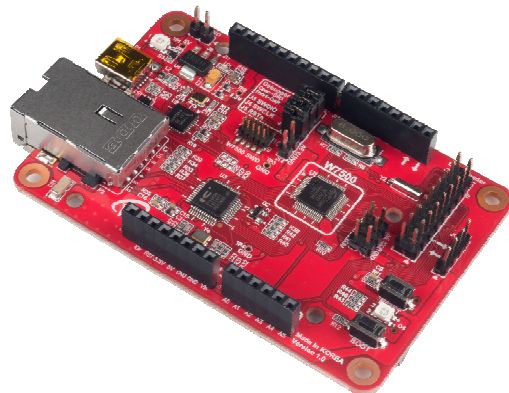


SUMP PUMP MONITOR USER MANUAL

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Project Description: (General Description of Project)

This project measures real-time AC currents of a sump pump. The data values calculated utilizing these real-time measurements are sump pump cycles, gallons pumped and the run times. The information calculated is used for data logging and viewing on trends. See photo 1.

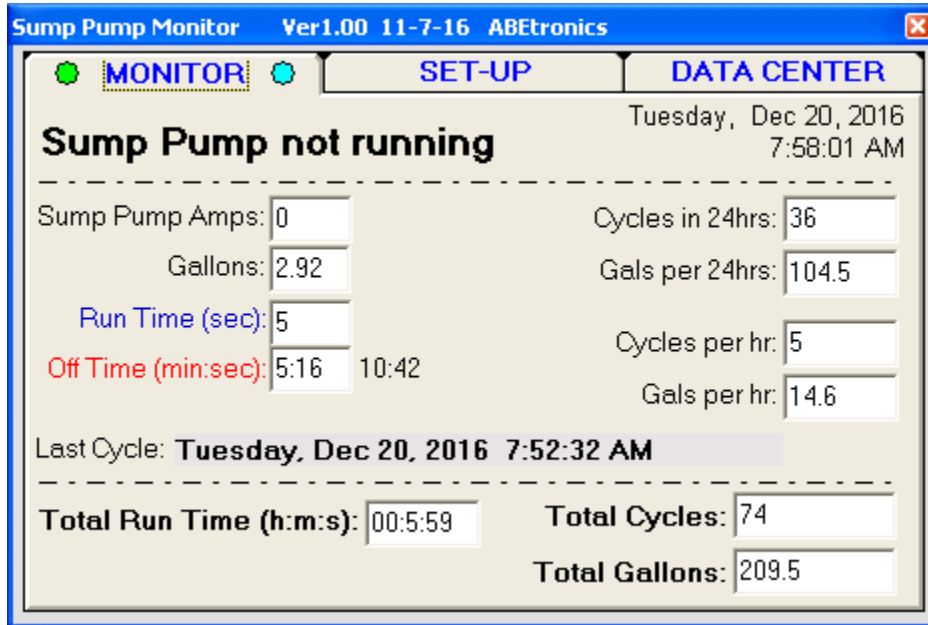


Photo 1: Sump Pump "Monitor" Screen displaying Real Time measurements and calculated values.

The components used in this project are installed into an active main AC voltage load center; as a result care must be taken when installing these components. The block diagram on the next page illustrates the connections between the project's main components. See photo 2.

A 5vdc power supply provides power to the Wizwiki-W7500 board which converts this into 3.3vdc power. The 3.3vdc is used to power the AC Current Transformer (CT) which is connected to the analog input of the Wizwiki-W7500 board to allow measurement of single phase AC currents. The real time measurements are sent to a PC running the sump pump APP on the ethernet network. An ethernet cable is run to the main ac voltage load center for this purpose.

Block Diagram:

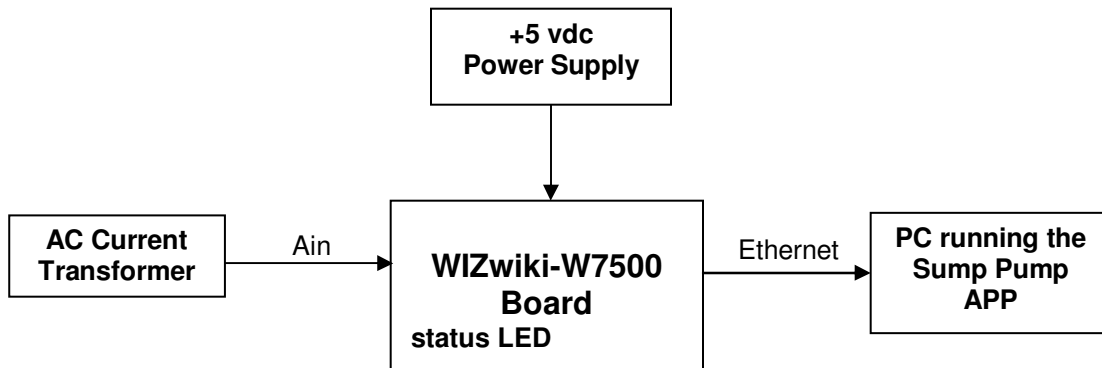


Photo 2:

Block Diagram showing connections between the project's main components..

Photo 3 depicts the completed board. All components are wired together using a proto-type add on board and jumper wires. The LED on the WIZwiki-W7500 Board will indicate sump pump status:

Green = running, **Blue** = stopped

PC ethernet communication status:

Red = no connection to the PC.

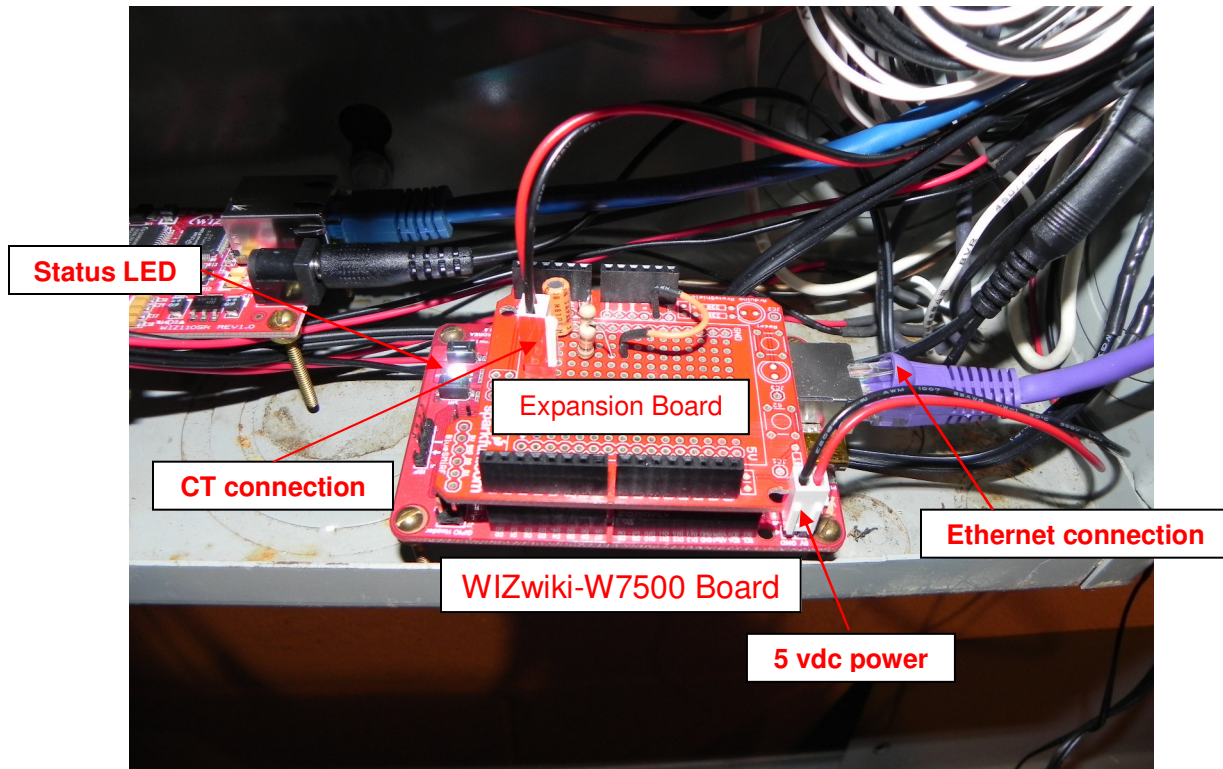
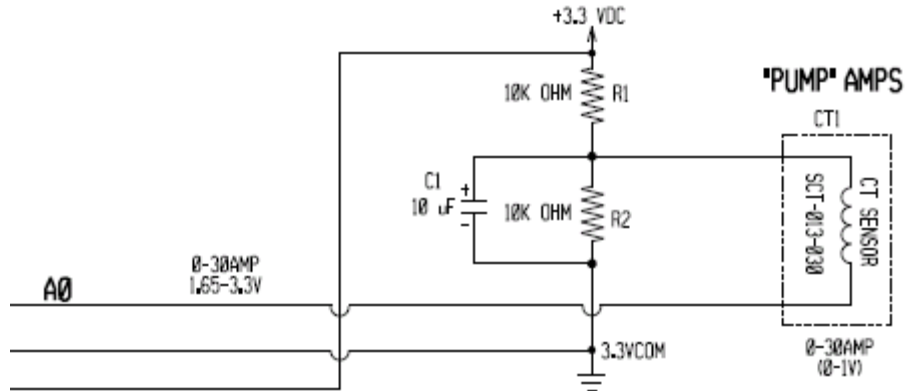


Photo 3:

Completed board showing component layout and wiring connections.

Hardware / Software Details: (Real-Time AC Current measurements)

The AC current of the sump pump is measured. The CT used is rated at 0-30 amperes and produce 1.0vdc per ampere. The signal is wired to the WIZwiki-W7500 board analog input. See [Circuit Diagram 1](#) below for wiring details.



Circuit Diagram 1:

Hardware wiring connections of the AC Current Transformer to the analog input.

The AC current waveform is measured by taking precise timed samples of the entire waveform. The highest reading is then determined to produce an accurate AC current reading. But before the waveform can be accurately measured, the AC zero crossing must be detected to ensure the full waveform is being properly detected and measured. See [Code Listing 1](#) for the zero crossing routine and [Code Listing 2](#) for the current measuring software routine.

Code Listing 1:

Routine to measure the AC waveform zero crossing.

```
//-----  
void VAC_Zero_Cross(void)  
//-----  
{  
    LP1=0;                // Indicator to exit while loop  
    if (LP2==1)  
    {  
        //Waits for the waveform to be close to 'zero' (500 adc)  
        while(LP1==0)  
    }  
}
```

```

    {
        wait_us(100);
        AMPreading=ain0.read();

//check its within range. (+/- 5)
        if ((AMPreading < 0.5) && (AMPreading > 0.4))
        {
            LP1=1;
        }
    }
    LP2=1;
}

```

Code Listing 2:

Routine to measure the AC waveform by taking 100 samples and sending them serially to a PC to be plotted.

```

//-----
void Measure_AMPS(void)
//-----
// Measure AC Current.
// 12bit ADC, 10MHz = 0.1usec conversion time.
// 12bit ADC (0-3.3v = 0-4095 values) 3.3/4096 = 0.81mv
// 1.65v = 2047 = 0 amps.
//-----
{
    AMPreadingHI=0.0;
    for (LP3=0; LP3<100; LP3++)
    {
        wait_us(200);
        AMPreading=ain0.read();
        if (AMPreadingHI < AMPreading) AMPreadingHI = AMPreading;
    }

    if (AMPreadingHI <0.51)
    {
        COLOR(_BLUE_);
    }
    else
    {
        COLOR(_GREEN_);
    }

    AMP_Reading_on_AO = AMPreadingHI;
    uart.printf("$%2.2f!", AMPreading);
    sprintf(httpHeader, "$%2.2f!", AMP_Reading_on_AO);
    client.send(httpHeader, strlen(httpHeader)); //send amps to PC.
}

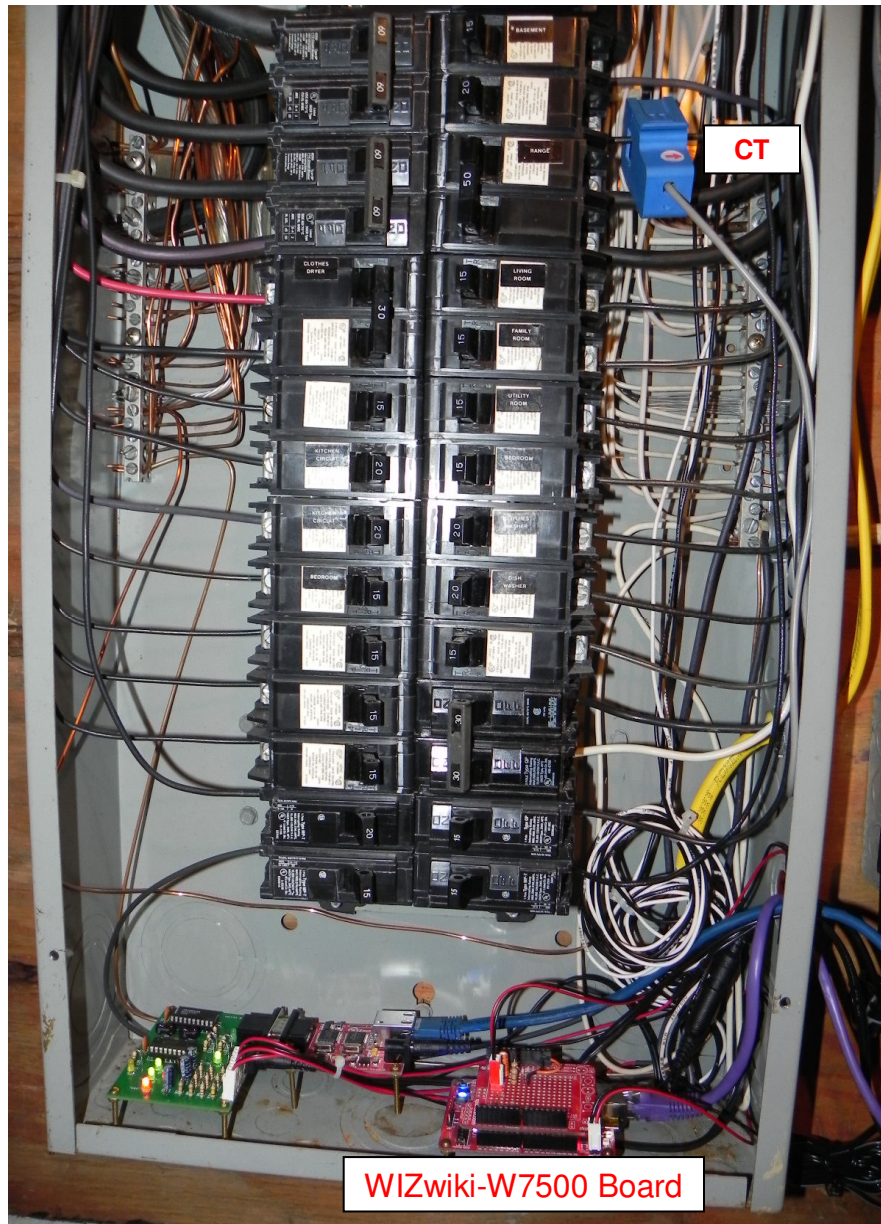
```


The CT is installed by clipping it around the cable on the circuit breaker feed the sump pump. The sump pump should be the only equipment connected to this circuit breaker. See Photo 4 below for CT connection.

WARNING

Be Very Careful while working inside the energized main AC load center.

Electrical shock can occur and could be deadly. Proper electrical personal protective equipment must be worn.



Hardware / Software Details: (Main Firmware Software Loop)

```
//=====
int main(void)
//=====
{
//RGB LED:
//WHITE = program running.
//RED   = not connected to PC.
//GRN   = pump running.
//BLUE  = pump not running.

    Serial_Interface_init();
    ethernet_init();
    LP1=0;           // Indicator to exit while loop
    LP2=0;

//-----
    while(true)
//-----
    {
        uart.printf("\nWait for new connection...\r\n");
        server.accept(client);
        client.set_blocking(false, 1500); // Timeout after (1.5)s
        uart.printf("Connection from: %s\r\n", client.get_address());

//-----
        while(true)
//-----
        {
            if(!client.is_connected())
            {
                COLOR(_RED_);
                break;           //exit while
            }

            // Mesure ADC 0 - Check Sump Pump Run Status
            VAC_Zero_Cross();
            Measure_AMPS();
            wait(1.0);
            COLOR(_WHITE_);
        }

//-----
        client.close(); //close connection to pc app.
        ethernet_init();
    }
}
}
```

Note: The firmware was programmed online using mbed program workspace. This made it easy to program and download the firmware into the WIZwiki-W7500 board which was attached to the USB port of the PC.

Hardware / Software Details: (Main Firmware Software Loop)

ARMmbed web sites: (signup for an account)

<https://developer.mbed.org/accounts/login/?next=%2Fcompiler%2F>

<https://www.mbed.com/en/>

<https://www.mbed.com/en/platform/mbed-os/>

WIZwiki-W7500 board information:

[http://wizwiki.net/wiki/doku.php?id=products:wizwiki_w7500:start#technical reference](http://wizwiki.net/wiki/doku.php?id=products:wizwiki_w7500:start#technical_reference)

Hardware / Software Details: (Ethernet Firmware Setup)

```
*=====
Project:      Sump Pump Monitor
Description:  Measure pump current to indicate run status. (10amp pump)
Date:        11-6-16
Author:      Jim Abraham
Board:       WIZwiki-W7500
Rev:
=====
```

```
*/
```

```
#include "mbed.h"
#include "EthernetInterface.h"
#include <stdio.h>
#include <string.h>

#define USE_DHCP    0 // 0= no dhcp
#define MAC        "\x00\x08\xDC\x11\x34\x78"
#define IP         "192.168.0.12"
#define MASK       "255.255.255.0"
#define GATEWAY    "192.168.0.254"
#define HTTPD_SERVER_PORT    80
#define HTTPD_MAX_REQ_LENGTH  1023
#define HTTPD_MAX_HDR_LENGTH  255
#define HTTPD_MAX_FNAME_LENGTH  127
#define HTTPD_MAX_DNAME_LENGTH  127

#if defined(TARGET_WIZwiki_W7500)
Serial uart(USBTX, USBRX);
#include "static_colors.h"
// LED R      : server listning status
// LED GREEN  : socket connecting status Ok
// LED BLUE   : socket connecting status Busy
#endif

EthernetInterface eth;
TCPSocketServer server;
TCPSocketConnection client;

//=====
// Data Variables.
//=====
int LP1,LP2,LP3;
float AMP_Reading_on_AO, AMPreadingHI, AMPreading;
char buffer[HTTPD_MAX_REQ_LENGTH+1];
char httpHeader[HTTPD_MAX_HDR_LENGTH+1];
```

Hardware / Software Details: (Ethernet Firmware Setup)

To use DHCP, set to a 1:

(This allows the router to set the ip address automatically)

```
#define USE_DHCP 1 // 1= use dhcp
```

If this method is used, plug in the WIZwiki-W7500 board to the PC USB port.
Use a terminal program to display the ip address assigned. (9600 baud)

To not use DHCP, set to a 0:

(Manually set the ip address)

```
#define USE_DHCP 0 // 0= no dhcp
```

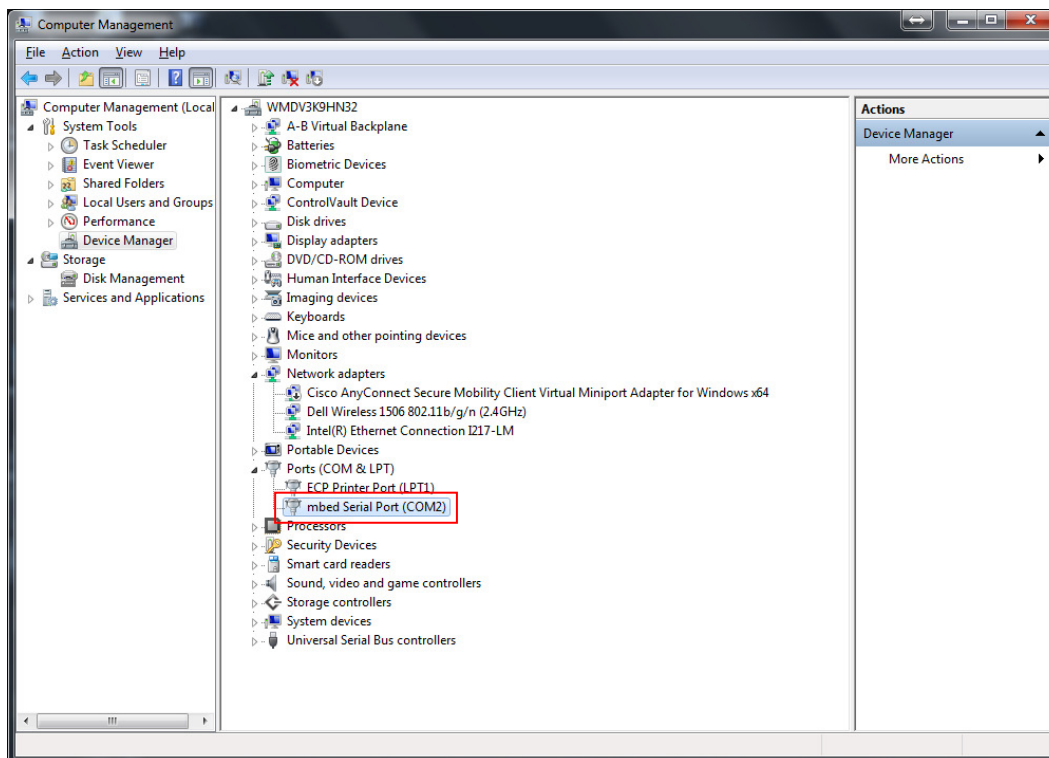
```
#define IP "192.168.0.12"
```

```
#define MASK "255.255.255.0"
```

```
#define GATEWAY "192.168.0.254"
```

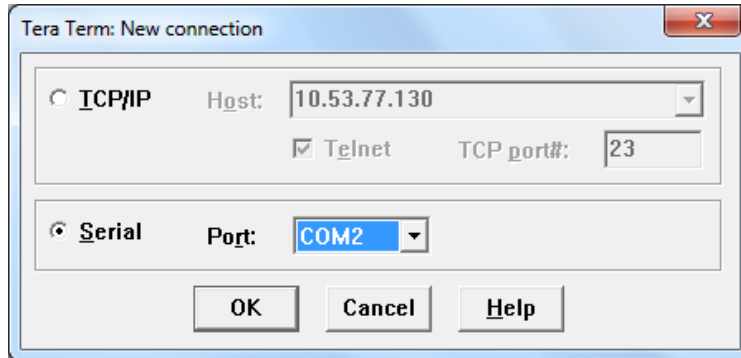
Note: can use DHCP first to check what ip address is assigned, then manually enter that ip address. (Only do this if you are the only one on the network, don't want to interfere with other PCs connecting to network)

To get ip address, connect the WIZwiki-W7500 Board to the PC USB port.
When the WIZwiki-W7500 Board is connected to the PC, a COM port is assigned.

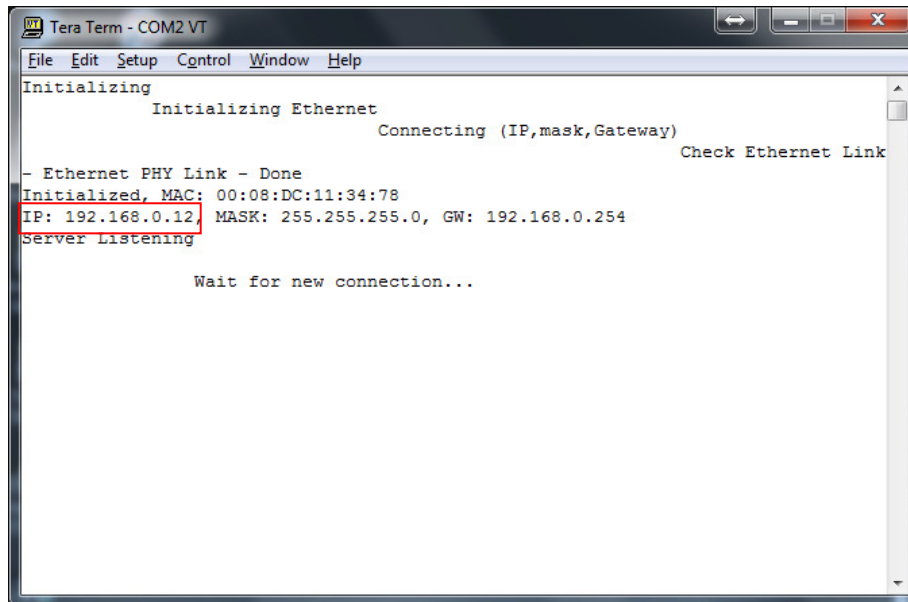


Hardware / Software Details: (Ethernet Firmware Setup)

Open a terminal program to view board output messages.

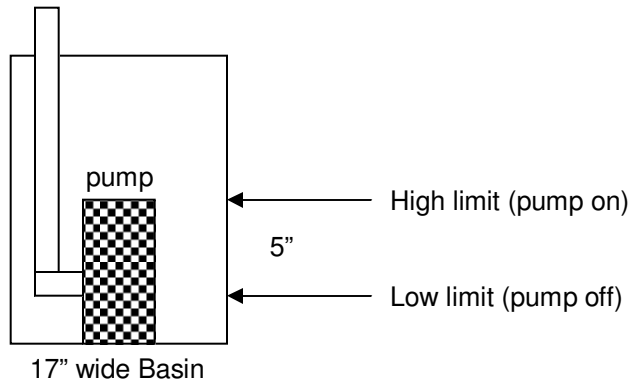


Messages from WIZwiki-W7500 Board:



Operational Details (Overview of project operation)

To calculate gallons pumped out of basin:



Measured:

$$V = (17/2)^2 \times 5 \times 3.14 \times 0.004329 = 4.91 \text{ gals in 5 seconds} = 0.982 \text{ gps}$$

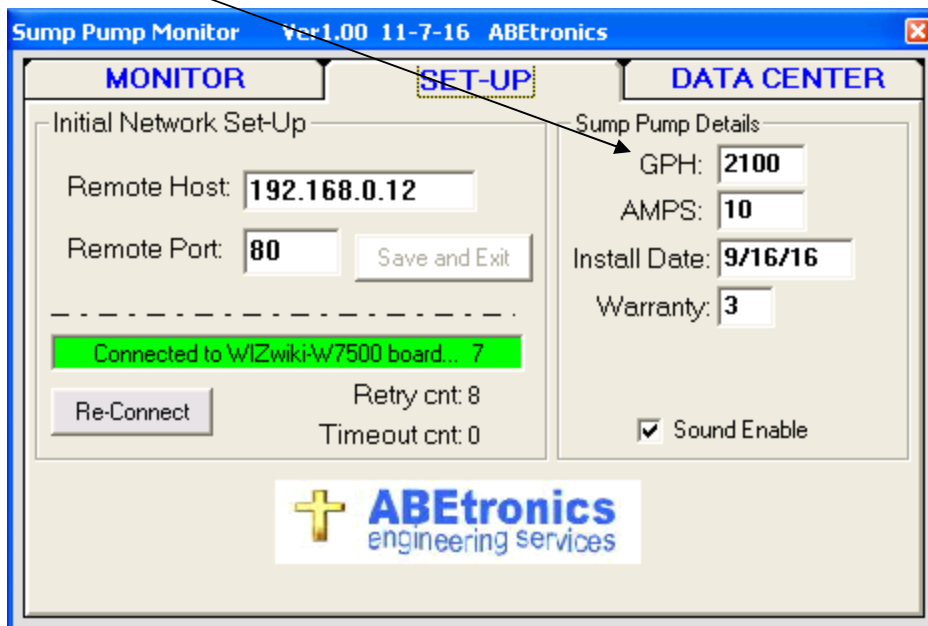
When measured the water height was not level side to side. (i.e. it was lower on the opposite side of float). So decided to use pump specification below.

Pump Specifications:

$$2100 \text{ gph} / 3600 = 0.583 \text{ gps}$$

It generally takes 5 seconds for the pump to lower the water level from the high limit to the low limit. So, 5 sec x 0.583 gps = 2.92 gals in 5 seconds.

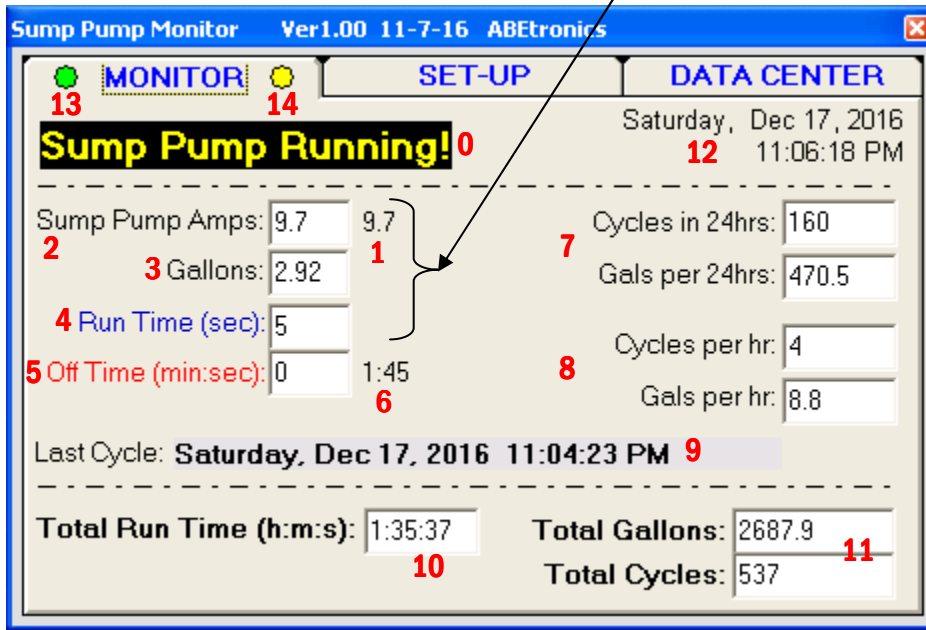
Enter the GPH on the setup screen. This value is used in the calculation above.



Operational Details (Overview of project operation)

Monitor Screen:

When the pump is running, the amps, gallons and run time will start to update on the screen.

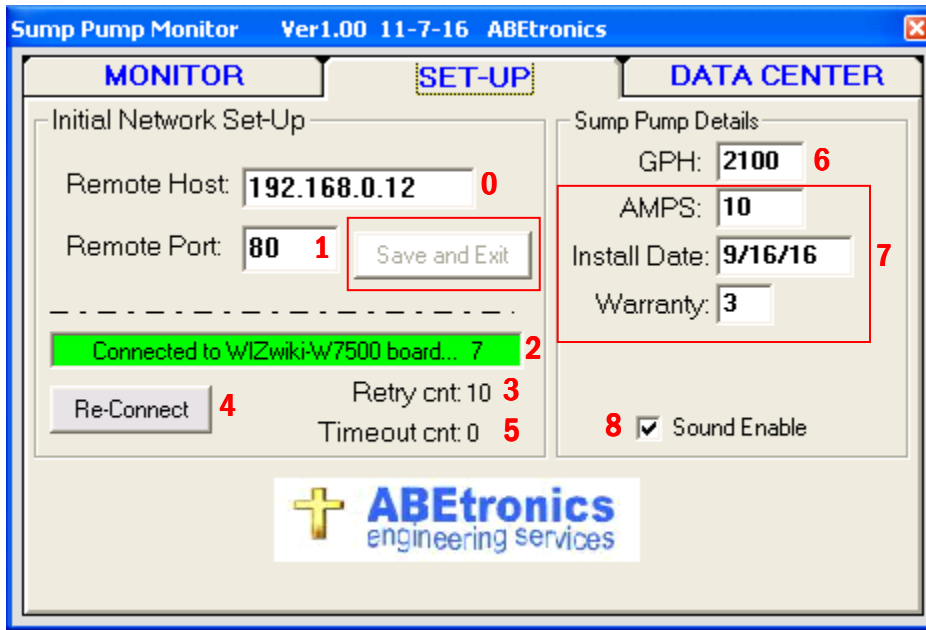


0. Pump Run Status Message.
1. Current amps.
2. Amps when running.
3. Gallons pumped.
4. Run Time in seconds.
5. Pump idle time (not running).
6. Previous Pump idle time.
7. 24 hr data collection.
8. hr data collection.
9. Last pump run time.
10. Total Run Time of Pump. (Life of Pump)
11. Total Gallons and Cycle of Pump. (Life of Pump)
12. Current date and time.
13. ethernet communication status.
14. Query WIZwiki-W7500 board status.

Operational Details (Overview of project operation)

Set-Up Screen:

Must enter the WIZwiki-W7500 board ip address and the remote port number in order for the program to communicate with the board.



Ethernet Set-Up:

0. IP address of WIZwiki-W7500 board.
1. Remote port # of WIZwiki-W7500 board.
2. Status of ethernet communication.
3. Retry counter: If after 30 seconds the connection is closed, try to reconnect.
4. Manually re-connect to board.
5. Timeout counter: if after 30 seconds the off time is not incrementing, try to reconnect.

Click on "Save and Exit" button to enter values.

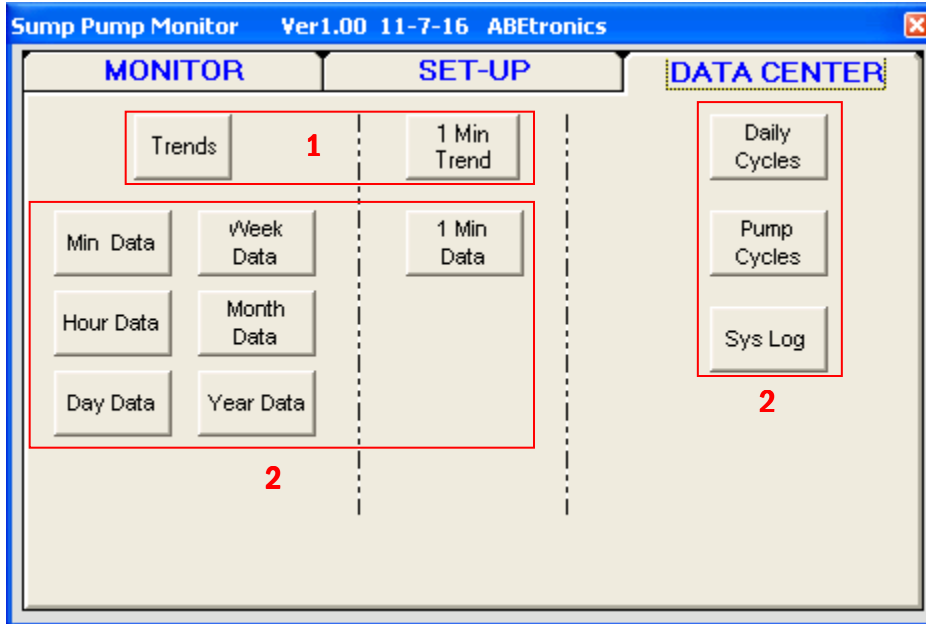
Sump Pump Details:

6. Used in calculating gallons/sec.
7. Pump information.
8. Enable the beep sound. When the pump begins to run a beep sound will sound once.

Operational Details (Overview of project operation)

Data Center Screen:

Data is collected and presented in trends.

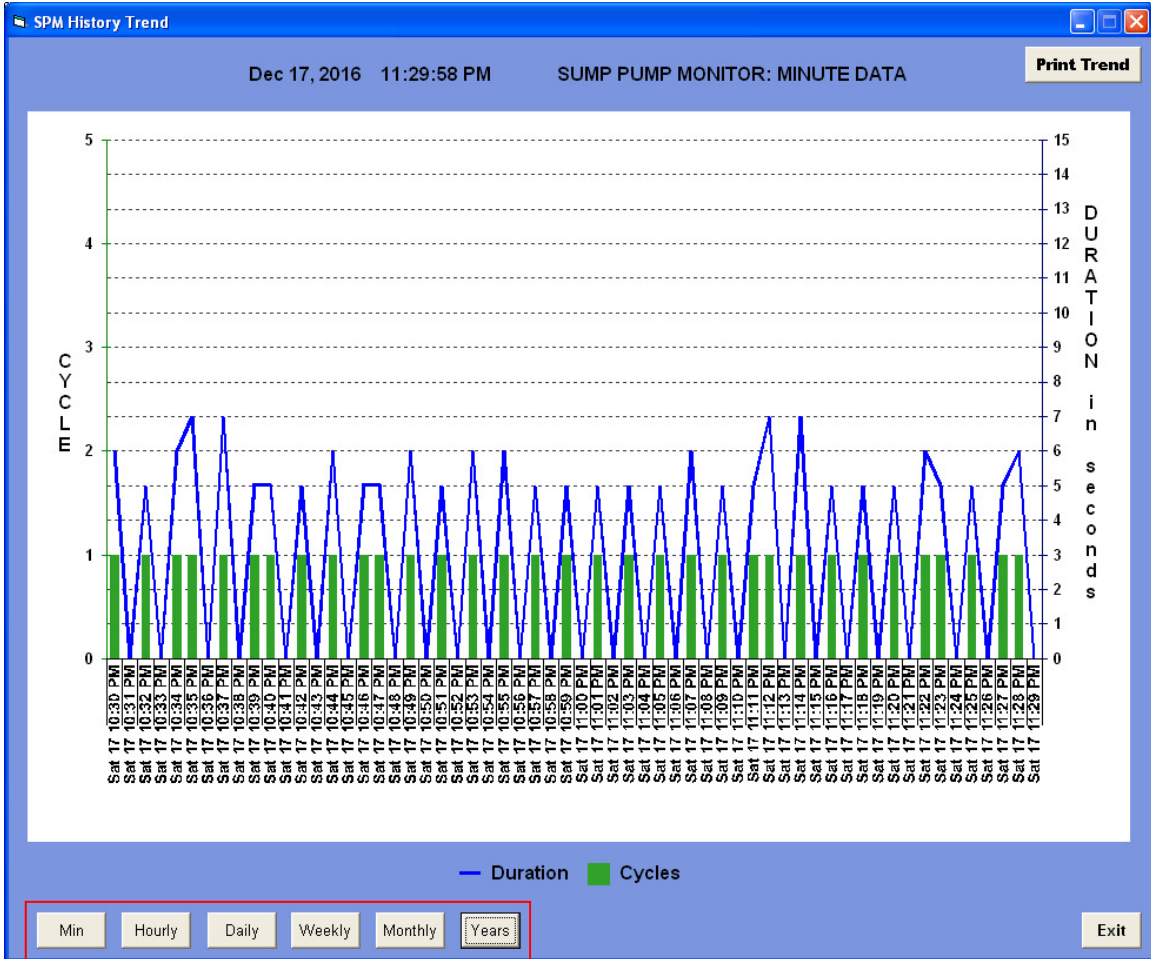


1. Display Trends
2. Open Data files

Operational Details (Overview of project operation)

Data Center Screen:

History Trend:

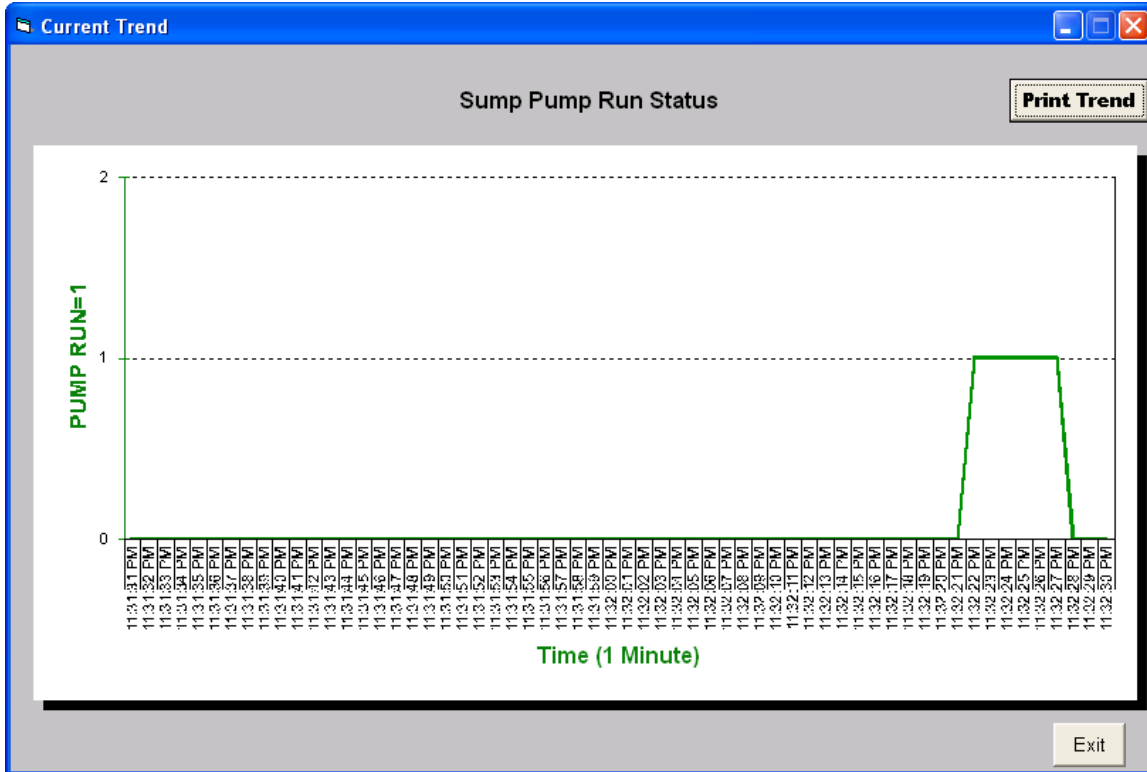


Select what time period to display trend data.

Operational Details (Overview of project operation)

Data Center Screen:

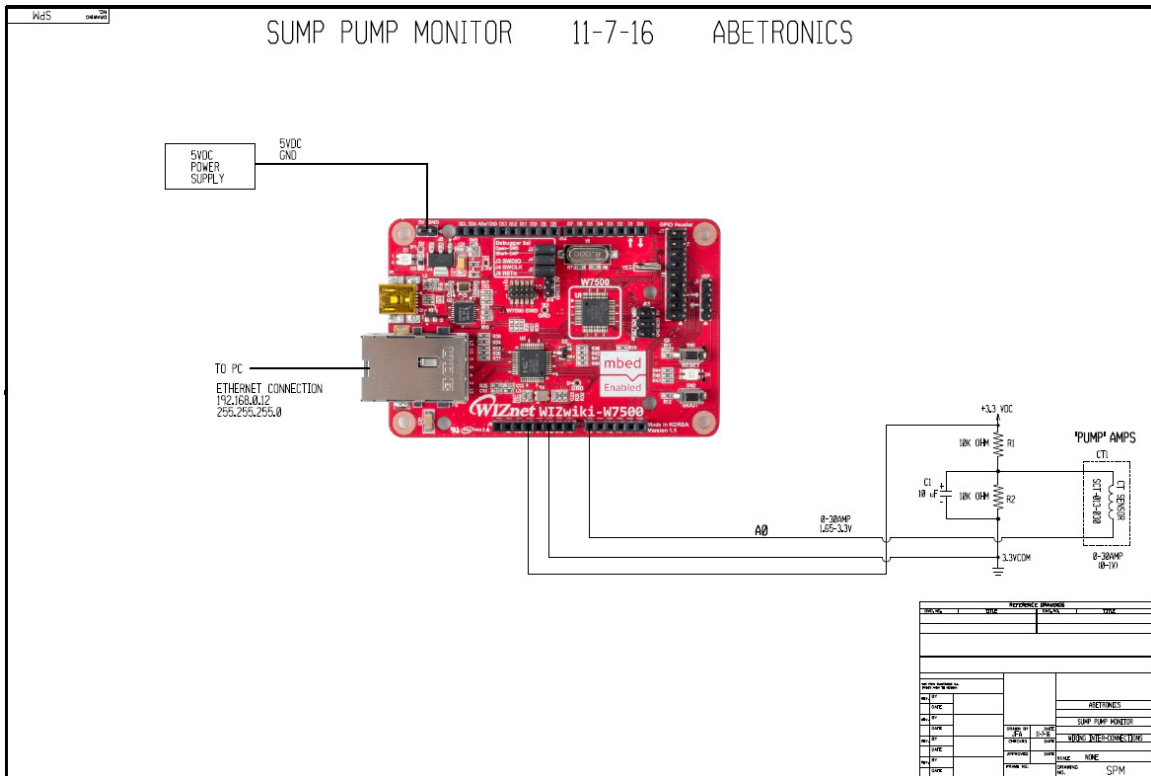
1-Minute Trend



Displays each pump cycle in more detail.

The waveform will move across the trend. When no data present, the trend will not update.

Project Hardware Information: (Hardware Parts List and Schematic)



Parts List:

- 1 ea. 5 vdc power supply
- 1 ea. WIZwiki-W7500 board
- 1 ea. Firmware for WIZwiki-W7500 board (free download)
- 2 ea. 10k ohm resistors
- 1 ea. 10uF 16v capacitor
- 1 ea. Current transformer SCT-013-030
- 1 ea. CAT5 Ethernet cable
- 1 ea. Sump Pump Monitor PC program (free download)
- 1 ea. PC to run sump pump monitor program