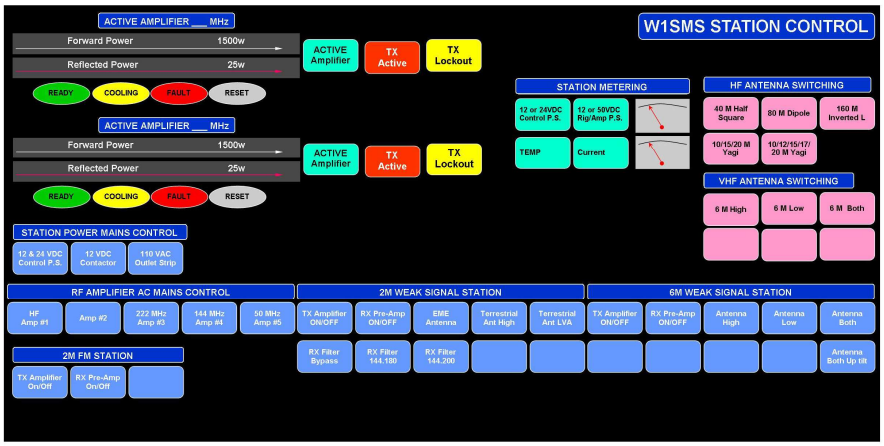
Six Meter Complete Station Control and Monitoring

Presented by W1SMS at the Six Meter BBQ Conference



My presentation (see the complementary PowerPoint slides) will focus on the desire to add a complete remote capability to the W1SMS station.

Over the years, my various station designs have included some type of remote function starting with remote location of VHF transverters & high power amplifiers in a room adjacent to the shack to today's sophisticated and fully remote capability where the shack is now a personal computer or handheld device and a few displays.

W1SMS Steven M. Simons Lunar Link VHF/UHF Amplifier W1SMS@manitousys.com
http://manitousys.com/home/products/communications-amplifiers/

My personal quest for a full remote capability has me wading waist deep through piles of relays & contactors, reels of wires (and they call this hobby wireless) as well as getting educated on the finer points of digital control technology - even living in Silicon Valley from 1980>83, I somehow bypassed the hobby of playing with personal computers and software.

I'd like to provide inspiration to those who may want to test the waters with a simple controller or dive in from the high board and remote a station in another grid square.

So, a bit of history first; I started my ham career in 1974 in Philadelphia and joined the Mount Airy VHF Radio Club - better known as the Packrats. There were many Elmers in the club at that time who mentored me in the fine art of antenna, transverter & amplifier design and construction. Needless to say I built lots of new components and converted older commercial equipment leading to a contest worthy VHF/UHF station.

As my station's equipment racks became full of high speed blowers, the ambient noise level became unbearable thus forcing a decision to move the equipment into the garage located on the other side of the wall. This initial attempt at remote control was rudimentary and included only a bank of contactors to control the AC mains power to the amplifiers and shack power supplies.

The next logical step was migrating the VHF, UHF transverters and preamps out with the amplifiers and switching the 28MHz IF and keying lines. RF power metering was brought back to the operating position in the shack to individual panel meters. Band selection was done via a rotary wafer switch. I should also note that all contest logging was done longhand.

- Moving the noisy amplifiers out of the shack
- Enhanced control of V/UHF transverters + amps
- A cross country QTH move to CM97 and yet another re-build with added features
- A QTH move back to FN31 in 1983 to the land of V/UHF activity

WA3WAS
KF6AJ
W1SMS

W1SMS station history

Two cross country QTH moves (to California and back to Connecticut) resulted in station re-builds integrating my latest version of manually operated switching boxes chock full of toggle switches and LED indicators. New features were added such as transmit sequencing and a switched set of RF power meters. Multiple HF transceivers were also employed to allow simultaneous operation on multiple V/UHF bands. Antenna switching was also manually done by rotary switches and remote coaxial relays.

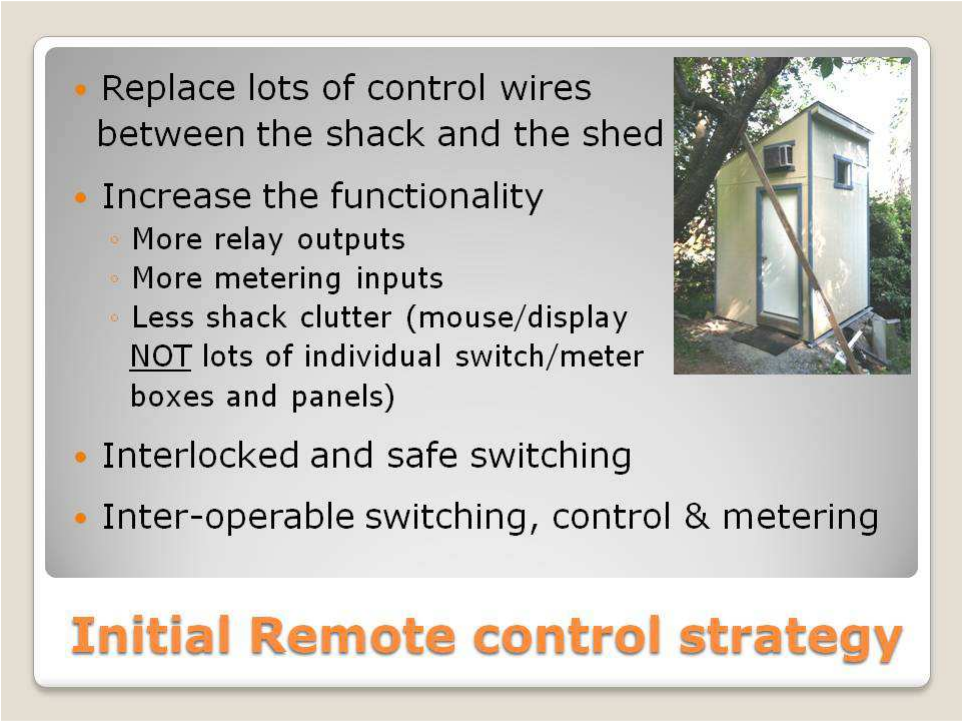
Fast forward to 2009 when a new, 120' stationary tower was erected as well as a dedicated and environmentally controlled transmitter shed located near the tower's base and designed to house a majority of the station equipment.

- Another QTH move in 2006 & 120' of Rohn 55 was erected with a 7' x 7' shed near the base.
- The 2012 Sandy hurricane encouraged it to bend in half. A 135' rotating tower rose in its place.

W1SMS station history

At this time, I started to research software driven control technology and the available products. In 2012 the Sandy hurricane roared up the East Coast causing lots or destruction in its path ! At my QTH many tall pine trees on the property were blown over. Three of the larger ones landed on the Southern, top guy wire causing the tower to fail.

A 135' tall rotating tower replaced the wreckage.



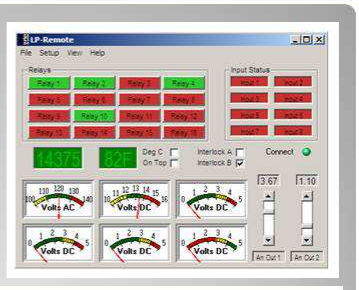
Remoting a single band VHF or even a multi-band HF station is less complex than a multi-band VHF-UHF station where each band has its own set of hardware - transverters, preamps and, amplifiers.

As the amount of bands grow, so does the complexity. I currently have planned for a station capable of operation on HF through 47 GHz frequencies.

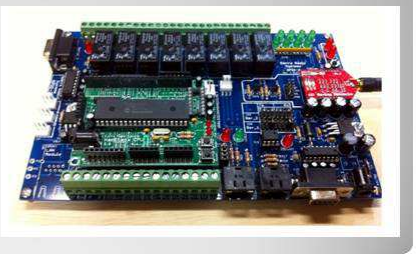
Simple & individual switchboxes and meters are certainly reliable however they start consuming the available shack space. During a contest, one can forget which meter you are looking at or even toggle an antenna switch during transmit. Attempting to switch RF when running full power digital modes will result in an expensive replacement T-R relay. We now see the limitations of using non-interlocked switching !

Another feature of smart control is the ability to be inter-operable - that is for contest logging and radio control software to provide outputs to drive the remote control. The capability does exist in these software programs - the trick is accessing it.

- Newer remote switching technology researched and vendors selected.
  - LP Remote
  - Hamstack



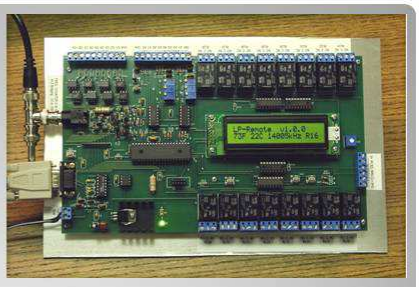
- Both products could solve the needs of switching over the (local) network.



Defining & securing the hardware

I researched the LP Remote and Hamstack control products during a Hamvention visit. Both were PIC based controller kits; with the Hamstack requiring one to learn the “C” programming language while the LP Remote came with an operational dashboard which enabled the output relays to be toggled on and off via a mouse connected to the host computer in the shack.

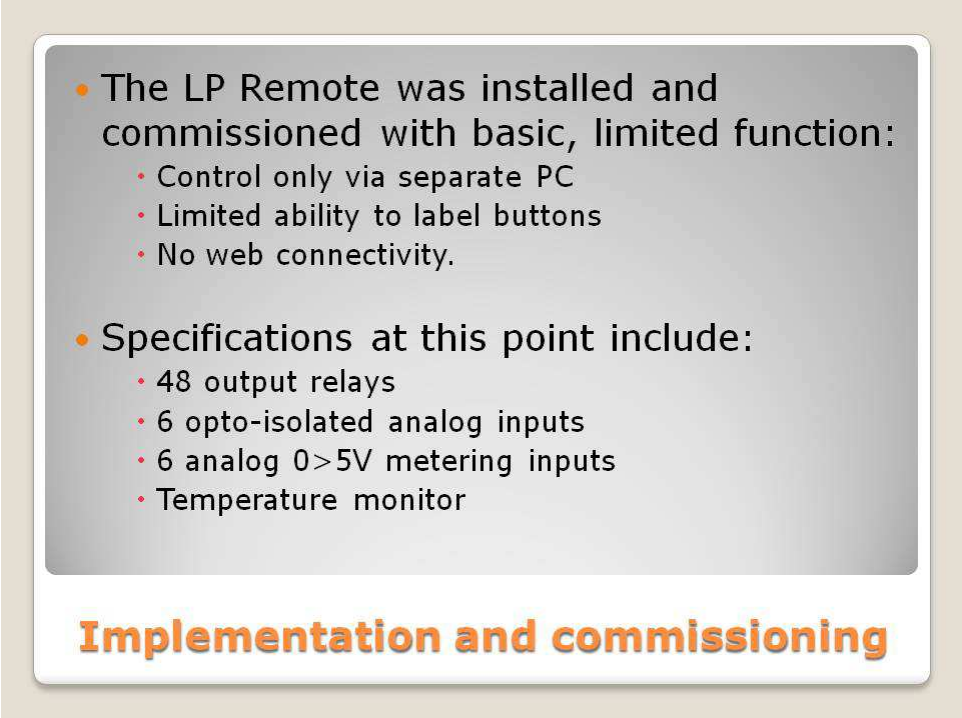
- Both LP Remote & Hamstack products purchased.



- The LP Remote was commissioned based on the included control software.
- Now the real life test begins !

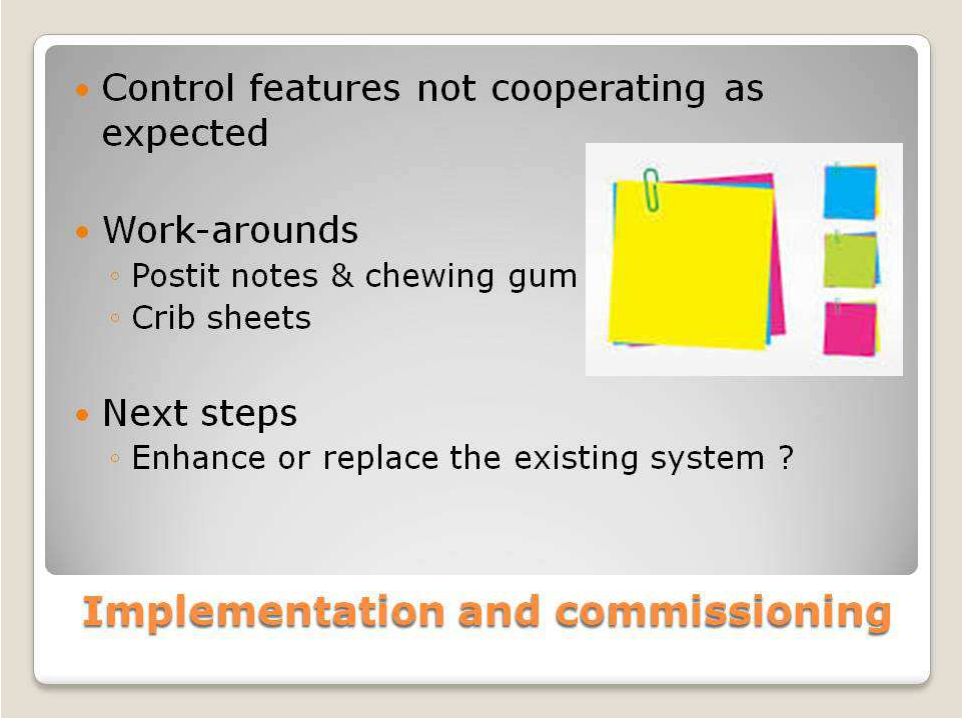
Defining & securing the hardware

I purchased both products to evaluate. I felt that using the included LP Remote software would save time so, I made a commitment to that product and the Hamstack was set aside.



Turning my attention back to the station building, the LP Remote was prepared and tested on the bench - it performed well however it had limitations; the operating software was just a beta version and bugs prevented labeling of the buttons on the screen. After the manufacturer said the product is low volume and not supported anymore I had a few different software knowledgeable friends interrogate it. The bottom line was that it would take lots of work and that some of the modules (meters) were no longer available. If we did get it operational to my liking, it functionality was still limited as it had no real web connectivity and was limited in its scope of possibilities.

So, we have a control system with 48 output relays, 6 opto-isolated analog inputs and 6 analog 0>5V metering inputs. Additionally, a single temperature can be monitored using a thermistor. The shack control was accomplished using a older XP computer and a mouse - with no connectivity to logging programs or the Flex 5000 radio and its PwrSDR software.



At this point, my frustration level rose as some of the basic control needs were not being met (labels on the buttons). A simple solution was to apply cut pieces of Post It notes to the display! To switch those remote relays, I needed to consult a crib sheet - yes, another piece of paper cluttering up the operating space.

Well, its been a couple of years that I limped along with the post it notes and hand scribbles - the hardware however, had been powered up continuously and always operated properly - so, I took this result as a good thing !

Consulting the vendor, as well as a few global users he referred me to, resulted in learning about the same thing: that the product was not a big seller and the vendor was not going to provide much support. One user did write his own software but had moved and not turned it on since and, the other user was in the process of ripping it out to make room for something new.

I was successful in obtaining the product source code and having two of my “digital go-to” ham friends look at it. One comment was that it was only an alpha version and the meter display modules were no longer available, the other friend was able to add some labels however, I started giving the potential results a 2nd thought.

So, do we revise or replace the existing system?

- Various control / performance possibilities
  - Maintain local control only
  - Internet control
  - Interactive control via logging or SDR dashboards
- Different hardware options
  - Beaglebone
  - Raspberry Pi
- Multiple operating systems
  - Windows
  - Linux

Revised remote control strategy

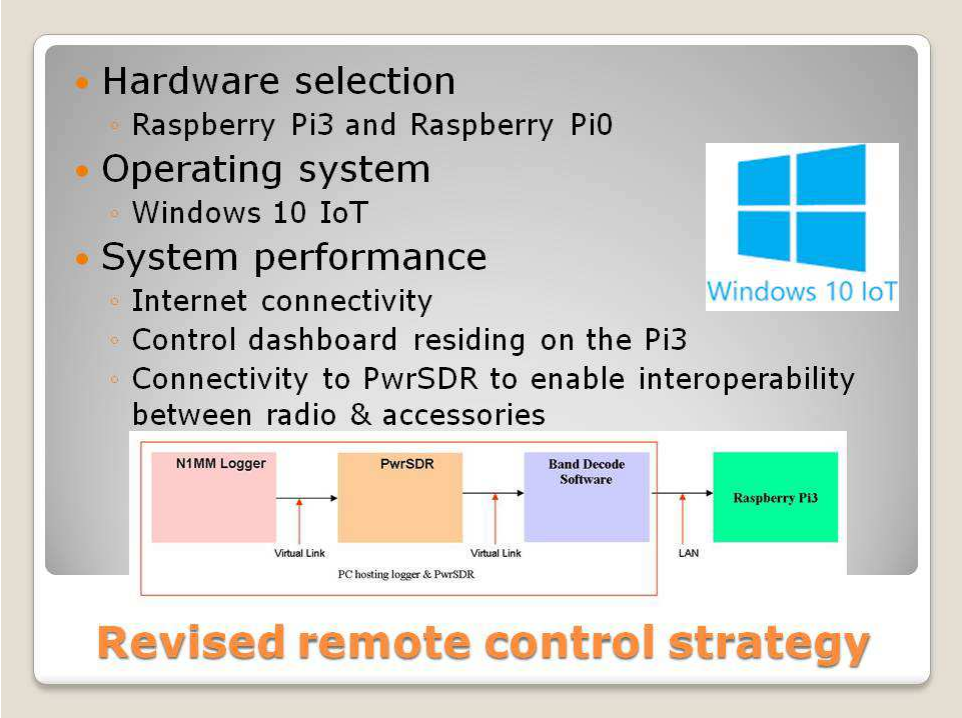
Some more research and discussions with those “go to” friends surfaced different directions and hardware configurations.

As single board computers are now accepted in both the hobby and industrial worlds, we decided to go in that direction. This approach will give us lots of connectivity & control possibilities !

The single board computer choices are basically a Beaglebone or Raspberry Pi. The two operating system options include Windows and Linux.

The current LP Remote product includes local control only with the dashboard software residing on a host PC and connected to the remote boards via RS232 - or in my case, through a pair of Ethernet>RS232 adapters.

Increasing the performance with a Raspberry Pi3 running Windows 10 IoT gave us complete internet connectivity and control, keeps the dashboard software on the Pi3 and communicates with the existing LP Remote boards using the I2C protocol.



Ed, KB1OIE and I spent a bunch of hours going over the W1SMS station configuration and debating how to accomplish the desired control and metering tasks. As he has developed Raspberry Pi / Windows based control solutions for his industrial customers, we decided that it would be a good idea to leverage work that was already done.

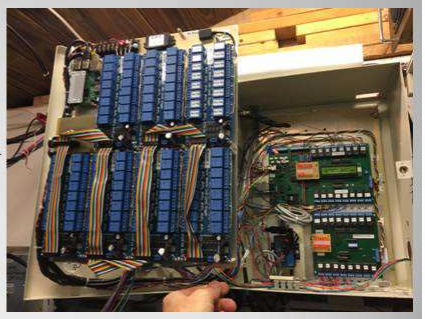
A Raspberry Pi3 running Windows 10 IoT would serve as the system's main computer with Raspberry Pi0 devices used to extend the system as embedded controllers or perhaps around the transmitter shed and on the tower to switch antenna selection relays.

The system would connect to the internet through my LAN connection; using an optical link from the shed to the shack and then through the router and cable modem to the outside world.

A special program that resides in the computer that controls the Flex 5000A and PwrSDR program acts as an interface to the Raspberry Pi3 through the LAN. This program will decode (using CAT commands) the selected band from PwrSDR and advise the Pi3 to select a specific bank of relays. These relays will be used to switch in the HF through microwave station's metering and control functions to the Pi3.

See the graphic above.

- Maintaining the existing system
  - Keep the LP Remote main and expansion boards.
  - Remove the original PIC controller chip
  - Replace w/latest PIC & new program
  - All original LP Remote functions maintained !



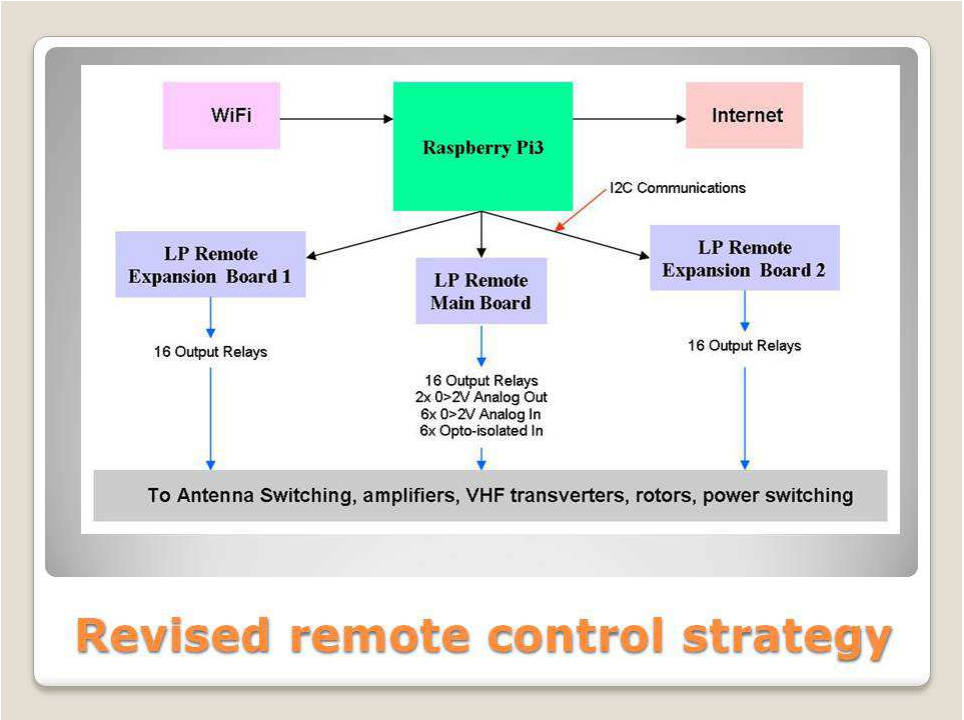
Revised remote control strategy

We debated whether to start from a clean slate or find a way to maintain key parts of the existing system. As I had already started wiring up the output relays to control the antenna switches, AC & DC power supplies and amplifiers, it was decided to keep the LP Remote main board and the two expansion boards.

The original PIC controller chip was removed and replaced with the latest chip pre-mounted on a development board. The development board was installed in the original PIC socket.

Programming this new PIC was easy as the development board included a USB port. The new software was written to enable control all I/O devices on the LP Remote main board and communicate with the Raspberry Pi3 via I2C. It should be noted that the two expansion boards were already set up for I2C communication, so all we needed to do was program the proper addresses.

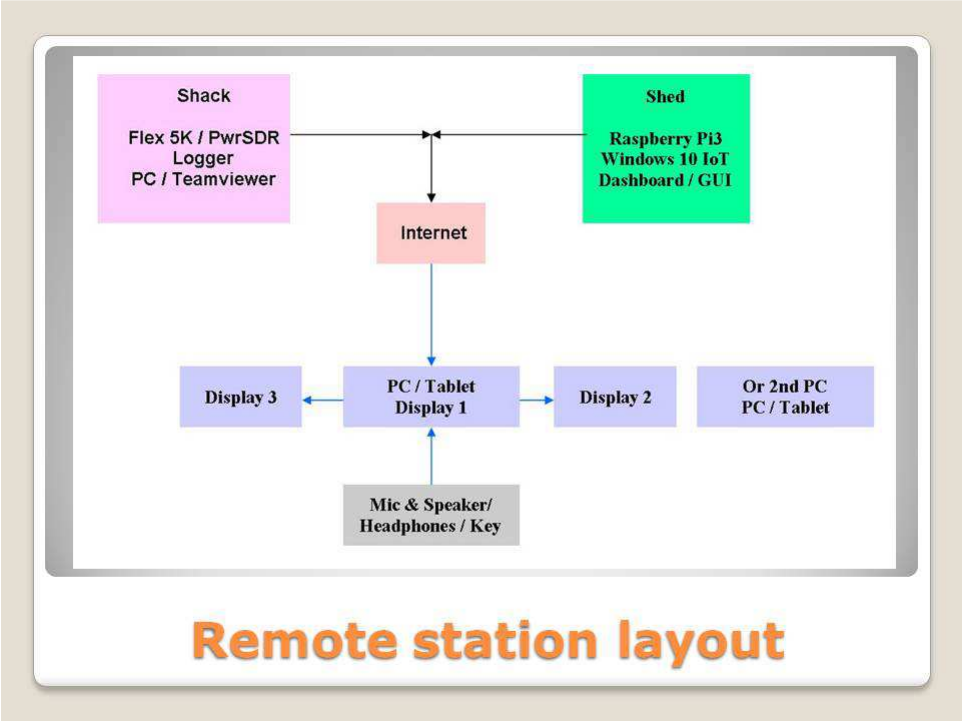
Now, we have maintained the original functionality of the LP Remote board !



The up-fitted LP Remote boards all become “dumb” I/Os and communicate with the Raspberry Pi3 using the I2C communications protocol.

The Pi’s built in wifi can also communicate with other local devices.

As the Pi has its own IP address and contains the operating software and user interface or dashboard, any external device may be used to display and control the station.

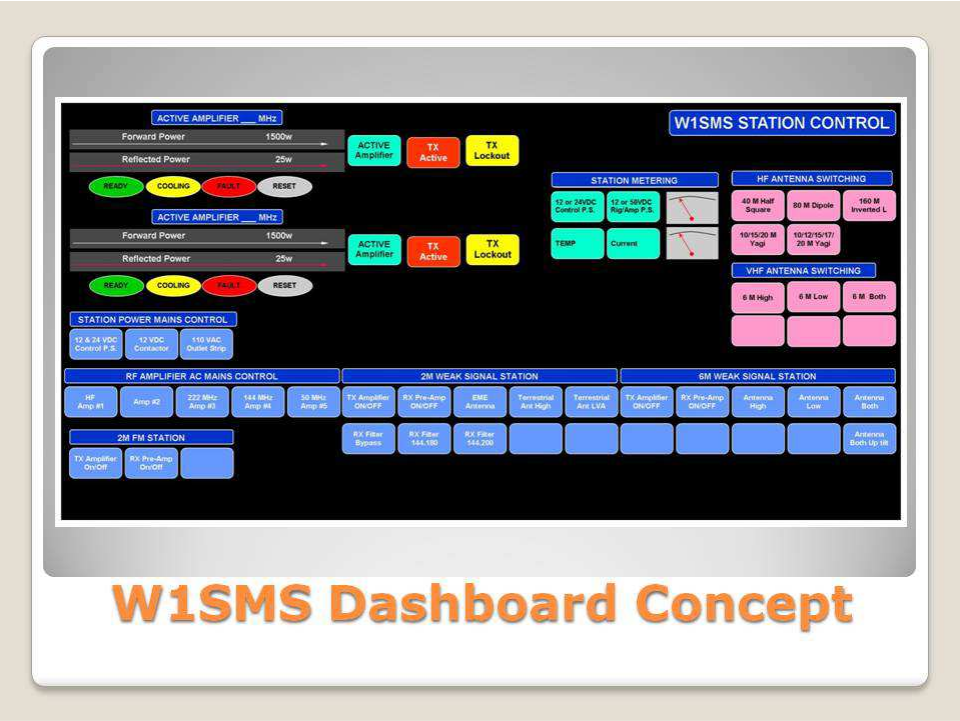


The schematic above shows both the Shack and the Shed control centers connected to the internet.

Either a single PC running multiple browser instances or two separate PC's are used for the control.

At least three displays are required to view PwrSDR, N1MM logger and the Raspberry Pi dashboard.

Operating accessories such as headphones, speakers, a key and mic are added as required.



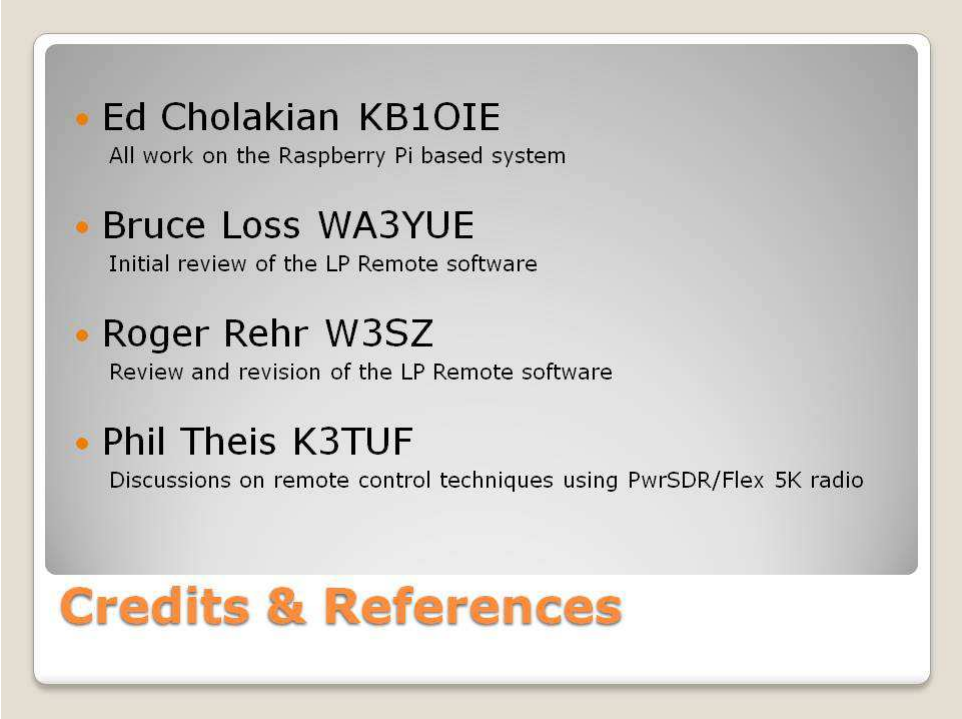
The slide above shows the original W1SMS dashboard concept.

This slide shows a screen shot of the W1SMS live dashboard. Further development will include additional switching as well as a video feed and other metering screens.

The W1SMS station includes a modified 3CX3000A7 based 50MHz amplifier. Critical controls and metering such as Forward / Reflected RF Power display, fault indication / reset and standby / operate will be accessed by the station controller.

The slide above shows the RF deck and the complementary high voltage power supply & controls.

Critical resources for this project are shown above.



I owe a debt of gratitude to Ed Cholakian, KB1OIE, for his massive efforts to integrate the single board computer and write the various software programs to make this project a reality.

I wish to also acknowledge my good friends WA3YUE, W3SZ and K3TUF for their co-operation, mentoring, assistance and, inspiration in making this project a reality.

A hearty thanks to Flex Radio & DX Engineering for sponsoring the Six Meter BBQ as well as giving me the opportunity to present this paper.

de: W1SMS