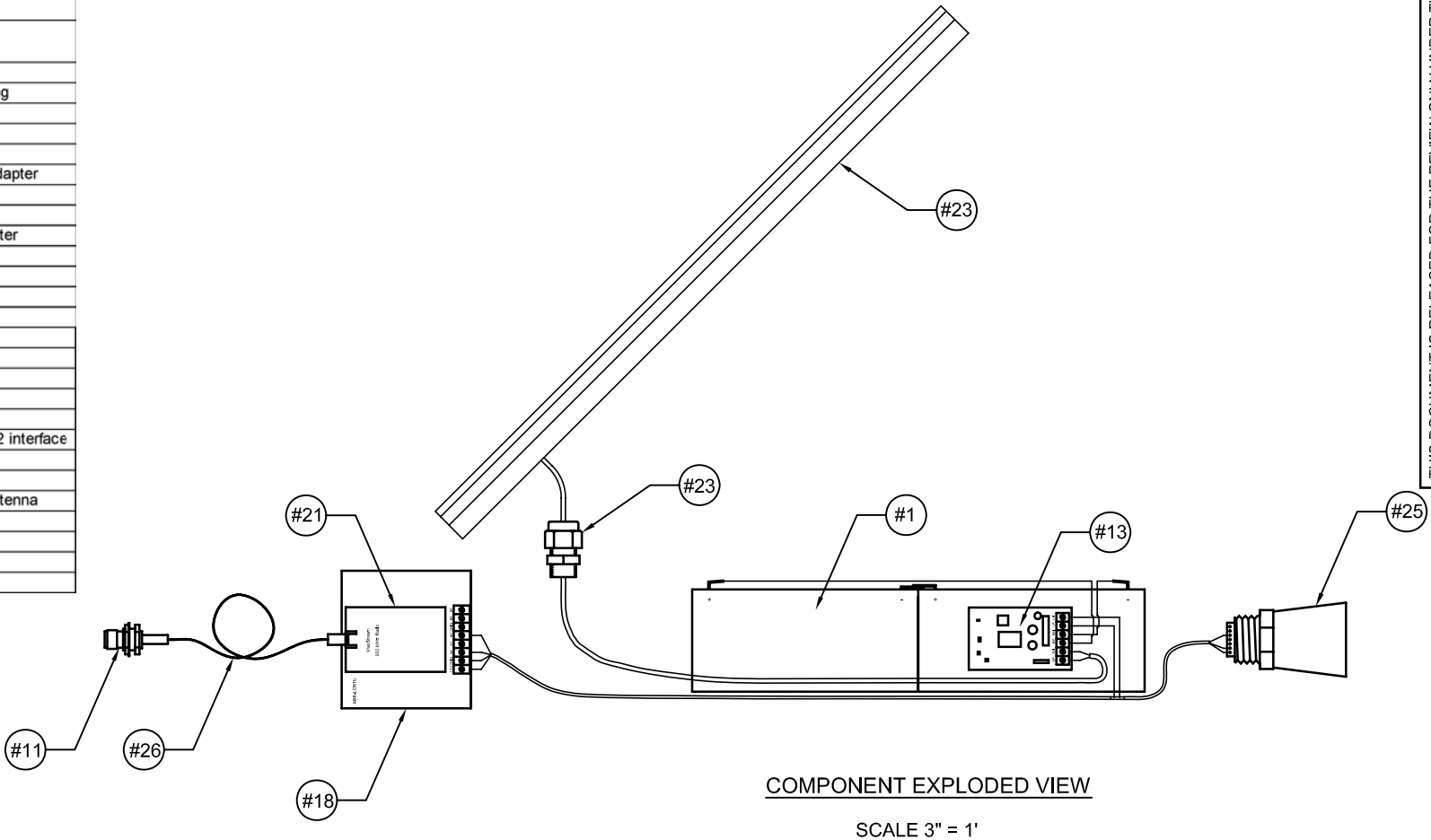
LCRTU Enclosure  
HARLINGEN IRRIGATION DISTRICT  
Assembly Details  
Enclosure Section

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LCRTU Enclosure  
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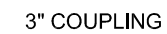
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## **APPENDIX B**

### **Sample PVC fittings**

Cantex conduit pipe

Cantex end cap

Cantex coupling

Cantex male adapters

Cantex female adapters

Mueller bushing

Pressure fittings

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#### WHAT'S NEW

CANTEX Administrative Headquarters  
Relocates.

New Freight Terms effective  
November 10, 2008

#### DOWNLOAD MSDS

#### DOWNLOAD CATALOG

#### NEW PRODUCTS



**EZ BOX® 21 Cubic Inch  
Old Work Box** offers a full  
21 cubic inch wiring capacity  
for the installation of switch or  
outlets in an existing  
structure. [Details...](#)



**Forte-Duct® Conduit and  
Duct** is light weight with the  
CANTEX standard long bell.  
[Details...](#)



**EZ GUARD®** protects high  
voltage electrical bushing on  
utility poles from contact with  
wildlife causing unnecessary  
power outages. [Details...](#)



## FORTE-DUCT® CONDUIT - UL SCHEDULE 40



[Select part number for detailed information and technical drawing.](#)

Lighter weight and proven durability in direct burial installations. Use with standard PVC  
Schedule 40 fittings. Available in 3" - 6".

U.L. listed for above and below grade applications.

## Product Details

<< [Return to product list](#)

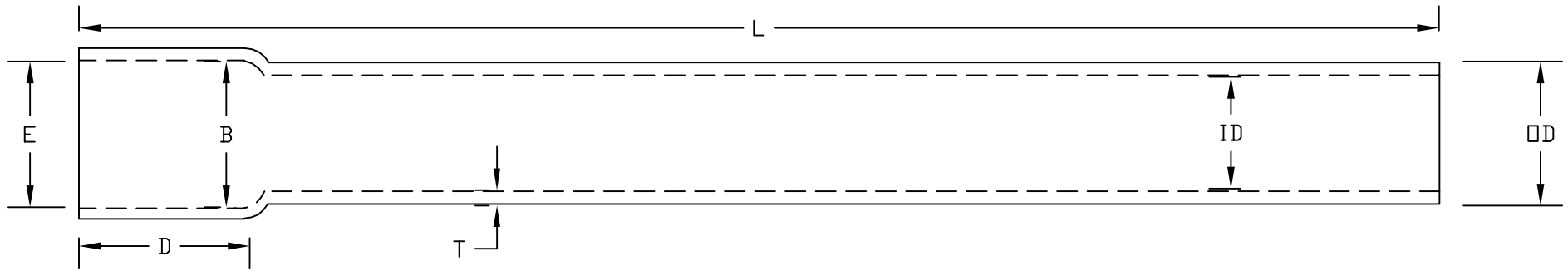
**Item Number** A61DA12  
**Description** 3" UL40 FORTE DUCT 10' BE  
**ITF number** 30088700956323  
**UPC number** 088700956322



<< [Back](#)

**Additional Info**

[Technical Drawing](#)



Part Number	Size	T Min.	OD	ID Min.	E	B	D Min.	L Min.
A61DA12	3"	0.216"	3.500"	3.008"	3.515"	3.492"	1.594"	120"
A61EA12	4"	0.237"	4.500"	3.961"	4.515"	4.491"	1.750"	120"
A61FA12	5"	0.258"	5.563"	4.975"	5.593"	5.553"	1.937"	120"
A61GA12	6"	0.280"	6.625"	5.986"	6.658"	6.614"	2.125"	120"

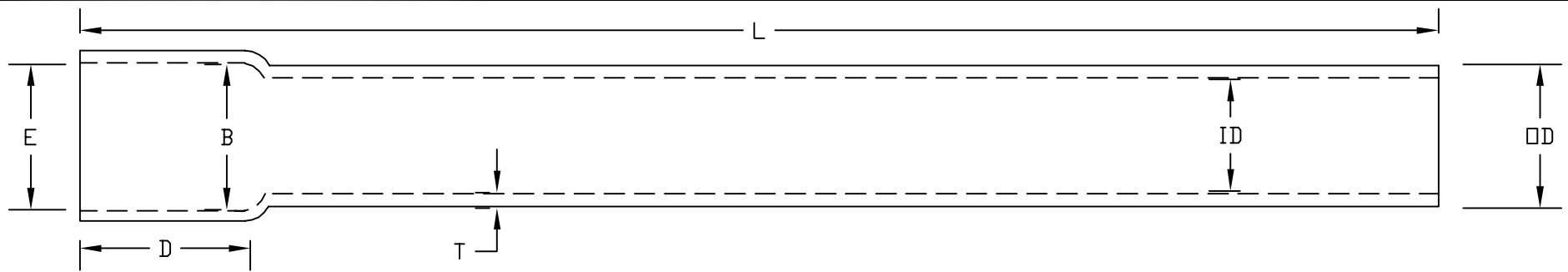
Dimensions are Nominal. See NEMA TC-2 for tolerances.

Meets NEMA TC-2 requirements  
 Max 90° C Wire  
 Sunlight Resistant  
 Approved for exposed applications  
 Approved for direct bury  
 Approved for concrete encasement  
 Use approved PVC Cement for joining  
 Use proper equipment for field bending

**CANTEX**

INC.  
 Fort Worth, TEXAS

Forte Duct SCH 40 Rigid PVC  
 Cellular Core Conduit



Part Number	Size	T Min.	OD	ID Min.	E	B	D Min.	L Min.
A52AE12	½"	0.109"	0.840"	0.578"	0.852"	0.836"	0.652"	120"
A52AG12	¾"	0.113"	1.050"	0.780"	1.064"	1.046"	0.719"	120"
A52BA12	1"	0.133"	1.315"	1.004"	1.330"	1.310"	0.875"	120"
A52BC12	1 ¼"	0.140"	1.660"	1.335"	1.677"	1.655"	0.938"	120"
A52BE12	1 ½"	0.145"	1.900"	1.564"	1.918"	1.894"	1.062"	120"
A52CA12	2"	0.154"	2.375"	2.021"	2.393"	2.369"	1.125"	120"
A52CE12	2 ½"	0.203"	2.875"	2.414"	2.890"	2.868"	1.469"	120"
A52DA12	3"	0.216"	3.500"	3.008"	3.515"	3.492"	1.594"	120"
A52DE12	3 ½"	0.226"	4.000"	3.486"	4.015"	3.992"	1.687"	120"
A52EA12	4"	0.237"	4.500"	3.961"	4.515"	4.491"	1.750"	120"
A52FA12	5"	0.258"	5.563"	4.975"	5.593"	5.553"	1.937"	120"
A52GA12	6"	0.280"	6.625"	5.986"	6.658"	6.614"	2.125"	120"
A52JA12 *	8"	0.322"	8.625"	7.853"	8.670"	8.610"	4.875"	120"

\* 8 inch not UL Listed

Dimensions are Nominal

UL Listed (UL651)

UL File # E34052

UL Category Code DZXR

UL Control Number 41UM

NEMA TC2 Compliant

See NEC Article 352 for use

Sunlight Resistant

Max 90° C Wire

Complies with Federal Specification WC-1094



**CANTEX**

INC.

Fort Worth, TEXAS

Schedule 40 Rigid PVC Conduit



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#### WHAT'S NEW

CANTEX Administrative Headquarters  
Relocates.

New Freight Terms effective  
November 10, 2008

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#### NEW PRODUCTS



**EZ BOX® 21 Cubic Inch  
Old Work Box** offers a full  
21 cubic inch wiring capacity  
for the installation of switch or  
outlets in an existing  
structure. [Details...](#)



**Forte-Duct® Conduit and  
Duct** is light weight with the  
CANTEX standard long bell.  
[Details...](#)

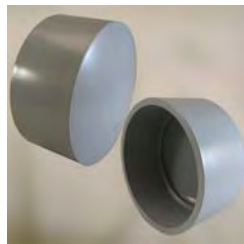


**EZ GUARD®** protects high  
voltage electrical bushing on  
utility poles from contact with  
wildlife causing unnecessary  
power outages. [Details...](#)



## NM FITTINGS & ACCESSORIES

### END CAPS



[Select part number for detailed information and technical drawing.](#)

## Product Details

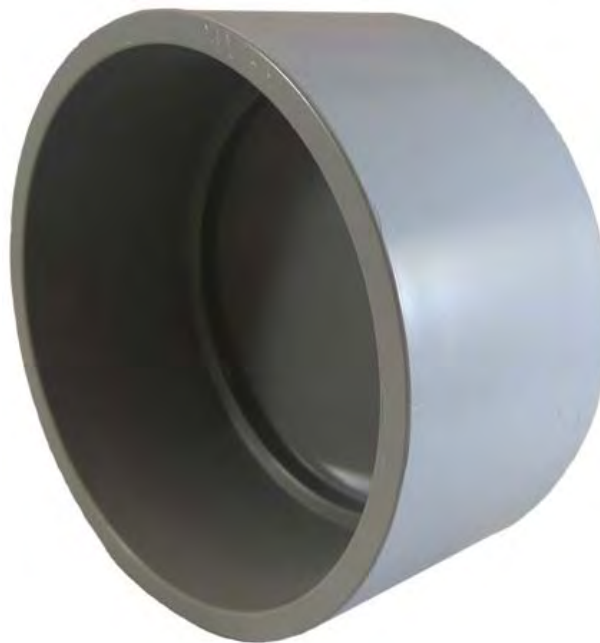
<< [Return to product list](#)

**Item Number** 5140039

**Description** 3 UL END CAPS

**ITF number** 30088700527691

**UPC number** 088700527690



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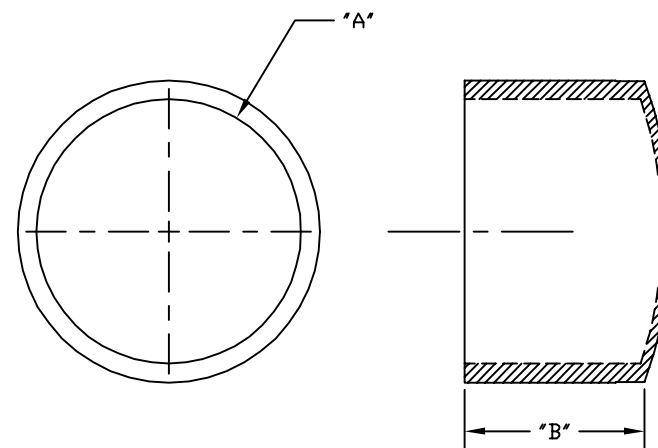
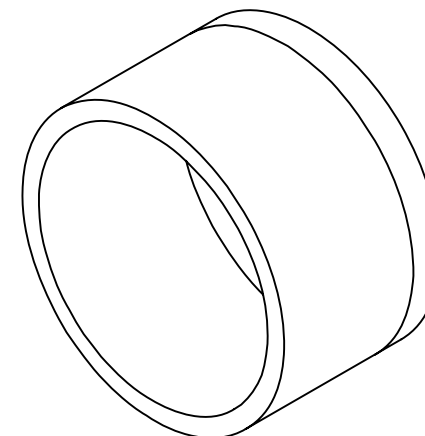
### Additional Info

[Material Safety Data Sheet](#)

[Technical Drawing](#)

PART NUMBER	SIZE	"A"	"B"
5140031	1/2"	7/8"	7/8"
5140032	3/4"	1 1/16"	1 1/16"
5140033	1"	1 3/8"	1 1/4"
5140034	1 1/4"	1 11/16"	1 5/16"
5140035	1 1/2"	1 15/16"	1 9/16"
5140037	2"	2 3/8"	1 5/8"
5140038	2 1/2"	2 7/8"	2"
5140039	3"	3 9/16"	2 3/8"
5140036	3 1/2"	4"	2 5/16"
5140040	4"	4 1/2"	2 3/8"
5140041	5"	5 9/16"	2 1/2"
5140042	6"	-	-

1/2" through 1 1/2" have dome top  
 2" through 6" have flat top  
 UL Listed  
 UL File # E81590  
 UL Category Code DWTT  
 UL Control Number 93G7  
 Material is Rigid PVC  
 Meets NEMA TC3 Requirements



**CANTEX**  
 INC.  
 Fort Worth, TEXAS

Caps  
 Schedule 40 & 80 Special Fittings

Drawn By: CD Branch

Date: 09/25/07

Ref.

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**EZ BOX® 21 Cubic Inch Old Work Box** offers a full 21 cubic inch wiring capacity for the installation of switch or outlets in an existing structure. [Details...](#)



**Forte-Duct® Conduit and Duct** is light weight with the CANTEX standard long bell. [Details...](#)

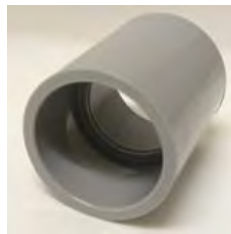


**EZ GUARD®** protects high voltage electrical bushing on utility poles from contact with wildlife causing unnecessary power outages. [Details...](#)



## NM FITTINGS & ACCESSORIES

### SCHEDULE 40 COUPLINGS WITH CENTER STOP



A connector used to join lengths of conduit pipe. The fitting consist of two female ends with a center stop. Both pieces of pipe should seat at the stop for proper positioning.



## Product Details

<< [Return to product list](#)

**Item Number** 6141630

**Description** 3 UL CPLG CC

**ITF number** 30088700569516

**UPC number** 088700061088



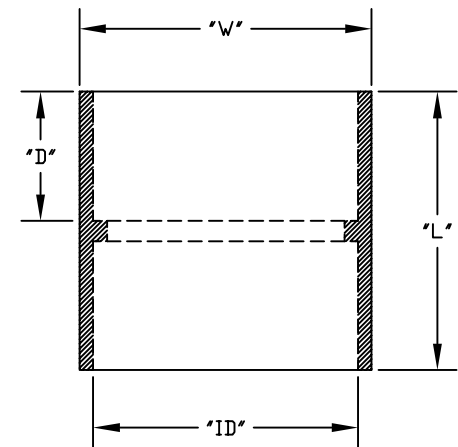
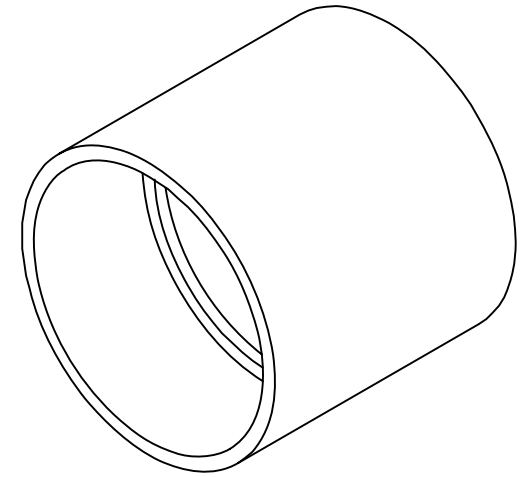
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### Additional Info

[Material Safety Data Sheet](#)

[Technical Drawing](#)

PART NUMBER	TRADE SIZE	"W"	"L"	"ID"	"D"
6141623	½"	1 ¼"	1 ½"	7⁄8"	5⁄8"
6141624	¾"	1 5⁄16"	1 9⁄16"	1 ¼"	5⁄8"
6141625	1"	1 5⁄8"	2"	1 5⁄16"	1"
6141626	1 ¼"	2"	2 1⁄8"	1 11⁄16"	1"
6141627	1 ½"	2 ¼"	2 3⁄8"	1 15⁄16"	1 1⁄8"
6141628	2"	2 11⁄16"	2 7⁄16"	2 3⁄8"	1 ¼"
6141629	2 ½"	3 ¼"	3 ½"	2 7⁄8"	1 ¾"
6141630	3"	4"	3 7⁄8"	3 ½"	1 13⁄16"
6141631	3 ½"	4 1⁄8"	4"	4"	1 15⁄16"
6141632	4"	5"	4 3⁄16"	4 ½"	2"
6141633	5"	6 1⁄8"	5 3⁄8"	5 5⁄8"	2 ½"
6141634	6"	7 ¼"	6 3⁄8"	6 5⁄8"	3"
*6141635D	8"	N/A	N/A	N/A	N/A



UL Listed UL651  
 UL File # E81590  
 UL Category Code DWTT  
 UL Control Number 93G7  
 Meets NEMA TC3 Requirements  
 CSA Certified  
 See NEC Article 352 for use  
 Material is Rigid PVC

\* Not UL Listed



**CANTEX**

INC.  
Fort Worth, TEXAS

**Couplings**  
**Schedule 40 & 80 Fittings**

Drawn By: CD Branch

Date: 09/12/07

Ref.



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New Freight Terms effective  
November 10, 2008

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**Forte-Duct® Conduit and Duct** is light weight with the CANTEX standard long bell. [Details...](#)



**EZ GUARD®** protects high voltage electrical bushing on utility poles from contact with wildlife causing unnecessary power outages. [Details...](#)



## NM FITTINGS & ACCESSORIES MALE ADAPTER

### MALE ADAPTER

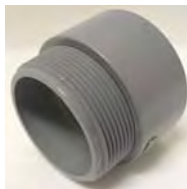


1/2" through 2"

[Select part number for detailed information and technical drawing.](#)

A connector used to transition from plain end PVC conduit to a threaded metal or PVC female bell. Can also be used to connect PVC conduit to a box or other threaded body with the use of a lock nut.

The fitting consists of one solvent weld female end and one threaded male end. Both ends will fit the same diameter conduit.



2-1/2" through 8"

[Select part number for detailed information and technical drawing.](#)



## Product Details

<< [Return to product list](#)

**Item Number** 5140110  
**Description** 3 UL ADAPT M CT  
**ITF number** 30088700568649  
**UPC number** 088700062085



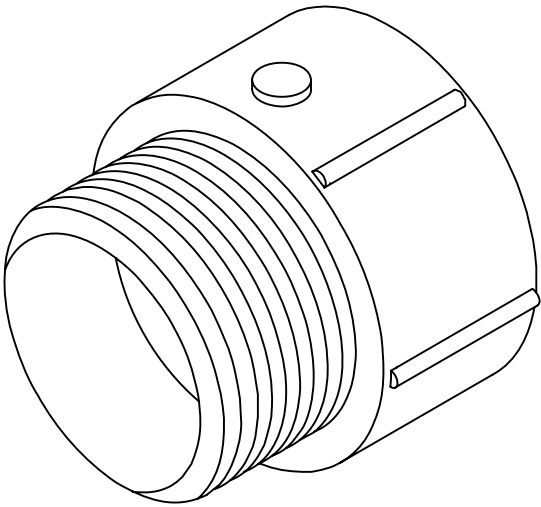
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### Additional Info

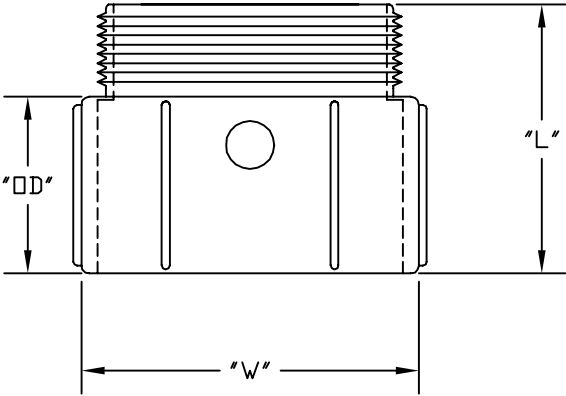
[Material Safety Data Sheet](#)

[Technical Drawing](#)

PART NUMBER	TRADE SIZE	"L"	"W"	"OD"
5140108	2	2 <sup>3</sup> / <sub>16</sub> "	2 <sup>1</sup> / <sub>16</sub> "	1 <sup>3</sup> / <sub>8</sub> "
5140109	2 1/2	2 <sup>7</sup> / <sub>8</sub> "	3 <sup>5</sup> / <sub>16</sub> "	2"
5140110	3	3	3 <sup>15</sup> / <sub>16</sub> "	2 <sup>3</sup> / <sub>16</sub> "
5140111	3 1/2	3 <sup>3</sup> / <sub>16</sub> "	4 <sup>1</sup> / <sub>2</sub> "	2 <sup>9</sup> / <sub>16</sub> "
5140112	4	3 <sup>7</sup> / <sub>16</sub> "	5	2 <sup>9</sup> / <sub>16</sub> "
5140113	5	4 <sup>3</sup> / <sub>4</sub> "	6 <sup>1</sup> / <sub>4</sub> "	3
5140114	6	4 <sup>15</sup> / <sub>16</sub> "	7 <sup>5</sup> / <sub>16</sub> "	2 <sup>1</sup> / <sub>16</sub> "
*5140115D	8	-	-	-



UL Listed  
 UL File # E81590  
 UL Category Code DWTT  
 UL Control Number 93G7  
 Meets NEMA TC3 Requirements  
 CSA Certified  
 See NEC Article 352 for use  
 Material is Rigid PVC



**CANTEX**  
 INC.  
 MINERAL WELLS, TEXAS

Terminal Adapters 2" & Larger  
 Schedule 40 & 80 Fittings

Drawn By: CD Branch
 Date:09/12/07
 Ref.

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**Forte-Duct® Conduit and Duct** is light weight with the CANTEX standard long bell. [Details...](#)



**EZ GUARD®** protects high voltage electrical bushing on utility poles from contact with wildlife causing unnecessary power outages. [Details...](#)



## NM FITTINGS & ACCESSORIES

### FEMALE ADAPTER



A connector often used to transition threaded metal conduit to PVC conduit. Can also be used to join PVC to PVC. The fitting consists of two female ends. One end is threaded and the other is solvent weld. Both ends fit the same diameter conduit.



## Product Details

<< [Return to product list](#)

**Item Number** 5140050

**Description** 3 UL ADAPT F CT

**ITF number** 30088700527738

**UPC number** 088700569409



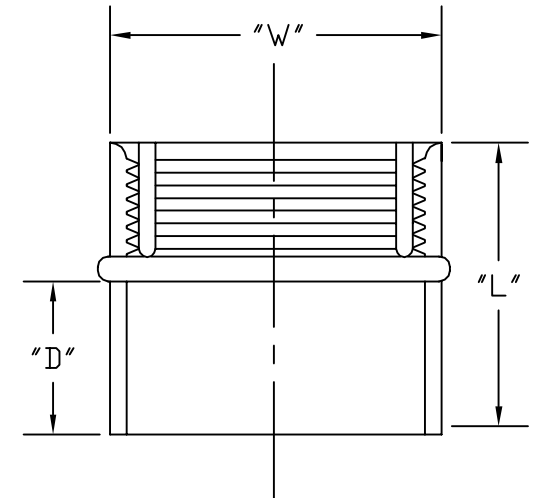
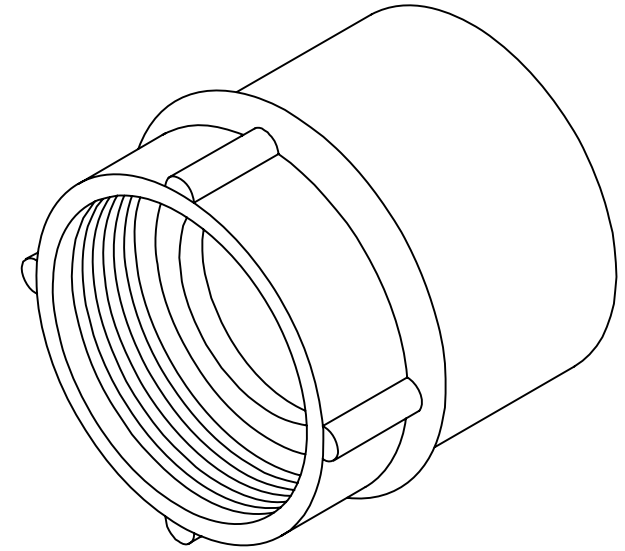
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**Additional Info**

[Material Safety Data Sheet](#)

[Technical Drawing](#)

PART NUMBER	TRADE SIZE	"W"	"L"	"ID"
5140043	1/2	1"	1 7/16"	1 1/16"
5140044	3/4	1 1/4"	1 5/8"	1 1/16"
5140045	1	1 9/16"	1 7/8"	7/8"
5140046	1 1/4	2"	1 15/16"	15/16"
5140047	1 1/2	2 1/4"	2 1/8"	15/16"
5140048	2	2 11/16"	2 1/8"	15/16"
5140049	2 1/2	3 5/16"	3"	1 5/16"
5140050	3	4	3 1/16"	1 1/4"
5140051	3 1/2	4 1/2"	3"	1 3/16"
5140052	4	5"	3 1/4"	1 3/8"
5140053	5	6 1/8"	3 11/16"	1 5/16"
5140054	6	7 1/4"	4 3/8"	1 5/8"
*5140055D	8	9 5/16"	7	2 1/4"



UL Listed UL 651  
 UL File # E81590  
 UL Category Code DWTT  
 UL Control Number 93G7  
 Meets NEMA TC3 Requirements  
 CSA Certified  
 See NEC Article 352 for use  
 Material is Rigid PVC  
 \* 8 inch not UL Listed



**CANTEX**

INC.  
Fort Worth, TEXAS

**Female Adapters  
Schedule 40 & 80 Fittings**

Drawn By: CD Branch

Date: 09/25/07

Ref.



# MUELLER Bushing, 1 1/2 x 1 In Spigot x Slip, PVC NEW

[Plumbing](#) > [Fittings](#) > [PVC and CPVC Pipe Fittings](#)

Bushing, Reducing, Pipe Size 1 1/2 x 1 In, Spigot x Slip Connection, Material of Construction PVC, Schedule 40, Max Temp 140 F, Color White, Standards ASTM D 2466, D 1784, F 1498, NSF/ANSI 14 & 61

Grainger Item #	5WPN6
Price (ea.)	<b>\$0.95</b>
Brand	MUELLER
Mfr. Model #	437-211
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	0.09
Usually Ships**	<a href="#">Today</a>
Catalog Page No.	N/A
Country of Origin (Country of Origin is subject to change.)	USA



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Qty.

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Price shown may not reflect your price. [Sign in](#) or [register](#).

Tech Specs	Additional Information	Compliance & Restrictions	MSDS	Required Accessories	Optional Accessories	Alternate Products	Repair Parts
Item		Bushing					
Type		Reducing					
Pipe Size		1-1/2 x 1"					
Connection		Spigot x Slip					
Material of Construction		PVC					
Max. Temp. (F)		140					
Color		White					
Schedule		40					
Standards		ASTM D 2466, D 1784, F 1498, NSF/ANSI 14 & 61					
Package Quantity		1					

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## PVC Sch. 40 Pressure Fittings

### COUPLING



#### SLIP X SLIP

Part	Size	Box	Ctn	List
429-005	1/2	50	400	0.36
429-007	3/4	50	600	0.49
429-010	1	50	300	0.86
429-012	1-1/4	25	200	1.18
429-015	1-1/2	25	150	1.26
429-020	2		20	1.93
429-025	2-1/2		10	4.27
429-030	3	1	15	6.68
429-040	4	1	5	9.66
429-060	6	1	5	30.56

#### REDUCING

429-101	3/4 x 1/2	50	600	0.89
429-131	1 x 3/4	50	200	1.52
429-338	3 x 2	5	30	23.19
429-422	4 x 3		4	28.96

### COUPLING



#### THREADED FPT x FPT

Part	Size	Box	Ctn	List
430-005	1/2	50	400	0.68
430-007	3/4	50	600	1.26
430-010	1	50	300	1.66

### RISER



#### EXTENDER FPT x MPT

Part	Size	Box	Ctn	List
434-005	1/2	50	400	0.99

### ADAPTER



#### FEMALE SLIP x FPT

Part	Size	Box	Ctn	List
435-005	1/2	50	400	0.60
435-007	3/4	50	600	0.77
435-010	1	50	300	0.89
435-012	1-1/4	25	200	1.38
435-015	1-1/2	25	150	1.58
435-020	2		20	2.12

#### SLIP x REDUCING FPT

435-101	3/4 x 1/2	50	600	1.09
435-131	1 x 3/4	50	200	1.44

#### FPT x REDUCING SLIP

435-074	3/4 x 1/2	50	600	1.09
435-102	1 x 3/4	50	200	1.44

### ADAPTER



#### MALE SLIP x MPT

Part	Size	Box	Ctn	List
436-005	1/2	50	800	0.49
436-007	3/4	50	600	0.54
436-010	1	50	400	0.97
436-012	1-1/4	25	200	1.18
436-015	1-1/2	25	150	1.58
436-020	2	10	120	2.08

#### SLIP x REDUCING MPT

436-074	3/4 x 1/2	50	600	0.97
436-102	1 x 3/4	50	400	1.38
436-132	1-1/4 x 1	25	200	3.23
436-169	1-1/2 x 1-1/4	25	150	3.64
436-213	2 x 1-1/2	10	120	4.40

#### MPT x REDUCING SLIP

436-101	3/4 x 1/2	50	400	0.89
436-131	1 x 3/4	50	400	2.97
436-212	1-1/2 x 1-1/4	25	200	4.40
436-251	2 x 1-1/2	10	120	5.02

### DRAIN PAN ADAPTER



#### MALE

#### SLIP X MPT w/ Metal Lock Nut

Part	Size	Box	Ctn	List
436-107**	3/4"	50	600	3.20

### BUSHING



#### MALE

#### SPIG x SLIP

Part	Size	Box	Ctn	List
437-101	3/4 x 1/2	50	400	0.56
437-130	1 x 1/2	50	800	1.02
437-131	1 x 3/4	50	800	1.02
437-166	1-1/4 x 1/2	25	200	1.38
437-167	1-1/4 x 3/4	25	200	1.38
437-168	1-1/4 x 1	25	200	1.38
437-209	1-1/2 x 1/2	25	300	1.46
437-210	1-1/2 x 3/4	25	300	1.46
437-211	1-1/2 x 1	25	300	1.46
437-212	1-1/2 x 1-1/4	25	300	1.46
437-248	2 x 3/4	10	160	2.42
437-249	2 x 1	10	160	2.42
437-250	2 x 1-1/4	10	160	2.42
437-251	x 1-1/2	10	160	2.42
437-290	2-1/2 x 1-1/4		80	3.88
437-291	x 1-1/2	10	80	3.88
437-292	2	10	80	3.88
437-338	3 x 2	10	60	5.71
437-339	x 2-1/2	10	60	5.71

### BUSHING



#### SPIG x FPT

Part	Size	Box	Ctn	List
438-101	3/4 x 1/2	50	400	0.89
438-130	1 x 1/2	50	800	1.44
438-131	1x 3/4	50	800	1.44
438-166	1-1/4 x 1/2	25	200	2.22
438-167	1-1/4 x 3/4	25	200	2.22
438-168	1-1/4 x 1	25	200	2.22
438-209	1-1/2 x 1/2	25	300	2.56
438-210	1-1/2 x 3/4	25	300	2.56
438-211	1-1/2 x 1	25	300	2.56
438-212	1-1/2 x 1-1/4	25	300	2.56
438-248	2 x 3/4	10	160	3.43
438-249	2 x 1	10	160	3.43
438-250	2 x 1-1/4	10	160	3.43
438-251	2 x 1-1/2	10	160	3.43
438-290	2-1/2 x 1-1/4	10	160	4.96
438-292	2-1/2 x 2	10	80	4.96
438-338	3 x 2	10	80	5.71
438-339	3 x 2-1/2	10	60	5.71
438-421	4 X 2-1/2	5	30	12.76
438-422	4 X 3	5	30	12.76

### BUSHING



#### MPT x FPT

Part	Size	Box	Ctn	List
439-101	3/4 x 1/2	50	400	1.58
439-130	1 x 1/2	50	800	2.22
439-131	1 x 3/4	50	800	2.22
439-167	1-1/4 x 3/4	25	200	3.30
439-168	1-1/4 x 1	25	200	3.30
439-210	1-1/2 x 3/4	25	200	3.99
439-211	1-1/2 x 1	25	200	3.99
439-212	1-1/2 x 1-1/4	25	200	3.99
439-249	2 x 1	10	160	4.27
439-251	2 x 1-1/2	10	120	4.27

### CAP



#### SLIP

Part	Size	Box	Ctn	List
447-005	1/2	50	400	0.49
447-007	3/4	50	400	0.56
447-010	1	50	400	0.89
447-012	1-1/4	25	300	1.26
447-015	1-1/2	25	200	1.38
447-020	2	10	120	1.66
447-025	2-1/2	10	60	5.29
447-030	3	10	60	5.79
447-040	4		5	13.16
447-060	6		5	31.54

### CAP



#### FPT

Part	Size	Box	Ctn	List
448-005	1/2	50	400	1.02
448-007	3/4	50	400	1.18
448-010	1	50	400	1.79
448-012	1-1/4	25	300	2.12
448-015	1-1/2	25	200	2.22
448-020	2	10	120	3.92

### PLUG



#### SPIG

Part	Size	Box	Ctn	List
449-005	1/2	50	400	1.18
449-007	3/4	50	400	1.38
449-010	1	50	800	1.66
449-012	1-1/4	25	200	2.22
449-015	1-1/2	25	300	2.82
449-020	2	10	160	3.49

### PLUG



#### THREADED MPT

Part	Size	Box	Ctn	List
450-005	1/2	50	400	1.46
450-007	3/4	50	400	1.57
450-010	1	50	800	2.56
450-012	1-1/4	25	200	2.69
450-015	1-1/2	25	200	2.89
450-020	2	10	160	3.73

### UNION

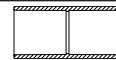


#### 150 PSI @ 73°F

#### SLIP x SLIP w/Buna O-ring

Part	Size	Box	Ctn	List
457-007*	3/4	10	80	6.02

### COUPLING



#### DEEP SOCKET SLIP

Part	Size	Box	Ctn	List
482-007	3/4	50	1.52	1.69

### R-TRAP



#### CONDENSATE DRAIN LINE

Part	Size	Box	Ctn	List
488-005	1/2 315 psi		50	2.10
488-007	3/4		50	2.38
488-010	1		10	3.85

### P-TRAP



#### CONDENSATE DRAIN LINE

Part	Size	Box	Ctn	List
489-007	3/4		50	2.38
489-010	1		10	3.85

**APPENDIX C**

**Sensor**

Sonar range

# XL- MaxSonar® - WR1™ (MB7060)

# XL- MaxSonar® - WRA1™ (MB7070)



## Weather Resistant (IP67) Sonar Range Finder with High Power Output, Noise Rejection, Auto Calibration & Long-Range Narrow Detection Zone

*This sensor provides very short to long-range detection and ranging, in a compact, robust PVC housing, designed to meet IP67 water intrusion, and matches standard electrical 3/4" PCV pipe fittings. This sensor has a new high power output along with real-time auto calibration for changing conditions (temperature, voltage or acoustic or electrical noise) that ensure you receive the most reliable (in air) ranging data for every reading taken. The low power 3.3V – 5V operation detects objects from 0-cm to 765-cm (25.1 feet) and provides sonar range information from 20-cm out to 765-cm with 1-cm resolution. Objects from 0-cm to 20-cm range as 20-cm. The interface output formats included are pulse width output (MB7060), real-time analog voltage envelope (MB7070), analog voltage output, and serial digital output.*

### Features

- High acoustic power output
- Real-time auto calibration and noise rejection for every ranging cycle
- Precise narrow beam
- Continuously variable gain
- Object detection includes zero range objects
- 3.3V to 5V supply with very low average current draw
- Readings can occur up to every 100mS, (10-Hz rate)
- Free run operation can continually measure and output range information
- Triggered operation provides the range reading as desired
- All interfaces are active simultaneously
  - Serial, 0 to Vcc
  - 9600Baud, 81N
  - Analog, (Vcc/1024) / cm
  - Pulse Width (MB7060)
  - Real-time analog envelope (MB7070)
- Sensor operates at 42KHz

### Benefits

- Acoustic and electrical noise resistance
- Reliable and stable range data
- Sensor dead zone virtually gone
- Low cost IP67 sensor
- Quality narrow beam characteristics
- Very low power ranger, excellent for multiple sensor or battery based systems
- Can be triggered externally or internally
- Sensor reports the range reading directly, frees up user processor
- Fast measurement cycle
- User can choose any of the sensor outputs
- No calibration requirement is perfect for when objects may be directly in front of the sensor during power up
- Easy hole mounting or mating with standard electrical fittings

### Applications and Uses

- Tank level measurement
- Bin level measurement
- Proximity zone detection
- People detection
- Robot ranging sensor
- Autonomous navigation
- Environments with acoustic and electrical noise
- Multi-sensor arrays
- Distance measuring
- Long range object detection
- Wide beam sensitivity
- Users who prefer to process the analog voltage envelope (MB7070)
- Industrial sensor
- Physical drop-in upgrade for LV-MaxSonar-WR1 product, part numbers: MB7001





## MB7060 & MB7070 Real-time Noise Rejection

While the XL-MaxSonar® is designed to operate in the presence of noise, best operation is obtained when noise strength is low and desired signal strength is high. Hence, the user is encouraged to mount the sensor in such a way that minimizes outside acoustic noise pickup. In addition, keep the DC power to the sensor free of noise. This will let the sensor deal with noise issues outside of the users direct control (in general, the sensor will still function well even if these things are ignored). Users are encouraged to test the sensor in their application to verify usability.

For every ranging cycle, individual filtering for that specific cycle is applied. In general, noise from regularly occurring periodic noise sources such as motors, fans, vibration, etc., will not falsely be detected as an object. This holds true even if the periodic noise increases or decreases (such as might occur in engine throttling or an increase/decrease of wind movement over the sensor). Even so, it is possible for sharp non-periodic noise sources to cause false target detection. In addition, \*(because of dynamic range and signal to noise physics,) as the noise level increases, at first only small targets might be missed, but if noise increases to very high levels, it is likely that even large targets will be missed.

\*HINT: In high noise environments, if needed, use 5V power to keep acoustic signal power high.

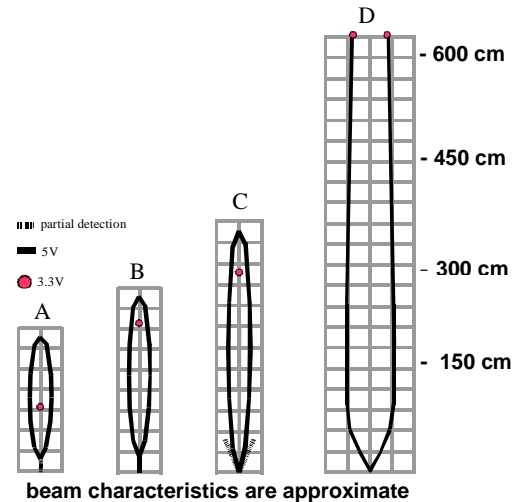
## MB7060 & MB7070 Beam Characteristics

People detection requires high sensitivity, yet minimal side-lobes requires low sensitivity. The MB7060 and MB7070 balances the detection of people with minimal side-lobes. Sample results for measured beam patterns are shown below on a 30-inch grid. The detection pattern is shown for;

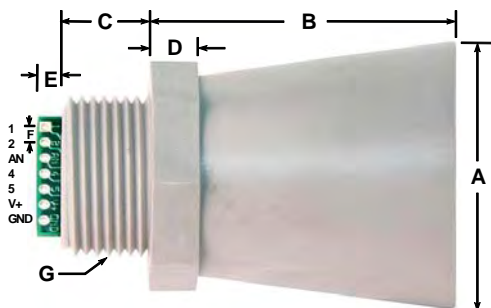
- (A) 0.25-inch diameter dowel,
- (B) 1-inch diameter dowel,
- (C) 3.25-inch diameter dowel,
- (D) 11-inch wide board moved left to right with the board parallel to the front sensor face and the sensor stationary.

This shows the sensor's range capability.

Note: The displayed beam width of (D) is a function of the specular nature of sonar and the shape of the board (i.e. flat mirror like) and should never be confused with actual sensor beam width.

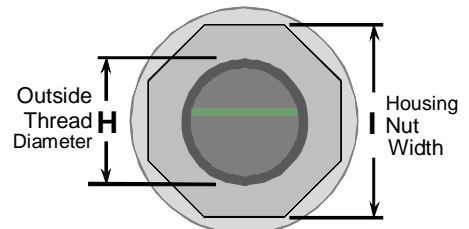


## MB7060 & MB7070 Mechanical Dimensions



A	1.72" dia.	43.8 mm dia.
B	2.00"	50.7 mm
C	0.58"	14.4 mm
D	0.31"	7.9 mm
E	0.18"	4.6 mm
F	0.1"	2.54 mm
G	3/4" National Pipe Thread Straight	
H	1.032" dia.	26.2 mm dia.
I	1.37"	34.8 mm
weight, 1.76 oz., 50 grams		

values are nominal



**MaxBotix® Inc.**

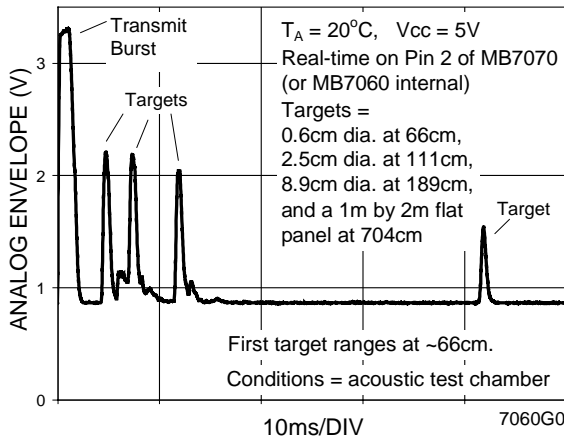
MaxBotix, MaxSonar, WR1 & WRA1 are trademarks of MaxBotix Inc.  
XL-WR1™ XL-WRA1™ • v1.1b • 07/2009 • Patents 7,679,996

Data Sheet Release: 04/28/10, pg. 3

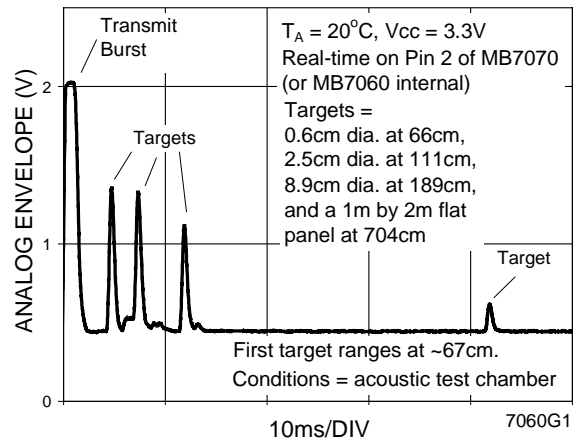
Email: [info@maxbotix.com](mailto:info@maxbotix.com)  
Web: [www.maxbotix.com](http://www.maxbotix.com)

## Typical Performance to Targets

Analog Envelope Output (Dowels, 5V)

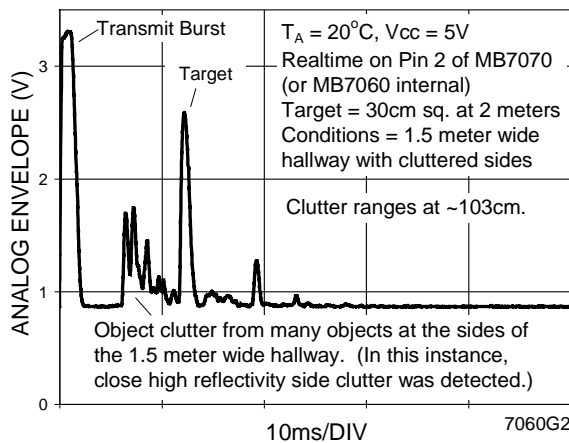


Analog Envelope Output (Dowels, 3.3V)

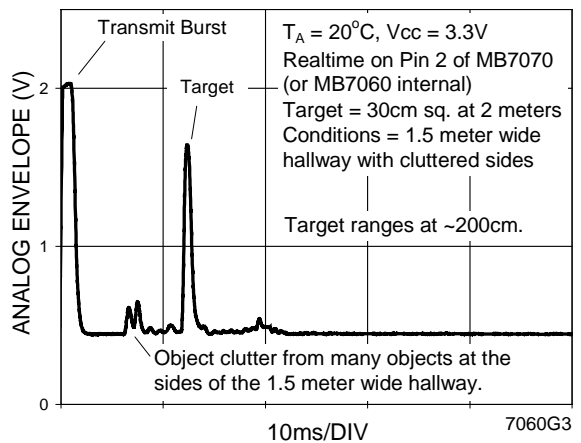


## Typical Performance in Clutter

Analog Envelope Output (Clutter, 5V)



Analog Envelope Output (Clutter, 3.3V)



## **APPENDIX D**

### **Antenna connection components**

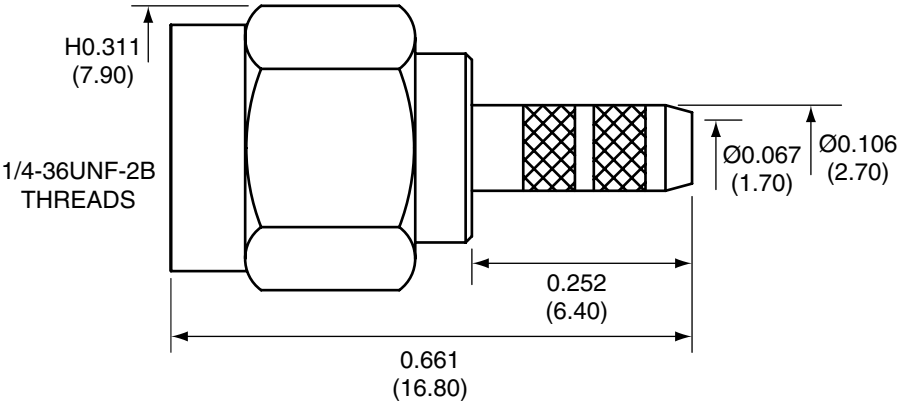
Male cable end

TNC connector

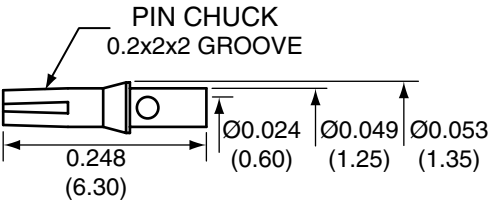
TNC bulkhead crimp jack

1			2	3	4
Description	Material	Finish			
Body	Brass	Nickel			
Socket	BE CU	Gold			
Insulation	Teflon	Teflon			
Washer	PH Bronze	Gold			
Gasket	SI Rubber	Rubber			
Crimp Ring	Brass	Nickel			

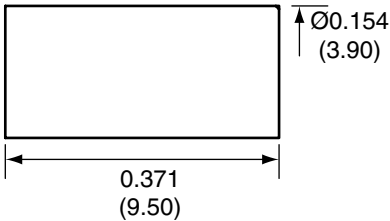
SIDE VIEW



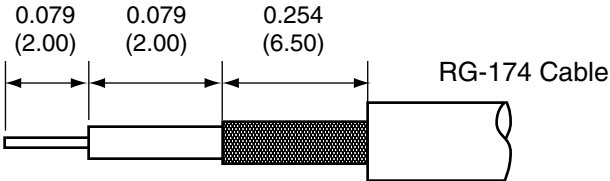
SOCKET



CRIMP RING



RECOMMENDED CABLE STRIPPING DIMENSIONS



CONREVSMA007 ASSEMBLY INSTRUCTIONS

1. Solder the socket to the center conductor.
2. Insert the socket, center conductor, and insulator into the body until the top of the socket is even with the white insulation in the body.
3. Wrap the braid around the tail of the body and crimp the ring with a 0.137" hex crimp tool (or one labeled for use with RG-174 cable)

Title		CONREVSMA007 ASSEMBLY INSTRUCTIONS	
RP-SMA MALE CABLE END CRIMP FOR RG174 CABLE		CONNECTOR CITY 159 ORT LANE MERLIN, OR 97532 PH (541)-471-6256 FAX (541)-471-6251	
Part No.	CONREVSMA007	Revision:	1.0
Dimensions:	INCHES (mm)	Date:	6/2/2006
		Sheet 1 of 1	

**CONNECTOR CITY**  
THE VALUE OF CONNECTIONS

# PORTABLE/TERMINAL ANTENNAS **SPOTS!**



## TNC CONNECTOR - STANDARD (TN TYPE)

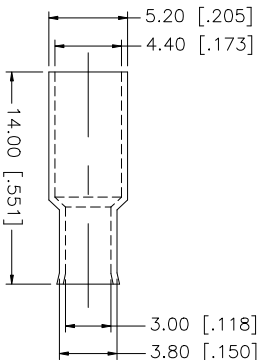
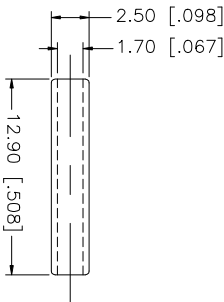
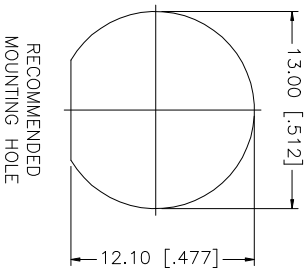
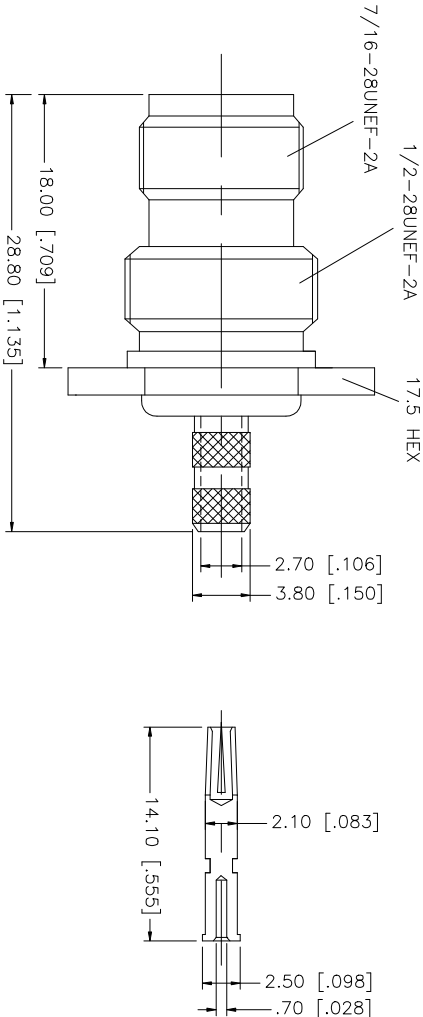
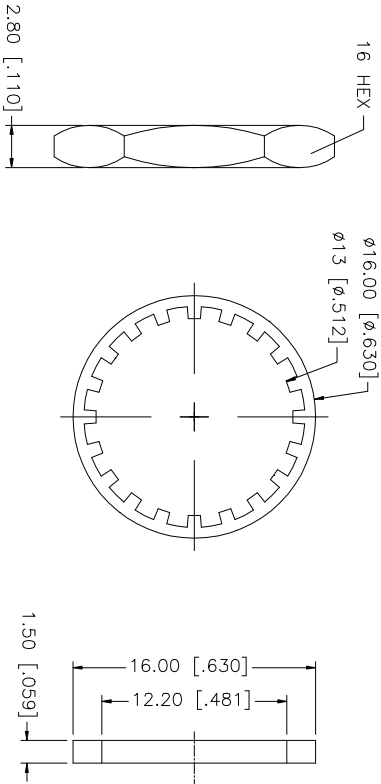
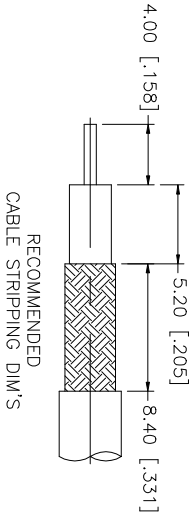
CODE 17

RADIAL/LARSEN PN	CONNECTOR	FREQUENCY RANGE (MHz)	ANTENNA TYPE	PERF. RATING <sup>1</sup>	APPROX. LENGTH
SPDA17832	TNC	824-894	Center Fed Dipole	****	8"
SPDA17918	TNC	890-960	Center Fed Dipole	****	8"
SPDA171800	TNC	1710-1850	Center Fed Dipole	****	6 1/2"
SPDA171900	TNC	1850-1990	Center Fed Dipole	****	6 1/2"
SPDA172400	TNC	2400-2500	Center Fed Dipole	****	6"
SPDA17RP2400	TNC RP	2400-2500	Center Fed Dipole	****	6"
SPDA17RP918	TNC RP	890-960	Center Fed Dipole	****	8"
SPHE17FREQ	TNC	Specify Freq. 30-80	Helical - 1/4 Wave Custom Tuned	****	11"
SPHL17136	TNC	130-142	Helical - Standard - 1/4 Wave	****	8"
SPHL17140	TNC	134-146	Helical - Standard - 1/4 Wave	****	8"
SPHL17144	TNC	138-150	Helical - Standard - 1/4 Wave	****	8"
SPHL17152	TNC	146-158	Helical - Standard - 1/4 Wave	****	8"
SPHL17156	TNC	150-162	Helical - Standard - 1/4 Wave	****	8"
SPHL17160	TNC	154-166	Helical - Standard - 1/4 Wave	****	8"
SPHL17167	TNC	160-174	Helical - Standard - 1/4 Wave	****	8"
SPWH17420	TNC	395-445	Whip - Standard - 1/4 Wave	*****	6"
SPWH17450	TNC	425-475	Whip - Standard - 1/4 Wave	*****	6"
SPNY17450	TNC	425-475	Whip - Standard - 1/4 Wave	*****	6"
SPWH17470	TNC	450-490	Whip - Standard - 1/4 Wave	*****	6"
SPWH17490	TNC	470-512	Whip - Standard - 1/4 Wave	*****	6"
SPWH17832	TNC	782-882	Whip - Standard - 1/4 Wave	*****	2 3/4"
SPNY17832	TNC	782-882	Whip - Standard - 1/4 Wave	*****	3"
SPNY17918	TNC	872-964	Whip - Standard - 1/4 Wave	*****	3"
SPHL17FT	TNC	Field Tunable 136-221	Helical - Standard - 1/4 Wave	****	8"
SPWH17FT	TNC	Field Tunable 400 -512	Whip - Standard - 1/4 Wave	****	6"

<sup>1</sup>Refer to Antenna Performance Chart on Page 14.



REV.	DATE	DESCRIPTION
NC	01/20/03	INITIAL RELEASE



- NOTE:
1. CRIMPED FERRULE  
HEX CRIMP SIZE .178"
  2. CRIMPED CONTACT PIN  
HEX CRIMP SIZE .068"

9	FERRULE	COPPER	NICKEL	1	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN MILLIMETERS. DIMENSIONS IN [ ] ARE IN INCHES AND FOR CUSTOMER REFERENCE ONLY.  UNLESS OTHERWISE SPECIFIED TOLERANCES FOR MILLIMETERS ARE: 0.5 - 8mm ± 0.20mm 8 - 30mm ± 0.40mm 30 - 120mm ± 0.50mm  UNLESS OTHERWISE SPECIFIED TOLERANCES FOR INCHES ARE: .020 - .315 = ± 0.007" .315 - 1.180 = ± 0.015" 1.180 - 4.724 = ± 0.020"	CAD FILE C:/122/122192.DWG	<div>Amphenol Connex</div> <div>TNC BULKHEAD CRIMP JACK (FOR RG174/u, 188A/u, 316/u CABLE)</div> <div>122192</div>							
8	SLEEVE	DELRIIN	NATURAL	1										
7	HEX NUT	BRASS	NICKEL	1										
6	LOCK WASHER	BRASS	NICKEL	1										
5	CONTACT PIN	PHOS. BRONZE	GOLD	1										
4	GASKET	RUBBER	RED	1										
3	BARREL	BRASS	NICKEL	1										
2	INSULATOR	DELRIIN	NATURAL	1										
1	HOUSING/BODY	BRASS	NICKEL	1										
DESCRIPTION					MATERIAL	FINISH	QTY	DO NOT SCALE DRAWING	DWG. NO. 122192.DWG			REV. NC	SIZE A	SCALE NA

Amphenol Connex

## **APPENDIX E**

### **Power supply components**

Battery

Solar panel

Solar panel mount

Solar charge controller

# PS-Series General Purpose Batteries

---

All PS Series batteries feature:

- Absorbent Glass Mat (AGM) technology for superior performance.
- Valve regulated, spill proof construction allows safe operation in any position.
- Power/volume ratio yielding unrivaled energy density.
- Approved for transport by air. D.O.T., I.A.T.A., F.A.A. and C.A.B. certified.
- U.L. recognized under file number MH 20845.
- CE certified.



2-volt



4-Volt



6-Volt



8-Volt



12-Volt

# POWER PS SONIC

## PS-630 6 Volt 3.5 AH

Rechargeable Sealed Lead Acid Battery



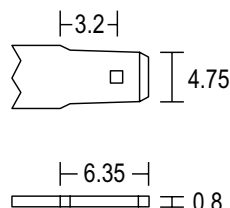
We've Got The Power.™



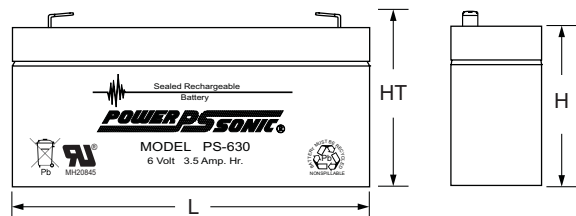
### Terminals

(mm)

- F1 - Quick disconnect tabs, 0.187" x 0.032" - Mate with AMP. INC. FASTON "187" series



### Physical Dimensions: in (mm)



L: 5.28 (134) W: 1.34 (34) H: 2.35 (60) HT: 2.56 (65)

Tolerances are +/- 0.04 in. (+/- 1mm) and +/- 0.08 in. (+/- 2mm) for height dimensions. All data subject to change without notice.

### Features

- Absorbent Glass Mat (AGM) technology for superior performance
- Valve regulated, spill proof construction allows safe operation in any position
- Power/volume ratio yielding unrivaled energy density
- Rugged impact resistant ABS case and cover (UL94-HB)
- Approved for transport by air. D.O.T., I.A.T.A., F.A.A. and C.A.B. certified
- U.L. recognized under file number MH 20845

### Performance Specifications

**Nominal Voltage** .....6 volts (3 cells)

#### Nominal Capacity

20-hr. (175mA to 5.25 volts) .....	3.50 AH
10-hr. (330mA to 5.25 volts) .....	3.30 AH
5-hr. (590mA to 5.10 volts) .....	2.95 AH
1-hr. (2.17A to 4.50 volts) .....	2.17 AH
15-min. (6.86A to 4.50 volts) .....	1.72 AH

**Approximate Weight** ..... 1.37 lbs. (0.62 kg)

**Energy Density** (20-hr. rate) ..... 1.26 W-h/in<sup>3</sup> (77.07 W-h/l)

**Specific Energy** (20-hr. rate) ..... 15.33 W-h/lb (33.79 W-h/kg)

**Internal Resistance** (approx.) ..... 28 milliohms

**Max Discharge Current** (7 Min.) ..... 10.5 amperes

**Max Short-Duration Discharge Current** (10 Sec.)..... 35.0 amperes

**Shelf Life** (% of nominal capacity at 68 °F (20 °C))

1 Month .....	97%
3 Months.....	91%
6 Months .....	83%

#### Operating Temperature Range

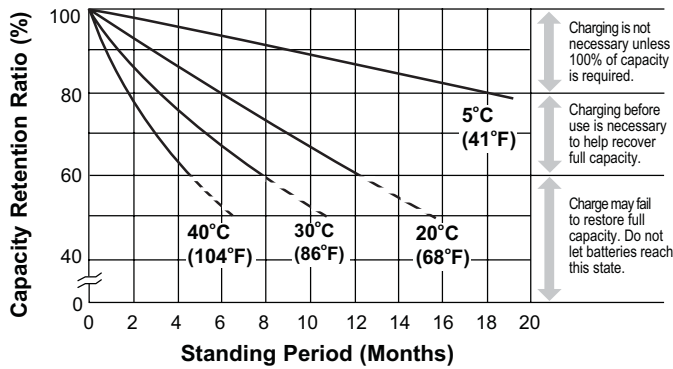
Charge.. ..... -4 °F (-20 °C) to 122 °F (50 °C)

Discharge..... -40 °F (-40 °C) to 140 °F (60 °C)

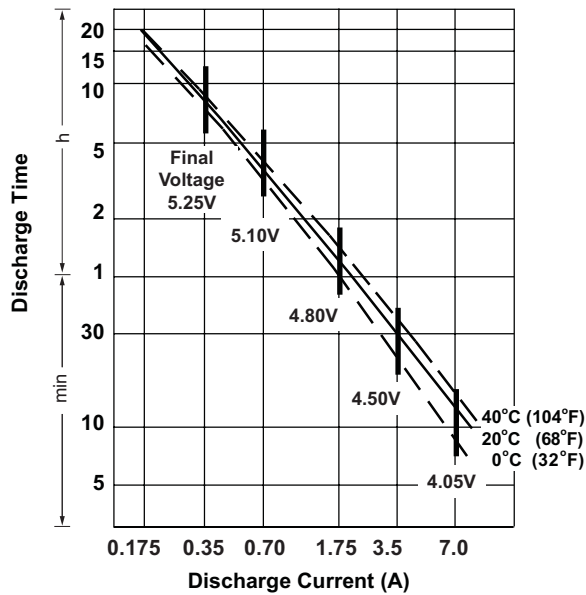
**Case** ..... ABS Plastic

**Power-Sonic Chargers** ..... PSC-6300A, 6500A, 6300A-C, 6500A-C

### Shelf Life & Storage



### Discharge Time vs. Discharge Current



### Charging

**Cycle Applications:** Limit initial current to 1.05A. Charge until battery voltage (under charge) reaches 7.20 to 7.35 volts at 68°F (20°C). Hold at 7.20 to 7.35 volts until current drops to under 35mA. Battery is fully charged under these conditions, and charger should be disconnected or switched to "float" voltage.

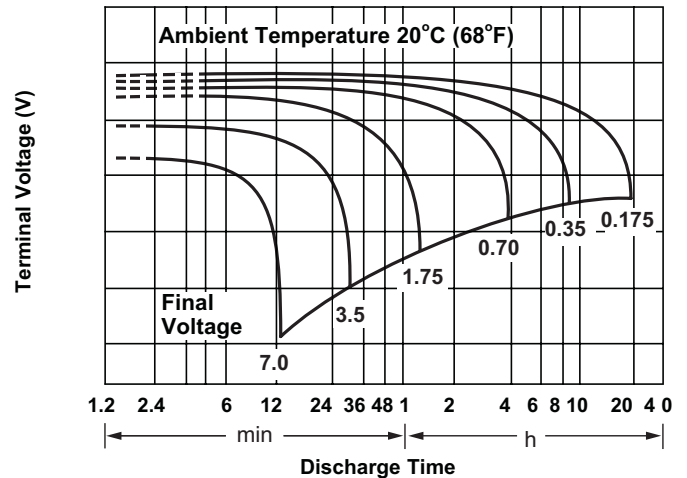
**"Float" or "Stand-By" Service:** Hold battery across constant voltage source of 6.75 to 6.90 volts continuously. When held at this voltage, the battery will seek its own current level and maintain itself in a fully charged condition.

**Note:** Due to the self-discharge characteristics of this type of battery, it is imperative that they be charged within 6 months of storage, otherwise permanent loss of capacity might occur as a result of sulfation.

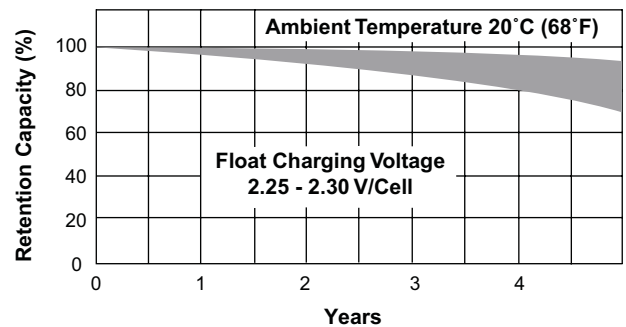
### Chargers

Power-Sonic offers a wide range of chargers suitable for batteries up to 100AH. Please refer to the Charger Selection Guide in our specification sheets for "C-Series Switch Mode Chargers" and "Transformer Type A and F Series". Please contact our Technical department for advice if you have difficulty in locating suitable models.

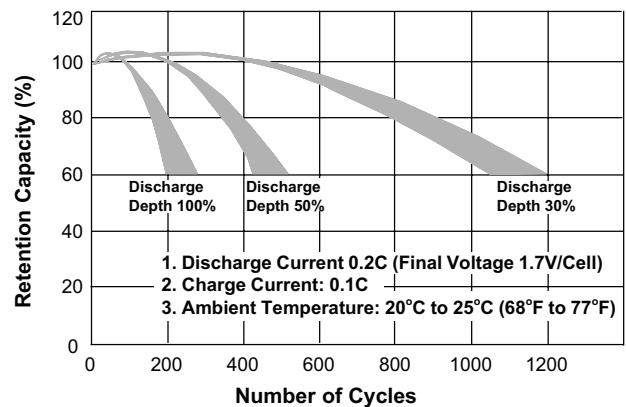
### Discharge Characteristics



### Life Characteristics in Stand-By Use



### Life Characteristics in Cyclic Use





## Engineered With Vision. Built With Care.

Power-Sonic has more than 38 years of battery industry experience and today our batteries are sold in more than 70 countries world-wide. Since our inception in 1970, our focus has been the design, manufacture and marketing of rechargeable batteries, specifically:

- Sealed lead-acid (SLA), also called valve regulated lead-acid (VRLA) batteries
- Powersport batteries
- Sealed nickel-cadmium (NiCd) and nickel-metal hydride (NiMH) batteries
- NiCd and NiMH configured packs (cell assemblies)
- SLA battery chargers
- NiCd and NiMH battery chargers

## Features

### Sealed/Maintenance-Free

The valve regulated, spill-proof construction allows trouble-free, safe operation in any position. There is no need to add electrolyte, as gases generated during overcharge are recombined in a unique "oxygen cycle."

### Valve Regulated Design

Our batteries incorporate a series of one-way low pressure valves. These self sealing valves allow the venting of any excess gasses that may be produced in the battery due to severe overcharging. Valve regulated batteries should never be recharged inside a sealed container.

### Design Flexibility

Batteries may be used in series and/or parallel to obtain choice of voltage and capacity. Due to recent design breakthroughs, the same battery may be used in either cyclic or standby applications. Over 60 models are available to choose from.

### Compact

Power-Sonic batteries use state-of-the-art design, high grade materials, and a carefully controlled plate-making process to provide excellent output per cell. The high energy density results in superior power/volume and power/weight ratios.

### Rugged Construction

The high impact resistant battery case is made of non-conductive ABS plastic to UL94-HB. This material imparts very good resistance to shock, vibration, chemicals and heat. Certain models feature flame retardant (FR) cases/covers to UL94 V-O.

### Wide Operating Temperature Range

Power-Sonic batteries may be discharged over a temperature range of -40°C to +60°C (-40°F to +140°F) and charged at temperatures ranging from -40°C to +50°C (-40°F to +122°F).

Our products are widely used in an ever broadening range of electronic and industrial applications. Our batteries continue to be used wherever cost effective and reliable DC power is required, be it as the principal power or standby power source.

Our aim is the ongoing improvement of our existing products, coupled with the development of new tailored products, to meet the ever increasing needs for stand alone power. Our advanced engineering techniques and state-of-the-art manufacturing processes ensure that we remain on the cutting edge of battery technology. These skills, coupled with our selection of the finest raw materials, allow us to produce batteries combining superior performance and value.

Providing our customers with reliable, yet economical, products is the cornerstone of our mission.

### Long Service Life

Under normal operating conditions, four or five years of dependable service life can be expected in stand-by applications, or between 200 and 1000 charge/ discharge cycles depending on the average depth of discharge.

### Deep Discharge Recovery

Special separators, advanced plate composition, and a carefully balanced electrolyte system have greatly improved the ability to recover from excessively deep discharge.

### Lead Calcium Plates

Heavy duty lead calcium plates provide an extra margin of performance and life in both cyclic and float applications and give unequalled recovery from deep discharge.

### Economical

The high watt-hour per dollar value is made possible by the materials used in a sealed lead-acid battery: they are readily available and low in cost.

### Operation in any Orientation

Our SLA batteries can be discharged in any orientation, without reduction in performance or leakage of electrolyte.

### High Rate Discharge

Low internal resistance allows discharge currents of up to ten times the battery's rated capacity. Relatively small batteries may thus be specified in applications requiring high peak currents.

### Long Shelf Life

A low self discharge rate allows storage of fully charged batteries for extended periods of time before charging is required. Lower storage temperatures further enhance shelf life characteristics.



## PS and PSG-SERIES: General Purpose Batteries

Model	Nominal Voltage V	Nominal Capacity A.H.	Current @ 20-hr. rate mA	Length		Width		Height		Ht. Over Terminal		Weight		Standard Terminals
				in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kgs.	
PS-260	2	6.0	300	1.97	50	1.34	34	3.94	100	4.13	105	0.89	0.40	F1
PS-445	4	4.5	225	1.89	48	2.09	53	3.70	94	3.86	98	1.30	0.59	F2
PSG-450	4	5.0	250	3.54	90	1.94	49	2.87	73	2.87	73	1.40	0.64	F2
PSG-480	4	8.0	400	3.54	90	1.94	49	4.00	102	4.00	102	2.09	0.95	F2
PS-490	4	9.0	450	4.01	102	1.73	44	3.74	95	4.02	102	2.20	1.00	F2
PS-4100	4	10.0	500	4.01	102	1.97	50	3.70	94	3.85	98	2.50	1.13	F1
PS-605	6	0.5	25	2.24	57	0.55	14	1.97	50	1.97	50	0.20	0.09	WL
PS-610	6	1.1	55	2.00	51	1.65	42	2.00	51	2.20	56	0.44	0.20	F1
PS-612	6	1.4	70	3.82	97	0.94	24	2.00	51	2.20	56	0.66	0.30	F1
PSG-625	6	2.5	125	4.15	105	1.63	41	2.70	69	2.70	69	1.17	0.53	F1
PS-628	6	2.9	145	2.60	66	1.30	33	3.86	98	4.06	103	1.30	0.59	F1
PS-630	6	3.5	175	5.28	134	1.34	34	2.35	60	2.56	65	1.37	0.62	F1
PS-632	6	3.5	175	2.60	66	1.30	33	4.65	118	4.80	122	1.37	0.62	F1
PS-640	6	4.5	225	2.76	70	1.86	47	3.94	100	4.25	108	1.60	0.73	F1
PS-650LS & LF	6	5.0	250	2.64	67	2.64	67	3.94	100	4.64	118	1.80	0.82	F1 or SP
PSG-650	6	5.0	250	5.28	134	1.94	49	3.00	76	3.00	76	2.15	0.98	F2
PS-665	6	6.5	325	3.86	98	2.20	56	3.78	96	4.02	102	2.70	1.22	FP
PS-670	6	7.0	350	5.95	151	1.34	34	3.70	94	3.94	100	2.42	1.10	F1
PSG-680	6	8.0	400	5.28	134	1.94	49	3.98	101	3.98	101	3.19	1.45	F2
PS-682	6	9.0	450	3.86	98	2.20	56	4.65	118	4.72	120	3.20	1.45	F1
PS-6100	6	12.0	600	5.95	151	2.00	51	3.70	94	3.86	98	4.30	1.95	F1 or F2
PS-6120FP	6	12.0	600	4.25	108	2.80	71	5.55	141	5.55	141	4.80	2.18	FP
PS-6120 Toy	6	13.0	650	4.25	108	2.80	71	5.55	141	5.55	141	4.80	2.18	TH or TS
PS-6200	6	20.0	1000	6.18	157	3.27	83	4.92	125	4.92	125	7.10	3.22	NB1
PS-6360	6	36.0	1800	6.25	159	3.35	85	6.50	165	6.93	176	12.10	5.49	F2 or NB1
PS-6580	6	58.0	2900	7.28	185	4.41	112	8.07	205	8.07	205	19.50	8.85	F2
PS-62000	6	210.0	10500	12.05	306	6.65	169	8.65	220	8.96	228	63.93	29.00	T8
PS-832	8	3.2	160	5.29	134	1.42	36	2.49	63	2.70	69	1.65	0.75	F1
PS-1208	12	0.8	40	3.78	96	0.98	25	2.44	62	n/a	n/a	0.77	0.35	WL
PS-1212	12	1.4	70	3.78	96	1.69	43	2.04	52	2.28	58	1.20	0.54	F1
PS-1220	12	2.5	125	7.00	178	1.38	35	2.36	60	2.56	65	2.10	0.95	F1
PS-1221	12	2.0	100	5.63	143	0.94	24	2.56	65	2.56	65	1.30	0.59	PC
PS-1221S	12	2.0	100	5.91	150	0.80	20	3.52	89	n/a	n/a	1.50	0.68	F1/0
PS-1223	12	2.3	115	7.17	182	0.94	24	2.40	61	2.40	61	1.70	0.77	PC
PS-1227	12	2.9	145	3.11	79	2.20	56	3.90	99	4.13	105	2.40	1.09	F1
PS-1228	12	2.8	140	5.24	133	1.30	33	3.82	97	4.09	104	2.60	1.18	F1
PS-1229	12	2.9	145	7.00	178	1.38	35	2.36	60	2.60	66	2.30	1.04	F1
PS-1230	12	3.4	170	5.24	133	2.64	67	2.36	60	2.60	66	2.90	1.32	F1
PS-1238	12	3.8	190	7.68	195	1.85	47	2.91	74	2.91	74	3.50	1.59	F1
PS-1250	12	5.0	250	3.54	90	2.76	70	3.98	101	4.21	107	3.50	1.59	F1 or F2
PS-1251FP	12	5.4	270	5.50	140	1.90	48	4.00	102	4.06	103	4.10	1.86	FP
PS-1270	12	7.0	350	5.95	151	2.56	65	3.70	94	3.86	98	4.80	2.18	F1 or F2
PS-1272	12	7.2	360	5.95	151	2.56	65	3.70	94	3.86	98	5.80	2.63	F1 or F2
PS-1282L	12	9.0	450	7.72	196	2.20	56	4.65	118	4.65	118	6.90	3.13	F1
PS-1282S	12	9.0	450	3.86	98	4.40	112	4.65	118	4.65	118	6.90	3.13	F1
PS-1290	12	9.0	450	5.95	151	2.56	65	3.70	94	3.86	98	6.00	2.72	F2
PS-12100	12	12.0	600	5.95	151	4.00	102	3.70	94	3.86	98	8.14	3.69	F1 or F2
PS-12120	12	12.0	600	5.95	151	3.86	98	3.70	94	3.94	100	7.92	3.59	F2
PS-12120L	12	12.0	600	8.45	215	2.75	70	5.75	146	5.75	146	8.80	3.99	FP
PS-12140	12	14.0	700	5.95	151	3.86	98	3.70	94	3.94	100	9.25	4.20	F2
PS-12180	12	18.0	900	7.13	181	3.00	76	6.59	167	6.59	167	12.60	5.72	F2 or NB2

\* FR: UL94 V-0 flame retardant case & cover

All data subject to change without notice.

## PS and PSG-SERIES: General Purpose Batteries *(continued)*

Model	Nominal Voltage V	Nominal Capacity A.H.	Current @ 20-hr. rate mA	Length		Width		Height		Ht. Over Terminal		Weight		Standard Terminals
				in.	mm	in.	mm	in.	mm	in.	mm	lbs.	kgs.	
PS-12260	12	26.0	1300	6.56	167	6.97	177	4.92	125	4.92	125	17.00	7.71	F2 or NB2
PS-12280	12	28.0	1400	6.50	165	4.92	125	6.97	177	6.97	177	20.70	9.39	NB1
PS-12350	12	35.0	1750	7.80	198	5.20	132	6.22	158	7.07	180	24.70	11.20	NB3
PS-12400	12	40.0	2000	7.76	197	6.50	165	6.69	170	6.69	170	29.10	13.20	NB4
PS-12550	12	55.0	2750	9.04	230	5.45	138	8.15	207	8.98	228	36.00	16.33	U
PS-12750	12	75.0	3750	10.25	260	6.60	168	8.15	207	8.98	228	50.60	22.95	U
PS-121000	12	100.0	5000	12.00	305	6.60	168	8.15	207	8.98	228	68.00	30.84	U
PS-1211000	12	110.0	5500	13.00	330	6.73	171	8.35	212	8.66	220	69.50	31.52	T11
PS-121400FR*	12	140.0	7000	13.50	343	6.73	171	10.80	274	11.15	283	99.00	44.91	T11

\* FR: UL94 V-0 flame retardant case & cover


## PSH-SERIES: High-Rate Discharge Batteries


- High capacity versions of standard size models designed primarily for high rate discharge applications.
- Exceptionally high energy density (watt-hours per cubic inch).
- Low internal resistance, well suited for short duration high rate discharge

PSH-655FR*	6	5.5	275	2.76	70	1.85	47	3.94	100	4.17	106	2.10	0.95	F1
PSH-1255FR*	12	6.0	300	3.54	90	2.76	70	3.98	101	4.21	107	4.00	1.81	F2
PSH-1280FR*	12	8.5	425	5.94	151	2.56	65	3.70	94	3.86	98	6.00	2.72	F2
PSH-12100FR*	12	10.5	550	5.94	151	2.56	65	4.37	111	4.61	117	7.00	3.18	F2
PSH-12180FR*	12	21.0	1050	7.14	181	3.03	77	6.59	167	6.59	167	13.20	5.99	NB2

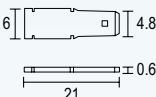
\* FR: UL94 V-0 flame retardant case & cover


## Terminal Options

**F1**  **FASTON**  
0.187" x 0.032"  
quick disconnect tabs.

**F2**  **FASTON**  
0.250" x 0.032"  
quick disconnect tabs

**FP**  **FASTON POLARIZED**  
Positive: "F2", Negative: "F1"

**F1/0**   
6 4.8  
21 ± 0.6

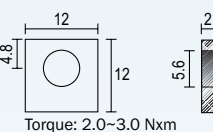
**SP**  **SPRING TERMINALS**  
Fully collapsible positive and negative contacts

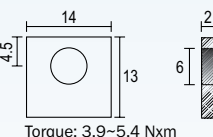
**TH**  **TOY BATTERY CONNECTORS**  
H-connector PS-6120 TH

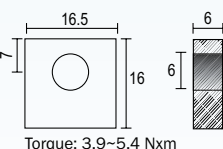
**TS**  **TOY BATTERY CONNECTORS**  
S-connector PS-6120 TS

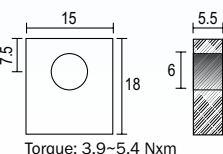
**PC** **PRESSURE CONTACTS**

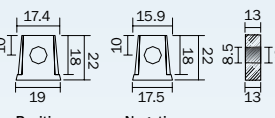
**WL** **INSULATED WIRE LEADS**  
• Molex Housing 5264-02 & 5263-PBT plug on PS-605  
• AMP Housing 1-480318-0 & 8116-1 on PS-1208

**NB1**   
Torque: 2.0~3.0 Nxm

**NB2**   
Torque: 3.9~5.4 Nxm

**NB3**   
Torque: 3.9~5.4 Nxm

**NB4**   
Torque: 3.9~5.4 Nxm

**U**   
Positive Negative  
Torque: 11.0~14.7 Nxm

**T6** **THREADED INSERT - 6mm STUD**  
16mm  
M6  
6mm  
Torque: 3.9~5.4 Nxm

**T8** **THREADED INSERT - 6mm STUD**  
20mm  
M6  
6mm  
Torque: 3.9~5.4 Nxm

**T11** **THREADED INSERT - 8mm STUD**  
20mm  
M8  
7mm  
Torque: 11.0~14.7 Nxm

**T12** **THREADED INSERT - 5mm STUD**  
12mm  
M5  
6mm  
Torque: 2.0~3.0 Nxm

All data subject to change without notice.

## Battery Construction

### Terminals

Depending on the model, batteries come either with AMP Faston type terminals made of tin plated brass, post type terminals of the same composition with threaded nut and bolt hardware, or heavy duty flag terminals made of lead alloy. A special epoxy is used as sealing material surrounding the terminals.

### Relief valve

In case of excessive gas pressure build-up inside the battery, the relief valve will open and relieve the pressure. The one-way valve not only ensures that no air gets into the battery where the oxygen would react with the plates causing internal discharge, but also represents an important safety device in the event of excessive overcharge. Vent release pressure is between 2-6 psi; the seal ring material is neoprene rubber.

### Plates (electrodes)

Power-Sonic utilizes the latest technology and equipment to cast grids from a lead-calcium alloy free of antimony. The small amount of calcium and tin in the grid alloy imparts strength to the plate and guarantees durability even in extensive cycle service. Lead dioxide paste is added to the grid to form the electrically active material. In the charged state, the negative plate paste is pure lead and that of the positive lead dioxide. Both of these are in a porous or spongy form to optimize surface area and thereby maximize capacity. The heavy duty lead calcium alloy grids provide an extra margin of performance and life in both cyclic and float applications and give unparalleled recovery from deep discharge.

### Separators

Power-Sonic separators are made of non-woven glass fiber cloth with high heat and oxidation resistance. The material further offers superior electrolyte absorption and retaining ability, as well as excellent ion conductivity.

### Electrolyte

Immobilized dilute sulfuric acid:  $H_2SO_4$ .

### Container & case sealing

Case and lid material is ABS, high impact, resin with high resistance to chemicals and flammability. Case and cover are made of non-conductive ABS plastic to UL94-HB or UL94 V-0. Depending on the model the case sealing is ultrasonic, epoxy or heat seal.

## Typical Applications

### Power Sources

- Back-up power
- Computers
- UPS

### Communications

- GPS equipment
- Marine communications
- Telecommunication systems

### Lighting

- Emergency lighting
- Exit lights
- Hand held lights

### Security Systems

- Burglar / Fire alarms
- Monitoring alarms
- Metal detectors

### Automotive

- Electronic memory accessories
- Braking / Fuel systems

### Recreation

- Fish finders
- Ride-on toys
- Electrical bicycles/scooters

### Portable Equipment

- Audio-visual devices
- Test and measuring equipment
- Consumer electronics

### Monitoring Equipment

- Fiber-optic test equipment
- Scientific instruments
- Weather instrumentation

### Agricultural

- Livestock/game feeders
- Containment fencing

### Military

- Aerospace
- Aircraft instrumentation
- Fire control systems

### Miscellaneous

- Invisible fences
- DC power lifts
- Floor scrubbers
- Laser products
- Robotics
- Advertising signs

## Battery Chargers

Power-sonic offers a wide range of chargers suitable for batteries up to 100AH. Please refer to the Charger Selection Guide in our specification sheets for "C-Series Switch Mode Chargers" and "Transformer Type A and F Series". Please contact our technical department for advice if you have difficulty in locating suitable models.

High-efficiency photovoltaic module using silicon nitride multicrystalline silicon cells.

### Performance

Rated power ( $P_{max}$ )	10W
Power tolerance	± 10%
Nominal voltage	12V
Limited Warranty <sup>1</sup>	12 years

### Configuration

<b>M</b>	Multimount frame with lo-pro J-Box and output cable
<b>J</b>	Clear universal frame and standard J-Box

### Electrical Characteristics<sup>2</sup>

#### SX310

Maximum power ( $P_{max}$ ) <sup>3</sup>	10W
Voltage at Pmax ( $V_{mp}$ )	16.8V
Current at Pmax ( $I_{mp}$ )	0.59A
Warranted minimum $P_{max}$	9W
Short-circuit current ( $I_{sc}$ )	0.69A
Open-circuit voltage ( $V_{oc}$ )	21.0V
Temperature coefficient of $I_{sc}$	(0.065±0.015)%/ °C
Temperature coefficient of $V_{oc}$	-(80±10)mV/°C
Temperature coefficient of power	-(0.5±0.05)%/ °C
NOCT (Air 20°C; Sun 0.8kW/m <sup>2</sup> ; wind 1m/s)	47±2°C
Maximum series fuse rating	1A (M/J)
Maximum system voltage	50V (US NEC rating) 50V (IEC 61215 rating)







### Mechanical Characteristics

Dimensions	<b>M</b>	Length: 421mm (16.57")	Width: 269mm (10.59")	Depth: 23mm (0.90")
	<b>J</b>	Length: 425mm (16.73")	Width: 273mm (10.74")	Depth: 50mm (1.97")
Weight	<b>M</b>	1.5 kg (3.3 pounds)		
	<b>J</b>	1.9 kg (4.2 pounds)		
Solar Cells		36 cells (57mm x 38) in a 4x9 matrix connected in series		
Junction Box	<b>J</b>	J-Version junction box with 4-terminal connection block; IP 65, accepts PG 13.5, M20, ½ inch conduit, or cable fittings accepting 6-12mm diameter cable. Terminals accept 2.5 to 10mm <sup>2</sup> (8 to 14 AWG) wire.		
Output Cables	<b>M</b>	AWG# 18 (0.75mm <sup>2</sup> ) 2 core ITC/PLTC; length - 4572mm		
Construction		Front: High-transmission 3mm (1/8 <sup>th</sup> inch) tempered glass; Back: Polyester; Encapsulant: EVA		
Frame	<b>M</b>	Clear anodized aluminum alloy type 6063T6 Multimount frame; Color: silver		
	<b>J</b>	Clear anodized aluminum alloy type 6063T6 Universal frame; Color: silver		

1. Module Warranty: 12-year limited warranty of 90% power output; 2-year limited warranty of materials and workmanship. See your local representative for full terms of these warranties.
2. These data represent the performance of typical BP modules, and are based on measurements made in accordance with ASTM E1036 corrected to SRC (STC.)
3. During the stabilization process that occurs during the first few months of deployment, module power may decrease by approx. 1% from typical  $P_{max}$ .

## Quality and Safety

	Manufactured in ISO 9001-certified factories; conforms to European Community Directives 89/33/EEC, 73/23/EEC, 93/68/EEC; certified to IEC 61215
	Module power measurements calibrated to World Radiometric Reference through ESTI (European Solar Test Installation at Ispra, Italy)
	Listed by Underwriter's Laboratories for electrical and fire safety (Class C fire rating)
	Approved by Factory Mutual Research in NEC Class 1, Division 2, Groups C & D hazardous locations.

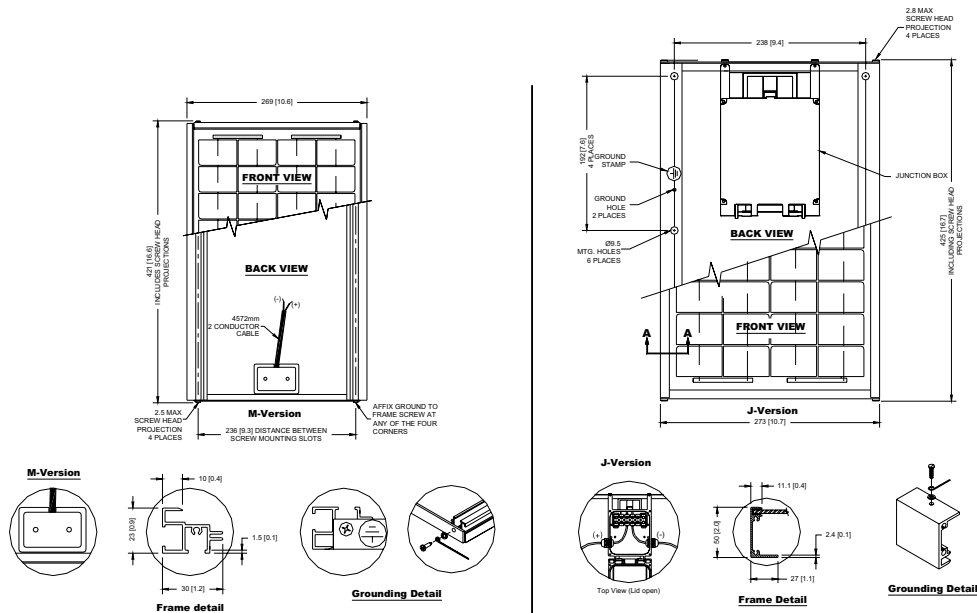
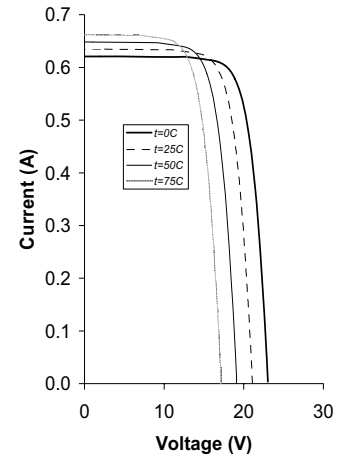
## Qualification Test Parameters

Temperature cycling range	-40°C to +85°C (-40°F to 185°F)
Humidity freeze, damp heat	85% RH
Static load front and back (e.g. wind)	2,400 pa (50psf)
Front loading (e.g. snow)	5,400 pa (113psf)
Hailstone impact	25mm Ø (1 inch) at 23 m/s (52mph)

## Module Diagram

Dimensions in brackets are in inches. Un-bracketed dimensions are in millimeters. Overall tolerances  $\pm 3\text{mm}$  (1/8")

SX310 I-V Curves



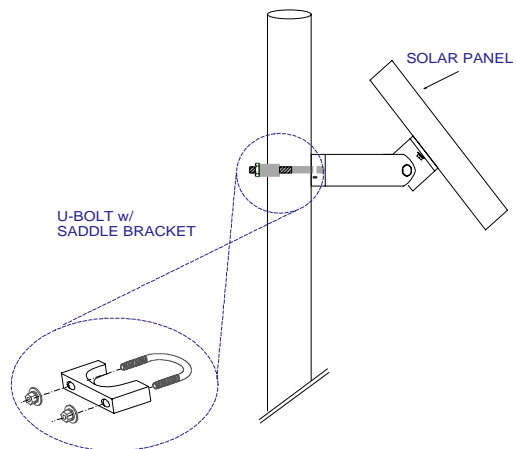
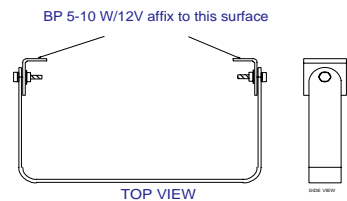
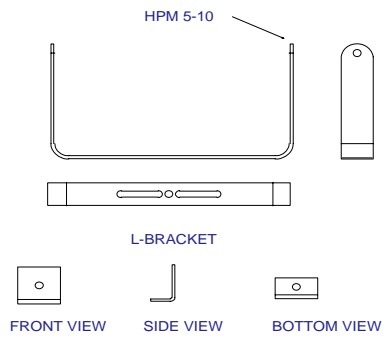
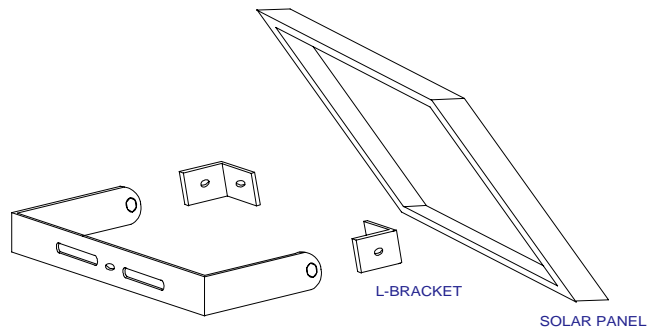
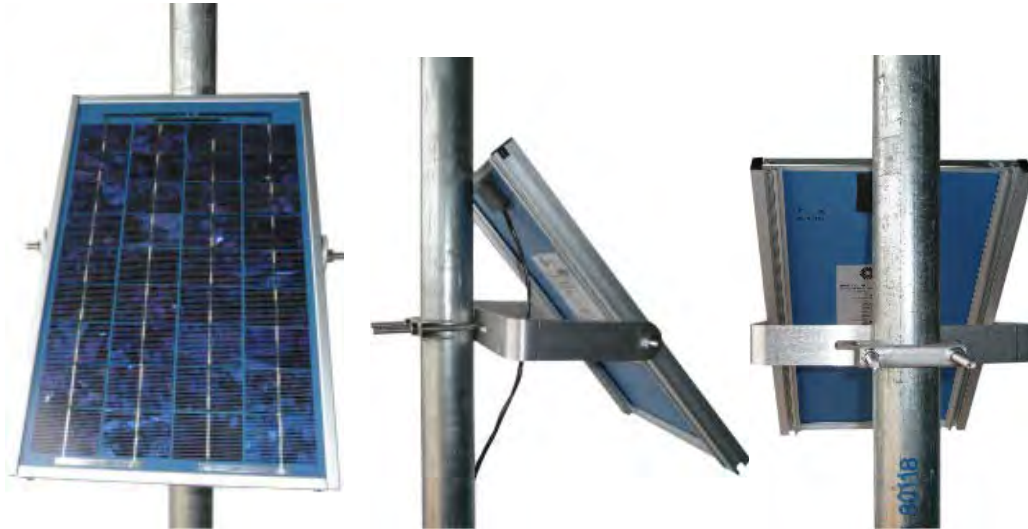
Included with each module: self-tapping grounding screw (J-Version), instruction sheet, and warranty document.

**Note:** This publication summarizes product warranty and specifications, which are subject to change without notice. Additional information may be found on our web site: [www.bpsolar.com](http://www.bpsolar.com)





## HPM 5-10





## 3 Amp 12VDC Solar Charge Controller

**Part Number:** CES-SS1203A

### 3 Amp 12VDC Solar Charge Controller

This Solar Charge Controller is highly recommended for use with our 5W and 10W solar panels. It's required if you are going to charge a 12VDC Battery. In addition to charging and maintaining a battery, this device will prevent the battery charge from discharging through the panel at night. Microcontroller based design.

#### Features:

- Voltage regulation
- PWM shunt Battery charging
- Floating charge
- Automatic reconnection
- LED Charge, and Power Out Indicators
- 6 Position Terminal Strip that fits 16AWG Bare Wire
- Mounting Flanges

#### Electronic Protection Features:

- Overloading protection
- Short circuit protection
- Reverse current protection
- Reverse polarity protection
- Lightning protection
- Overcharge protection
- Over-discharge protection

Solar Charge Controller Specs:	
Rated Voltage:	12 VDC
Max Current Load:	3A
Max PV Watts:	30 Watts
Over Charge Protection:	14.4VDC±0.1
Over Charge Resume:	13.3VDC±0.1
Over Discharge Protection:	11.1VDC±0.1
Over Discharge Protection:	13.2VDC±0.1
Load Protection:	16.5VDC±0.1
Over Voltage Resume:	15.0VDC±0.1
Ambient Temperature:	-15C ~ 55C Industrial Standard Microchip
Altitude:	≤4500 Meters

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## 3A 12V SOLAR CHARGE CONTROLLERCES-SS1203A

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### Product Details

**Product Name:** 3A 12V SOLAR CHARGE CONTROLLER  
**Part Number:** CES-SS1203A  
**Manufacturer:** COAST ELECTRONICS SUPPLY INC  
**Manufacturer #:** SS1203A  
**Price:** 13.97  
**UOM:** EA  
**Short Description:** 3A 12V SOLAR CHARGE CONTROLLER  
**Long Description:** 3 AMP 12 VDC SOLAR CHARGE CONTROLLER - RECOMMENDED FOR USE WITH 5W AND 10W SOLAR PANELS - IN ADDITION TO CHARGING AND MAINTAINING A BATTERY, THIS DEVICE WILL PREVENT THE BATTERY CHARGE FROM DISCHARGING THROUGH THE PANEL AT NIGHT - MICROCONTROLLER BASED DESIGN  
**Image:** [CES-SS1203A.PDF](#)  
**Quantity On Hand:** 7  
**Product Notes:** STOCK AVAILABLE

## **APPENDIX F**

### **Electronics**

Single board computer

Circuit board V1.12 radio side schematic

Circuit board V1.12 single board computer side schematic



# ***SBC28DC***

Single board computer for 28 pin DIP PICs

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# 1 Introduction

The following documentation is for the SBC28DC Revision 1, which is marked on the PCB as SBC28DC Rev1!

The SBC28DC is a single board computer for 28 pin PIC microcontrollers. It has a RS232 serial interface that is available via a standard 9 pin D-Sub, male connector.

This board has been optimized for the following 28 pin DIP PIC chips:

- PIC18F242, PIC18F252, PIC18F248, PIC18F258
- PIC18F2320, PIC18F2410, PIC18F2680 (CAN BUS), PIC18F2550 (USB)
- PIC16F870, PIC16F873(A), PIC16F876(A)
- PIC16C63, PIC16C66, PIC16C73(A), PIC16F73, PIC16C76, PIC16F76

This is only because the above mentioned chips have internal USARTs, which are connected to the serial drivers on this board. It can however also be used with **most other 28 pin DIP PIC chips**, as long as their power, reset(MCLR) and oscillator pins are situated in the same place as the chips listed above. The only difference is that if a USART is required, it will have to be done with software on the PIC chip. Examples of other PIC chips that can be used are:

- PIC16F872
- PIC16C62(A), PIC16C72
- Many more PIC chips that match the above mentioned criteria!

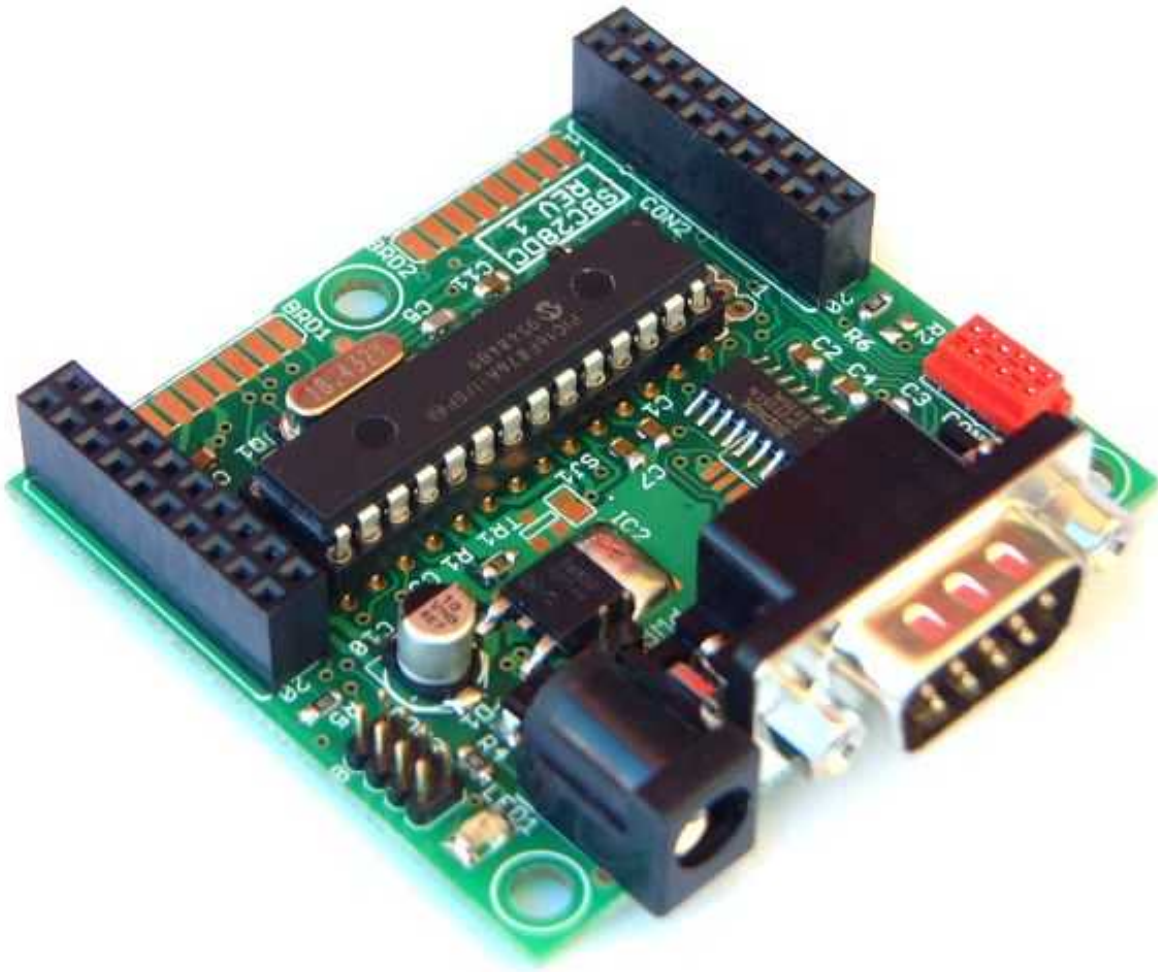


Figure 1



## 2 Features

- 22 I/O ports when using common PIC chips, for example the PIC16F876A or PIC18F252.
- Is part of our MicroX product range, and has a **Frontend connector** and **Compact Daughter board connector** for expansion. Any of our Daughter or Compact Daughter boards can be plugged into it. For example, a prototype Daughter board can be plugged into it for the user to do prototyping. For details on our MicroX range see [www.modtronix.com/microx](http://www.modtronix.com/microx).
- Compact size of 58mm x 54mm. For details see [www.modtronix.com/microx/dimensions](http://www.modtronix.com/microx/dimensions).
- Assembled with High Quality, Industrial Temperature components - electrolytic capacitors used are extra long lifetime rated!
- Diode protected 2.1mm power connector for a standard DC transformer.
- Wide operating voltage range from 7 to 30V. It is recommended to use a 7.5V or 9V DC power supply.
- On board 15kV ESD protected RS232 interface. Assembled with industrial temperature range interface driver chip.
- Standard 9 pin, D-Sub male connector with RS232 signals, ground and external power.
- The power pin (pin 9) on the D-Sub connector can be connected to the boards unregulated power supply (the input of the 2.1mm power connector) via a jumper. This can be used to obtain power for this board. When used, no power has to be supplied via the 2.1mm power connector. It will obtain it's power via the D-Sub connector.
- Power LED to indicate when device is powered.
- Micro Match socket with Power, I<sup>2</sup>C and SPI signals. The Micro Match connector can be used to daisy chain multiple I<sup>2</sup>C devices together.
- Has a standard Modtronix ICSP (In Circuit Serial Programming) connector for programming the on board PIC chip - CPU can be programmed in circuit. For details see <http://www.modtronix.com/picboards/prog>

## 3 Expansion Connectors

### 3.1 Daughter Board Connectors

The SBC28DC's Daughter Board connectors can be used as an expansion port to add additional functionality. It contains all free CPU port pins, power, I2C, SPI, RS232 signal,..... For the location of the Daughter Board connectors, see the *Dimensions* chapter of this document. The Daughter Board connectors port pins are mapped to the following signals:

<b>CON2 Daughter Board Connector</b>		<b>CON1 Daughter Board Connector</b>	
<b>Daughter Board Port Pin</b>	<b>Signal</b>	<b>Daughter Board Port Pin</b>	<b>Signal</b>
T0	Routed to T0 pin of Frontend Connector	T4	Routed to T4 pin of Frontend Connector
T1	Routed to T1 pin of Frontend Connector	T5	Routed to T5 pin of Frontend Connector
T2	Routed to T2 pin of Frontend Connector	T6	Routed to T6 pin of Frontend Connector
T3	Routed to T3 pin of Frontend Connector	T7	Routed to T7 pin of Frontend Connector
SIG0	RS232 receive signal at RS232 signal levels!	GND	Ground
SIG1	RS232 transmit signal at RS232 signal levels!	+5V	Regulated 0.5A 5V supply
B0	PIC pin RB0	VIN	Unregulated input voltage
B1	PIC pin RB1	CLR#	PIC pin /MCLR
B2	PIC pin RB2 – also used for CAN TXD <sup>(4)</sup>	A0	PIC pin RA0
B3	PIC pin RB3 – also used for CAN RXD <sup>(4)</sup>	A1	PIC pin RA1
B4	PIC pin RB4	A2	PIC pin RA2
B5	PIC pin RB5	A3	PIC pin RA3
B6	PIC pin RB6 – also used for ICP <sup>(1)</sup>	A4	PIC pin RA4
B7	PIC pin RB7 – also used for ICP <sup>(1)</sup>	A5	PIC pin RA5
C4	PIC pin RC4 – port pin assigned for I <sup>2</sup> C <sup>(2)</sup>	C0	PIC pin RC0
C5	PIC pin RC5	C1	PIC pin RC1
C6	PIC pin RC6 – also used for RS232/RS485 RX <sup>(3)</sup>	C2	PIC pin RC2
C7	PIC pin RC7 – also used for RS232/RS485 RX <sup>(3)</sup>	C3	PIC pin RC3 – port pin assigned for I <sup>2</sup> C <sup>(2)</sup>
D6	N.C. - not connected	D0	N.C. - not connected
D7	N.C. - not connected	D1	N.C. - not connected

(1) Port Pins B6 and B7 are also used for in circuit programming, if the board is programmed in circuit! If they are used, and the board should still be in circuit programmable, make sure their impedance is greater than a 1000 ohms!

(2) Port Pins C3 and C4 are assigned to be used as I<sup>2</sup>C pins. When no I<sup>2</sup>C devices are used, these ports can be used as general purpose I/O pins.

(3) These pins are also used for RS232 transmit and received! If RS232 interface is not used, these ports can be used as general purpose I/O pins.

(4) These pins are also used for CAN BUS transmit and receive signals when the CAN bus is used. If the CAN bus is not used, these pins can be used as general purpose I/O pins.

### 3.2 Frontend Connectors

The SBC28DC's Frontend connectors can be used as an expansion port to add additional functionality. It contains all free CPU port pins, power, I2C, SPI, RS232 signal,..... Most important pins have been placed on BRD1 connector, so a single IDC connector can be connected to it, and it's signals will be available via a ribbon cable. For the location of the Frontend connectors, see the *Dimensions* chapter of this document. The Frontend connectors port pins are mapped to the following signals:

<b>BRD2 Frontend Connector</b>		<b>BRD1 Frontend Connector</b>	
<b>Frontend Port Pin</b>	<b>Signal</b>	<b>Frontend Port Pin</b>	<b>Signal</b>
T0	Routed to T0 pin of Daughter Board	T4	Routed to T4 pin of Daughter Board
T1	Routed to T1 pin of Daughter Board	T5	Routed to T5 pin of Daughter Board
T2	Routed to T2 pin of Daughter Board	T6	Routed to T6 pin of Daughter Board
T3	Routed to T3 pin of Daughter Board	T7	Routed to T7 pin of Daughter Board
SIG0	RS232 receive signal – at RS232 signal levels!	GND	Ground
SIG1	RS232 transmit signal – at RS232 signal levels!	+5V	Regulated 0.5A 5V supply
B0	PIC pin RB0	VIN	Unregulated input voltage
B1	PIC pin RB1	CLR#	PIC pin /MCLR
B2	PIC pin RB2 – also used for CAN TXD <sup>(4)</sup>	A0	PIC pin RA0
B3	PIC pin RB3 – also used for CAN RXD <sup>(4)</sup>	A1	PIC pin RA1
B4	PIC pin RB4	A2	PIC pin RA2
B5	PIC pin RB5	A3	PIC pin RA3
B6	PIC pin RB6 – also used for ICP <sup>(1)</sup>	C2	PIC pin RC2
B7	PIC pin RB7 – also used for ICP <sup>(1)</sup>	C3	PIC pin RC3 – port pin assigned for I <sup>2</sup> C <sup>(2)</sup>
A4	PIC pin RA4	C4	PIC pin RC4 – port pin assigned for I <sup>2</sup> C <sup>(2)</sup>
A5	PIC pin RA5	C5	PIC pin RC5

- (1) Port Pins B6 and B7 are also used for in circuit programming, if the board is programmed in circuit! If they are used, and the board should still be in circuit programmable, make sure their impedance is greater than a 1000 ohms!
- (2) Port Pins C3 and C4 are assigned to be used as I<sup>2</sup>C pins. When no I<sup>2</sup>C devices are used, these ports can be used as general purpose I/O pins.
- (3) These pins are also used for CAN BUS transmit and receive signals when the CAN bus is used. If the CAN bus is not used, these pins can be used as general purpose I/O pins.

Figure 2 shows the location of the Frontend Connectors on the board.

## Frontend Connector on MicroX Main Board (SBC)

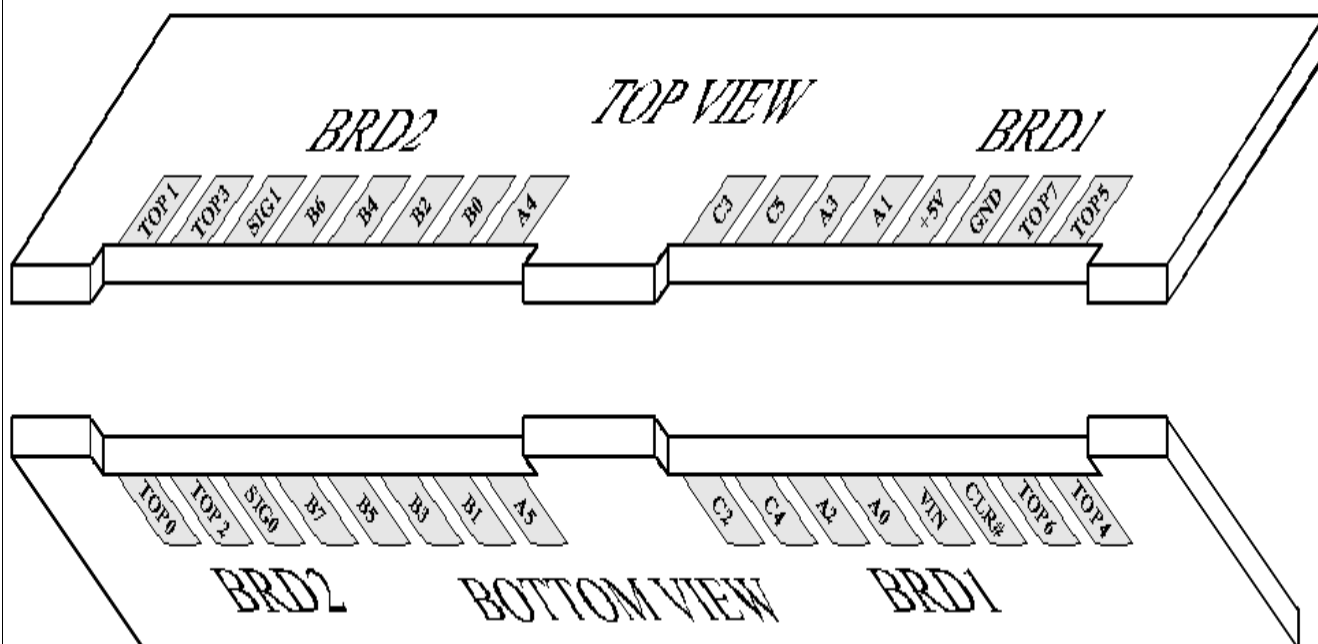


Figure 2

### 3.3 Connecting IDC connectors to the Frontend Connector

For an easy way of accessing the BRD1 and BRD2 Frontend Connectors signals, 2mm IDC connectors can be soldered onto one or both of the frontend connectors. By doing this, the frontend signals will be available via a standard 2mm ribbon cable. Note that the IDC connectors shown in the image are not soldered onto the Frontend Connector!



### 3.4 Expansion boards

The SBC28DC's Frontend connectors can be used as an expansion port to add additional functionality. It contains all free CPU port pins, power, I2C, SPI, RS232 signal,..... The image to the right shows the SBC28PC with a Sub-D 9 pin expansion board. For a list of Frontend Boards currently available from Modtronix Engineering, see [www.modtronix.com/products/sbc28dc](http://www.modtronix.com/products/sbc28dc).



Additionally, users can download PCB templates for creating their own Frontend expansion boards from our Downloads page – see [www.modtronix.com/downloads](http://www.modtronix.com/downloads).

## 4 Interfaces

### 4.1 Micro Match connector with I<sup>2</sup>C and SPI signals

The SBC28DC has a 6 pin female Micro Match type connector with I<sup>2</sup>C signals, SPI signals, Vcc and Ground. The PIC can be configured for either I<sup>2</sup>C or SPI mode, both can not be used at the same time. The Micro Match connector is manufactured by AMP, and is a very small, polarized and cheap connector! This connector is also supported by other manufactures of I<sup>2</sup>C equipment, which allows devices from different manufactures to be interchanged.

Male Micro Match connectors that fits into this connector are available from various distributors and also from the Modtronix online store. Particularly useful is the “male-on-wire” type connector, seeing that they can be crimped onto a standard 1.27mm ribbon cable. Multiple of these connectors can be daisy chained together to allow several I<sup>2</sup>C on a single bus. Pre made cables are also available from the Modtronix online store.

The pinouts of the Micro Match I<sup>2</sup>C connector is:

<i>Micro Match Connector Pin</i>	<i>I<sup>2</sup>C Signal</i>	<i>SPI Signal</i>
1	SDA - I <sup>2</sup> C data I/O (PIC port pin RC4)	SDI - SPI data in (PIC port pin RC4)
2	+5V	+5V
3	Ground	Ground
4	SCL - I <sup>2</sup> C clock (PIC port pin RC3)	SCK - SPI clock (PIC port pin RC3)
5	RC5 - Can be used as general purpose pin	SDO - SPI data out (PIC port pin RC5)
6	No Connection	No Connection

For further info on the pinouts have a look at the picture in the *Dimensions* section later on in this document.

For more info on the Micro Match I<sup>2</sup>C connector see [www.modtronix.com/info/i2c/micromatch](http://www.modtronix.com/info/i2c/micromatch)

### 4.2 RS232

The SBC28DC contains an industrial quality RS232 interface with transmit, receive, RTS, CTS and power signals. The signals are available on a 9 pin D-Sub, male connector.

Pin 9 can be configured via jumper J2 to be connected to the unregulated supply voltage. This can be used to obtain power for this board. When used, no power has to be supplied via the 2.1mm power connector. It will obtain it's power via the D-Sub connector. Pin 9 is usually assigned to the Ring Indicator (RI) signal. The RI signal is however not used very often any more.

When connecting this board to a computer, or any other device with a standard 9 pin, D-Sub connector that might have the RI signal present, **ensure that jumper J2 is not made!** If jumper J2 is made, the unregulated supply voltage will be put on pin 9 (RI signal), and this will conflict with the RI signal on the device connected to the SBC28DC!

The pinouts (except for pin nine with J2 jumper is inserted) comply to a standard DTE device.

<i>D-Sub Connector</i>	<i>Description</i>
1	No connection
2	RS232 receive - input
3	RS232 transmit - output
4	No connection
5	Signal Ground
6	No connection
7	Request To Send (RTS) – output. Indicates that we want to transmit something.
8	Clear To Send (CTS) – input. Indicates that we can transmit.
9	Vin supply signal

## 5 Configuration

The SBC28DC board can be configured via jumper J2. Refer to the PCB layout later on in this document for the location of these jumpers and headers.

### 5.1 Power via D-Sub connector

Pin 9 of the 9 pin, D-Sub connector can be configured via jumper J2 to be connected to the unregulated supply voltage. This can be used to obtain power for this board. When used, no power has to be supplied via the 2.1mm power connector. It will obtain it's power via the D-Sub connector.

When connecting this board to a computer, or any other device with a standard 9 pin, D-Sub connector that might have the RI signal present, **ensure that jumper J2 is not made!** If jumper J2 is made, the unregulated supply voltage will be put on pin 9 (RI signal), and this will conflict with the RI signal on the device connected to the SBC28DC!

## 6 Specifications

### 6.1 Absolute Maximum Ratings

<i>Item</i>	<i>Symbol</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>
Operating Temperature:	Top	-40		85	°C

### 6.2 Electrical Characteristics

<i>Item</i>	<i>Symbol</i>	<i>Condition</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>
DC Supply Voltage:	Vdd	-	7		35	V
Typical Operating Current with PIC16F876A at 20MHz	Idd	Vdd = 12V		16		mA



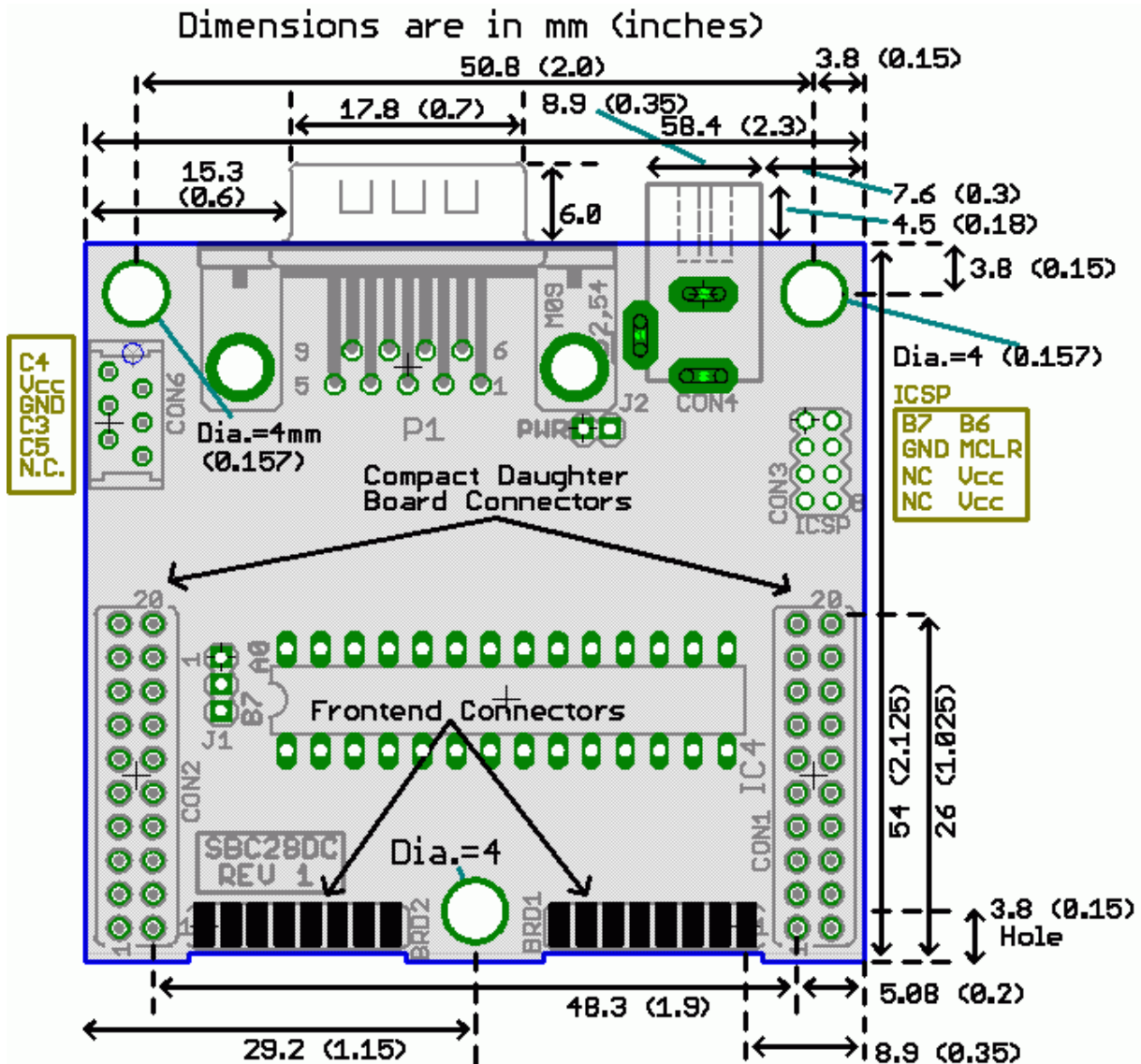
### 6.3 D.C. Characteristics of user I/O pins on Daughter Board connector.

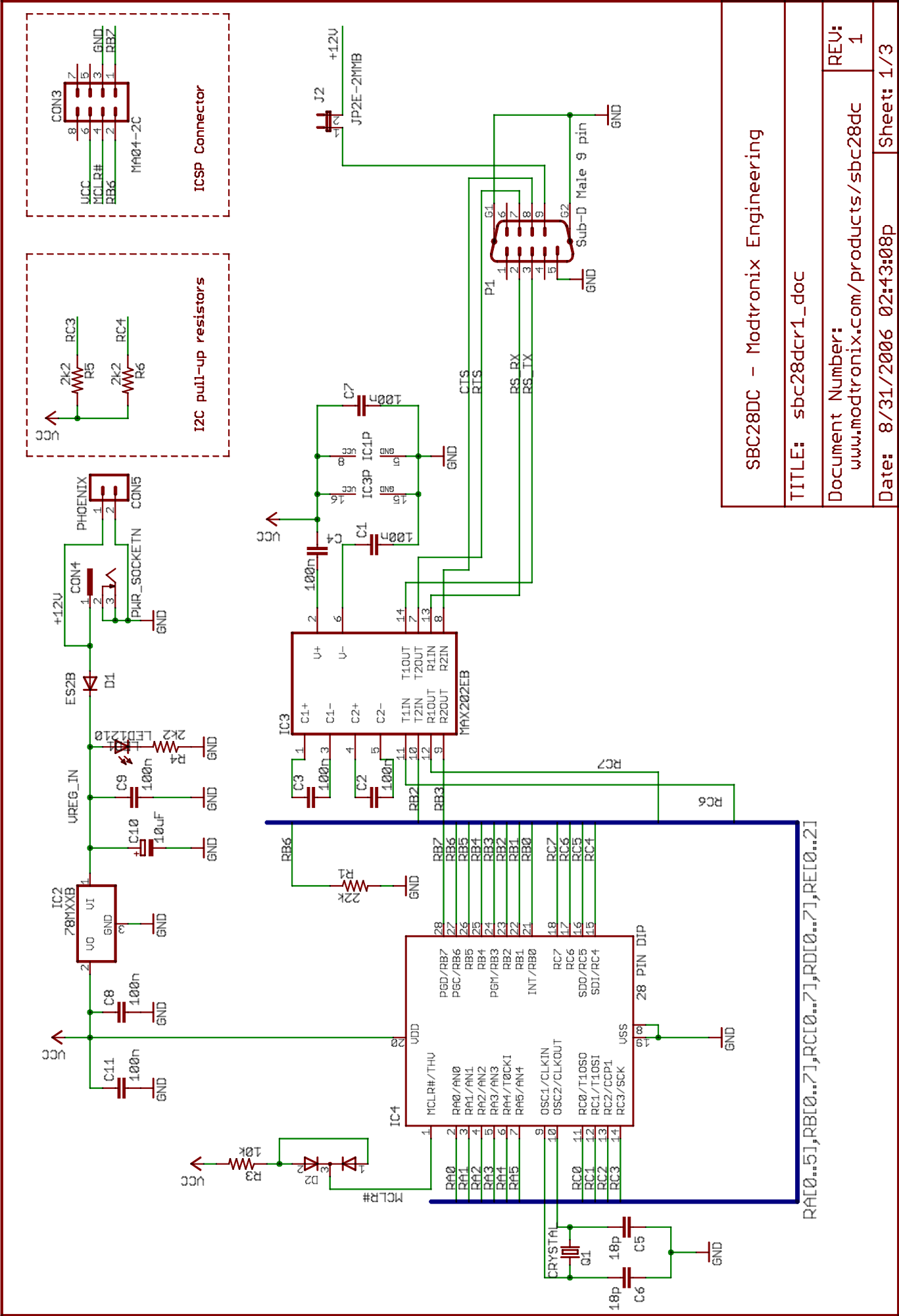
The following values are for common PIC chips like the PIC16F876A or the PIC18F252.

<i>Item</i>	<i>Symbol</i>	<i>Condition</i>	<i>Min</i>	<i>Typ</i>	<i>Max</i>	<i>Unit</i>
Input Low Voltage - configured as TTL input:	V <sub>IL</sub>		0		0.75	V
Input Low Voltage - configured as Schmitt Trigger input:	V <sub>IL</sub>		0		1	V
Input High Voltage - configured as TTL input:	V <sub>IH</sub>		2.05		5	V
Input High Voltage - configured as Schmitt Trigger input:	V <sub>IH</sub>		4		5	V
Output High Voltage:	V <sub>OL</sub>	I <sub>OL</sub> = 8.5mA			0.6	V
Output Low Voltage:	V <sub>OH</sub>	I <sub>OH</sub> = 3mA	4.3			V
Capacitive loading:	C <sub>IO</sub>			50		pF

Many inputs on the PIC are Schmitt Trigger inputs, consult the data sheet for details.

The SBC28DC conforms to the MicroX Compact Main Board Dimensions, as shown in Figure 3.





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www.modtronix.com/products/sbc28dc	
Date: 8/31/2006 02:43:08p	Sheet: 1/3

The diagram illustrates the Frontend Board Connector, showing two 2x10 female headers (CON2 and CON1) and two 2mm headers (BRD2 and BRD1). The pin assignments and signal names are as follows:

**CON2 (2x10 female 2.54mm hdr)**

Pin	Signal
1	TOP1
2	TOP2
3	T3
4	TOP2
5	RS_TX
6	RS_RX
7	SB6
8	SB7
9	SB4
10	SB5
11	RB2
12	RB3
13	RB0
14	RB1
15	RC6
16	RC7
17	RC4
18	RC5
19	C4
20	C5

**CON1 (2x10 female 2.54mm hdr)**

Pin	Signal
1	T5
2	TOP4
3	T6
4	TOP6
5	CLR#
6	MCLR#
7	GND
8	UREG_IN
9	+5V
10	A1
11	A0
12	A2
13	A4
14	A4
15	C1
16	RC0
17	RC1
18	RC2
19	C2
20	D0

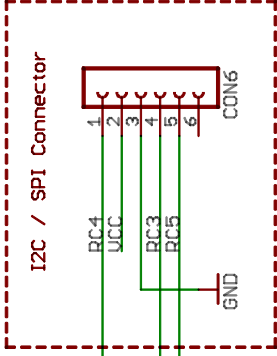
**BRD2 (2mm header)**

Pin	Signal
1	T1
2	TOP0
3	T2
4	TOP2
5	SB6
6	RS_RX
7	SB7
8	SB7
9	SB4
10	SB5
11	RB2
12	RB3
13	RB0
14	RB1
15	A4

**BRD1 (2mm header)**

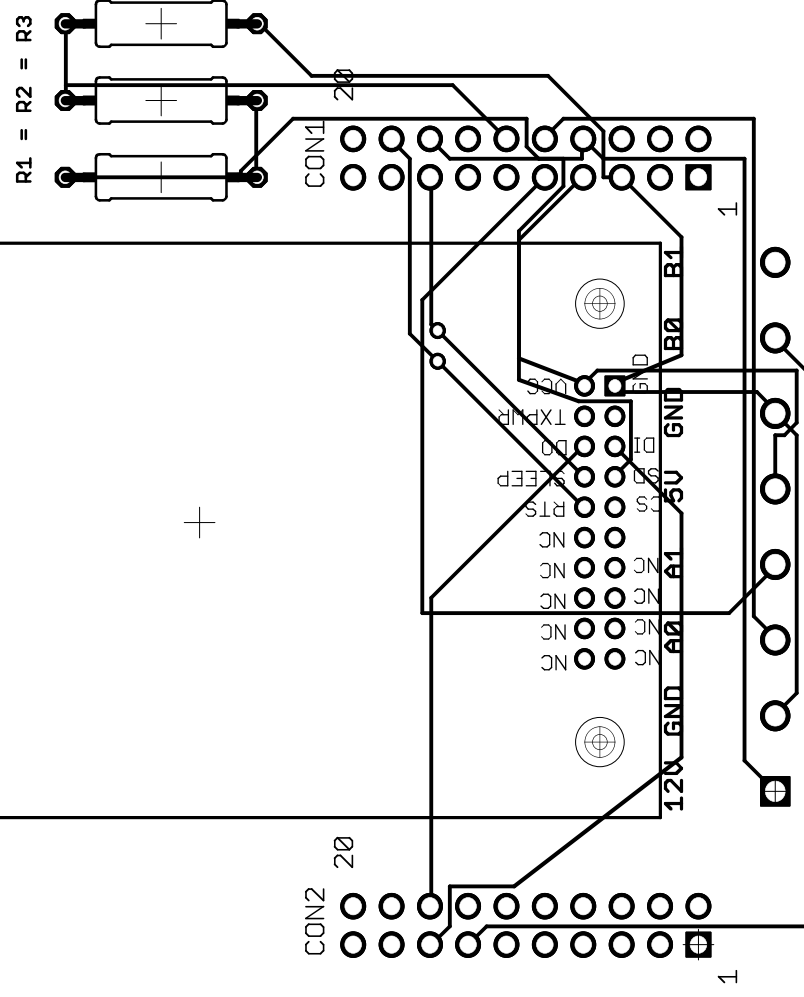
Pin	Signal
1	T5
2	TOP4
3	T6
4	TOP6
5	CLR#
6	MCLR#
7	GND
8	UREG_IN
9	+5V
10	A1
11	A0
12	A2
13	A4
14	C4/SOA
15	C3/SCK
16	C2

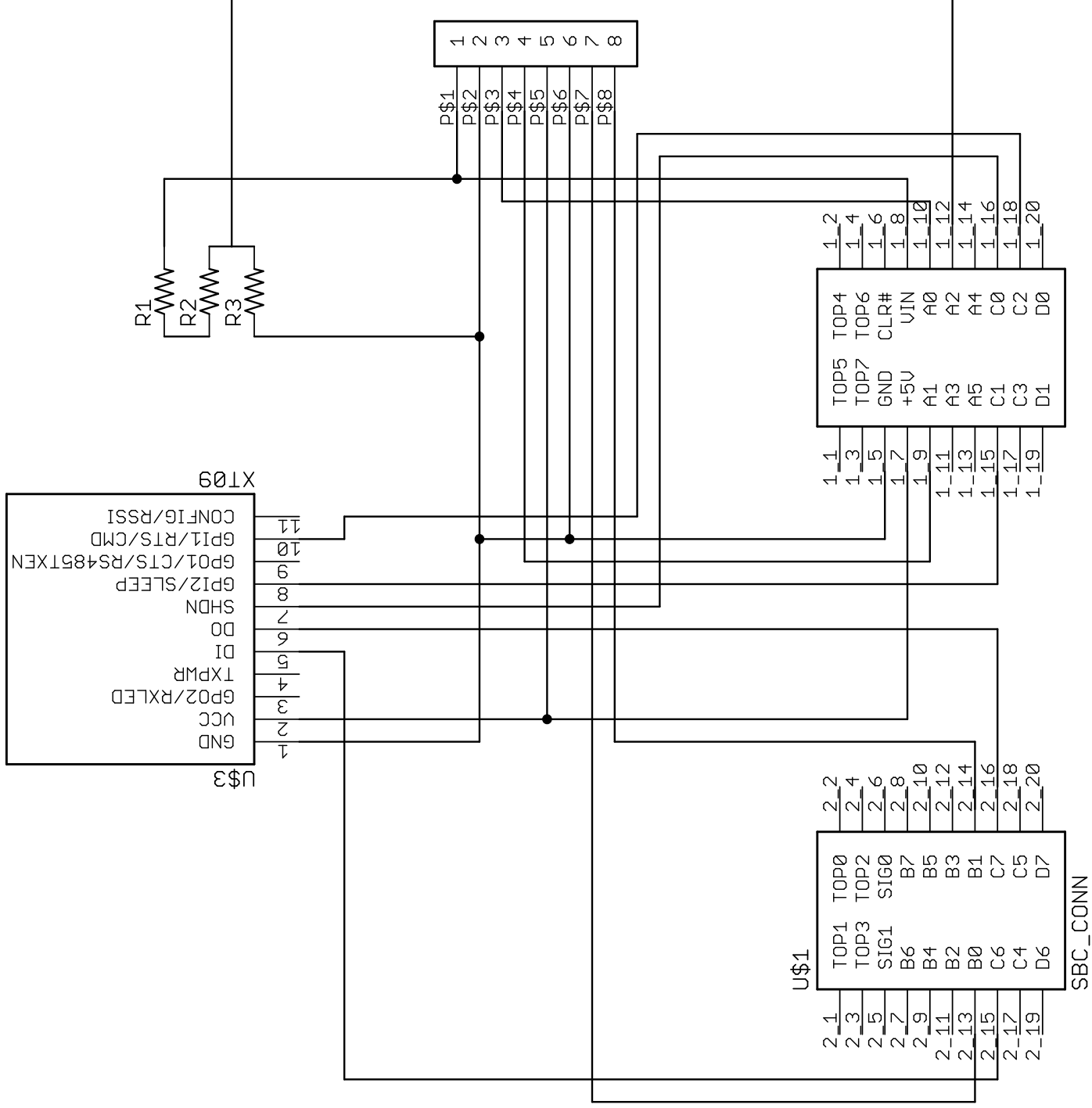
The diagram also shows the connection of the headers to the board signals, with CON2 and CON1 connected to the board signals and BRD2 and BRD1 connected to the board signals.




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RP-SMA	
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SBC\_CONN

U\$1

U\$3

XT09

**APPENDIX G**

**G                      Parts list**



## Low Cost Remote Telemetry Unit Materials List

Item #	Qty. per Unit	Item	Manufacturer	Model No.	Description	Source / Part #	Price Each	Price Per Unit
1	1	Enclosure Body	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" X 16"	Local Electrical Supply (10' length)	\$1.90	\$1.90
2	1	Enclosure Bottom Cap	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Standard Coupling	Local Electrical Supply	\$3.49	\$3.49
3	1	Enclosure Top Cap (Part A)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" End Cap	Local Electrical Supply	\$3.25	\$3.25
4	1	Enclosure Top Cap (Part B)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" X 4"	Local Electrical Supply (10' length)	\$0.50	\$0.50
5	1	Enclosure Top Cap (Part C)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Female Adapter	Local Electrical Supply	\$4.49	\$4.49
6	1	Enclosure Top Fitting	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3" Male Terminal Adapter	Local Electrical Supply	\$4.25	\$4.25
7	1	Sensor Assembly (Part A)	Local Plumbing	PVC	Schedule 40 PVC DWV 3" to 2" Adapter Bushing	Local Plumbing Supply	\$2.67	\$2.67
8	1	Sensor Assembly (Part B)	Local Plumbing	PVC	Schedule 40 PVC 2" to 1" Reducer Bushing	Local Plumbing Supply	\$1.89	\$1.89
9	1	Sensor Assembly (Part C)	Cantex	PVC	Schedule 40 PVC Rigid Nonmetallic Conduit 3/4" Threaded Adapter	Local Electrical Supply	\$0.75	\$0.75
10	1	Sensor Guard	Local Plumbing		Schedule 40 PVC DWV 3" to 1 1/2" Adapter Bushing Sewer	Local Plumbing Supply	\$3.26	\$3.26
11	2	Stainless Steel U Bolts	Local Hardware	3/8" SS	3/8" x 3 1/2" x 4 1/8" U Bolt; Stainless Steel	Austin Bolt / U24SS	\$2.00	\$4.00
12	4	Stainless Steel Hex Nut	Local Hardware	3/8" SS	3/8" - 16 Hex Finish Nut; Stainless Steel	Austin Bolt / 37CNFHS	\$0.10	\$0.40
13	4	Stainless Steel Flat Washer	Local Hardware	3/8" SS	3/8" Flat Washer; Stainless Steel	Austin Bolt / 37NWSFS	\$0.11	\$0.44
14	4	Stainless Steel Lockwasher	Local Hardware	3/8" SS	3/8" Split Lockwasher; Stainless Steel	Austin Bolt / 37NLOCS	\$0.07	\$0.28
15	1	Machine shop	NA	NA	Machine slots for circuit board	Castle	\$75.00	\$75.00
16	1	Solar Panel	BP Solar	SX 310M	10 Watt; 12 Volt; Photovoltaic Charge Panel	Ameresco Solar / BPSX-310M	\$75.69	\$75.69
17	1	Solar Panel Mount Bracket	Ameresco	HPM 5-10	Solar Panel Mount Bracket	Ameresco Solar / HPM 5-10	\$22.00	\$22.00
18	2	Lead Acid Battery; 6 VDC	Power-Sonic	PS-630	6 VDC; 3.5 AmpHr Rechargeable Lead Acid Battery	Allied / 621-0220	\$17.80	\$35.60
19	1	Solar Power Controller	CES	SS1203A	3A Solar Power Controller	BG Micro / SS1203A	\$16.49	\$16.49
20	1	RF bulkhead Jack	Amphenol	122192	RF Coaxial, TNC Bulkhead crimp Jack	Allied / 319-0083	\$3.73	\$3.73
21	1	MaxStream 9XTend 900 MHz	MaxStream	XT09-SI-MESH	900 MHz OEM Radio	Mouser	\$179.00	\$179.00
22	1	Whip Antenna	Larson	SPDA17918	872-964 MHz, Unity Gain, 1/4 Wavelength, TNC (M) Portable Antenna	Hutton / LAR-SPDA17918	\$12.85	\$12.85
23	1	Foot - Coax Cable	Belden	RG 174	RG 174 type 24.5 AWG solid .020" Coax Cable	Allied / 216-0116 (1' length)	\$9.48	\$9.48
24	1	TNC Bulkhead Jack	Mouser	523-122192	TNC BULKHEAD JACK	Mouser 523-122192	\$2.50	\$2.50
25	1	SMA ST CRMP PLG RG58	Mouser	523-132113RP	SMA ST CRMP PLG RG58	Mouser 523-132113RP	\$3.12	\$3.12
26	1	ABE-LCRTU Board	Advanced PCB	V1.12	Printed circuit board	Custom, in small quantities	\$20.00	\$20.00
27	1	Single Board Computer for PIC	Modtronix	SBC28DC	Single Board Computer for 28 pin PIC microcontroller with RS232 interface	Modtronix / SBC28DC	\$31.56	\$31.56
28	1	28 pin DIP PIC chip	Microchip	PIC18F258-I-SP	Dual Inline Package Programmable Interface Controller	Mouser / 579-PIC18F258-I/SP	\$6.52	\$6.52
29	1	3M 20P Connector	Mouser		3M 20P Connector	150220-6002-TB	1.77	\$1.77
30	3	Vishay Dale 10K Resistor	Mouser		Vishay Dale 10K Resistor	71-PTF6510K000AXBF	1.63	\$4.89
31	1	Molex 8P Terminal	Mouser		Molex 8P Terminal		1.08	\$1.08
32	4	4/40 Standoff	Mouser		4/40 Standoff	728-FC2101-440-SS	0.64	\$2.56
33	4	4/40 Screws	Mouser		4/40 Screws		0.04	\$0.16
34	4	4/40 Nuts	Mouser		4/40 Nuts		0.04	\$0.16
35	3	Feet - Hookup Wire 20 Ga Blue	Belden	9919-013100	Wire, Hookup, 20AWG, Stranded, PVC 300V - Blue	Allied / 214-0076 (100' length)	\$39.91	\$1.20
36	3	Feet - Hookup Wire 20 Ga Red	Belden	9919-002100	Wire, Hookup, 20AWG, Stranded, PVC 300V - Red	Allied / 214-0073 (100' length)	\$39.91	\$1.20
37	3	Feet - Hookup Wire 20 Ga Black	Belden	9919-010100	Wire, Hookup, 20AWG, Stranded, PVC 300V - Black	Allied / 214-0072 (100' length)	\$39.78	\$1.19
38	3	Feet - Hookup Wire 20 Ga Yellow	Belden	9919-004100	Wire, Hookup, 20AWG, Stranded, PVC 300V - Yellow	Allied / 214-0075 (100' length)	\$43.17	\$1.30
39	1	Enclosure Cord Grip	Altech	5308-904	Cord Grip 1.5 to 6 mm; NPT; 3/8" 11 mm; 17 mm; Neoprene	Allied / 500-5380	\$0.76	\$0.76
40	1	RP - SMA Straight Plug	Conector City	CONREVSMA007	RF Connector RPSMA Plug Female pin RG-174	Mouser / 712-CONREVSMA007	\$3.12	\$3.12
25	1	Ultrasonic Sensor	Maxbotix	MB7070	XL-MaxSonar-WRA1 (MB7070) Ultrasonic Sonar Sensor	MaxBotix / MB7070	\$104.95	\$104.95
						Total material cost per unit		\$649.44
	1	Base Antenna	PCTEL	MFB-9157	900 MHz Omni Base Station Antenna	Hutton / MAX-MFB-9157	\$108.10	
	1	Antenna Mount Kit	PCTEL	MMK4	Base Station Omni Antenna Mounting Brackets	Hutton / MAX-MMK4	\$33.37	

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