

The NorCal Christmas Power Meter

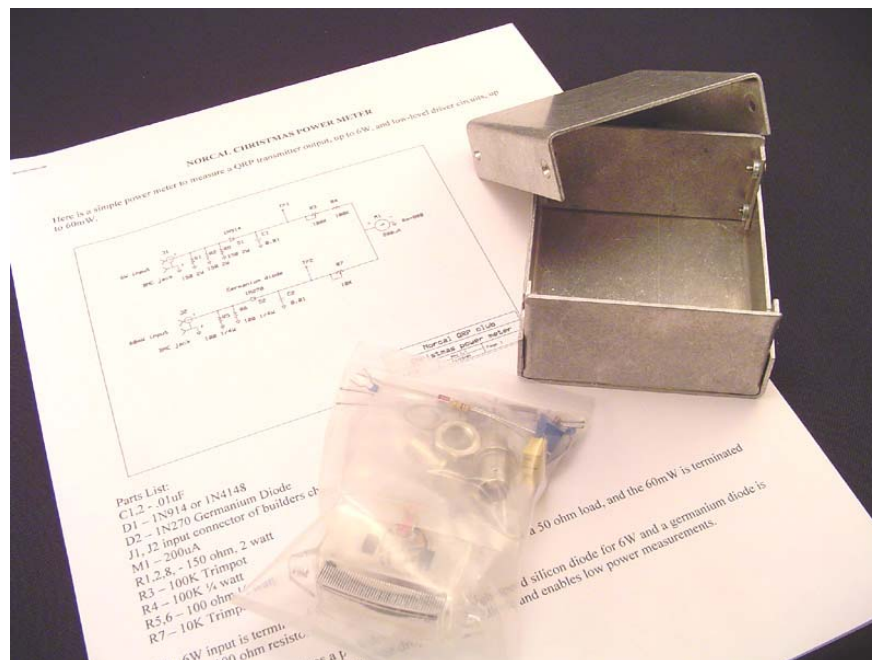
By Joe Porter W0MQY

Our local *grp builders group* is always looking for a project to build at our twice monthly building meetings. Our good friend Doug Hendricks has graciously provided us with the parts for an ideal group building project. Unfortunately this little gem is not a kit you can purchase but is intended to inspire you to roll your own. The complete information including an assembly manual with schematic, parts list, and photos, are available on the NorCal website. I am always interested in how kits or projects come about so I lifted the history and short story of how this little meter was born from the NorCal webpage and included here.

“This project came about during a brain storming session at the November 2005 NorCal meeting. Doug, KI6DS mentioned that he had some 200 uA meters that would make neat power meters and that he would be willing to donate them to the club. Song Kang volunteered to design and prototype the project, and James and Paul gave the go ahead. It was decided to give the kits away to members who attended the December meeting (we had enough for about 40 kits), and then put this article on the web page so others could roll their own. Merry Christmas from NorCal.

“This is not a kit project and not available by mail but rather a kit that will be given out at the December NorCal meeting to people who attend”

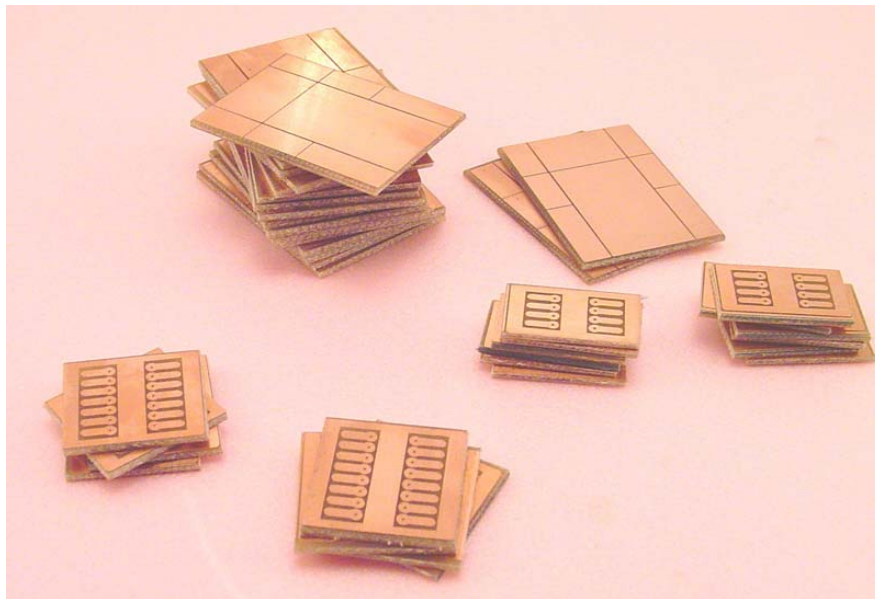
<http://www.norcalgrp.org/norcalchristmaspowermeter.htm>



I have to hand it to Doug and the NorCal guys using clever incentives to get their members to come to the meetings. If something like this wouldn't get you to come, then I don't know what would. Great idea guy's and if your local building group is looking for a project, this just might

be what your looking for. The neat little box in the photo is the famous BLT Tuner enclosure and can be purchased from “Hendricks QRP Kits” <http://www.qrpkits.com/bltcases.html> This great little box has the clamshell top and bottom, a front and rear panel, and is complete with “pem nuts” embedded in the aluminum for ease of assembly. The outside surface on the box parts have countersunk holes for flush mounted hardware and should please anyone who has a phobia about protruding screw heads on the finished project. *Way to go Doug !!!*

Once we decided to embark on this project, a short discussion by our group on how to assemble this little meter took place at our last meeting. Ideas for making a pc board were kicked around and the photo etch process seemed like a logical choice. The pattern that must be produced doesn't require a complicated layout and most any circuit board design package can do the job quite nicely. The manual gives the complete dimensions of a very simple pc pattern you can reproduce in several ways. The assembly manual suggested cutting the isolated pads of copper using a Dremel Tool or Xacto Knife. Either of these methods are satisfactory to produce a board but after a bit of discussion by our group, the consensus was that a pc board with an etched pattern would be nice to have. The results of my efforts are shown in the photo below.

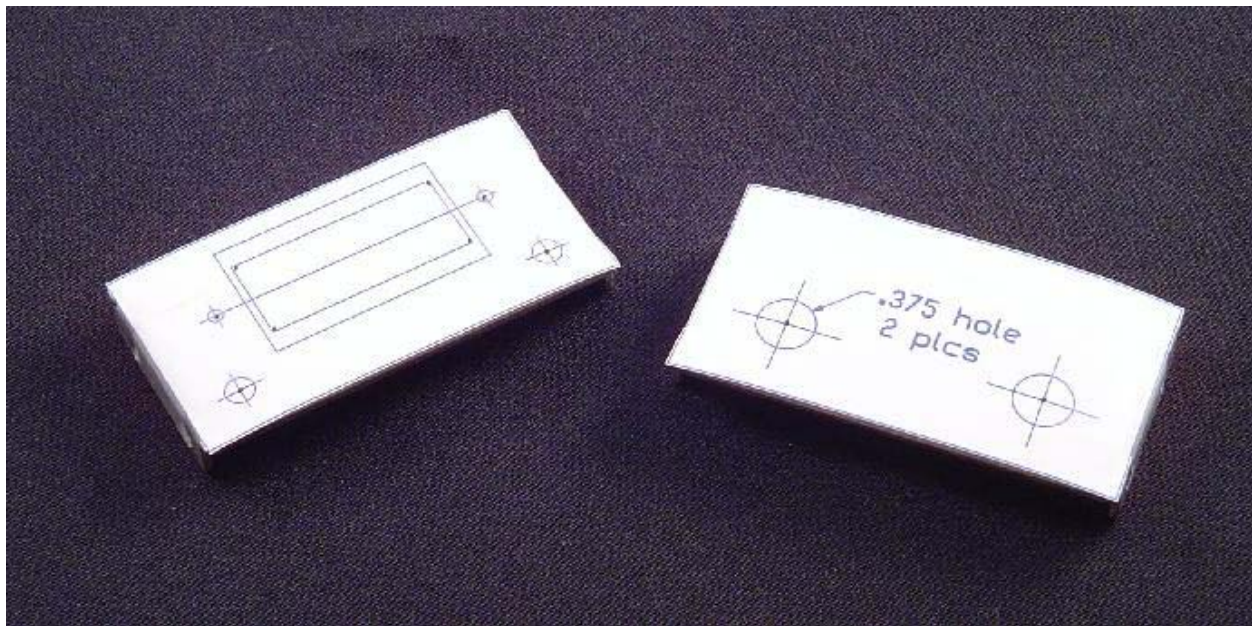


I use pre-sensitized circuit board in my process and beings this material is not cheap, I am always looking for ways to cut down on waste. Most qrp projects are not designed to fit standard size pc boards that are available from suppliers without creating waste. I created a master of the power meter board to the dimensions listed in the manual, then stepped and repeated this image to fit a 4 1/2" x 6 1/2" pre-sensitized pc board. It was determined that I could produce 9 power meter boards at one time with some scrap along the sides. The other small circuit boards you see in the photo are integrated circuit patterns for various sized chips I use in my projects. They fit nicely into the area of the board, which would normally be sheared off as scrap. These small pc boards were designed with a hole drill center in the circuit lands which allows either drilling to accommodate an IC socket or you can just bend the pins out on the socket and solder the socket to the board “surface mount” fashion. I find that these little boards are great for proto-typing a single chip circuit such as the LM386, NE555, or NE602's etc. The large pad patterns may be

used for any 14 or 16 pin circuit and my aim here was primarily to have a board I could use for my 16F84 PIC circuits. These boards are quite handy to assemble the run circuit for the pic and its associated parts and then super glue the whole sub-assembly to the mother board of a larger project. This same process could be applied to many projects using sub assemblies such as audio filters, audio amps, mixers, rf amps, and oscillators, as well as transmitter driver and final stages. None of the boards shown would be a good layout for a transmitter output filter but the same modular board style of building could be applied here also.

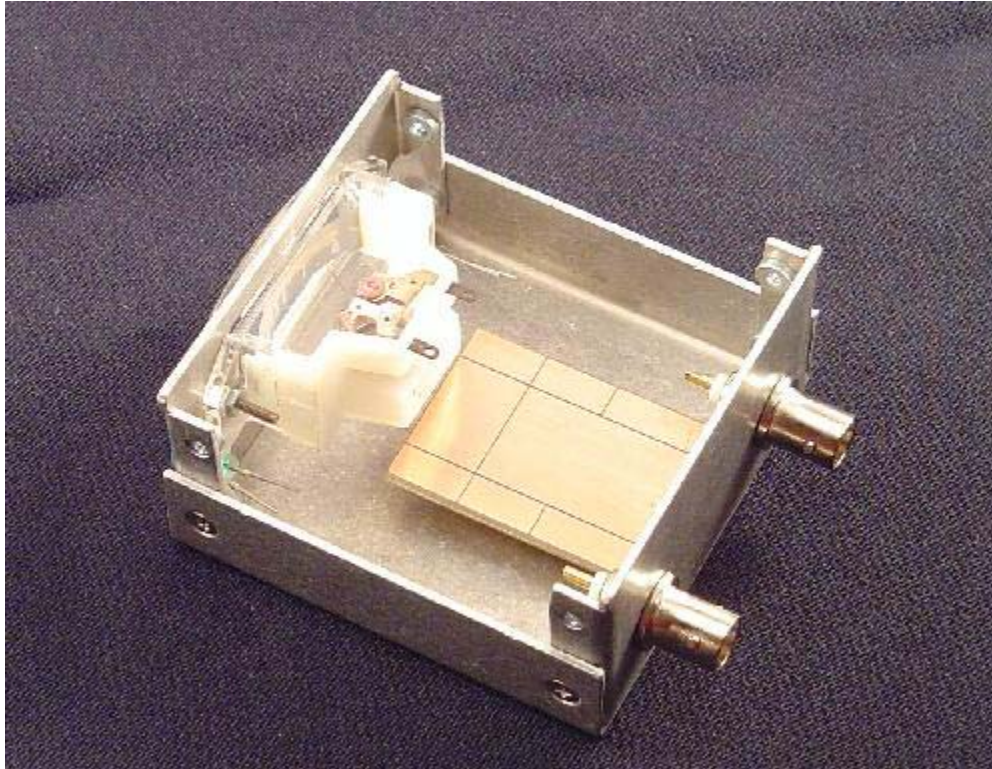
Construction Begins

There is some metal work to be done so I chose to begin construction by creating drill templates for the front and rear panels of the power meter. A trip to the NorCal webpage shows a finished power meter with the bnc connectors mounted on the front panel. I have always wanted cabling on my qrp equipment to extend from the rear panel if possible and that was the decision made here. Below is an image showing the templates created by software to exact scale, printed, and then transferred to the panels for center punching and drilling. The meter opening was created using a tool that my old machine shop instructor called a "***Nicholson Shaper***". This tool is more commonly known to us who don't own a mill or shaper as the hand file. It is a laborious task to create rectangle holes for mounting meters this way but I have lots of time and there is no expensive machine involved.



The templates are taped to the front and rear panels for marking and punching. If you are a true blue machinist, you would probably use a center drill to maintain hole location accuracy. The hand punch leaves a nice little dimple to keep the drill bit from skating all over the panel and leaving scratch marks that are difficult to cover with paint. If you use paper labels to print your artwork on, then you can cover a multitude of sins with these labels and no one will ever know that the drill bit created a nice little ditch across your front panel. The template and pre-punching is probably overkill from the metal working standpoint, but I have found over the years it causes a lot less frustration during assembly if the holes are where they are supposed to be. It also

allows you to check the parts to be added to the panel for clearances. Paper templates are cheap and you can redesign them and reprint them many times if you miscalculate just how much room that bnc connector or meter movement takes. The next image shows the final fit up of the enclosure with the meter, bnc connectors, LED's and pc board mounted.



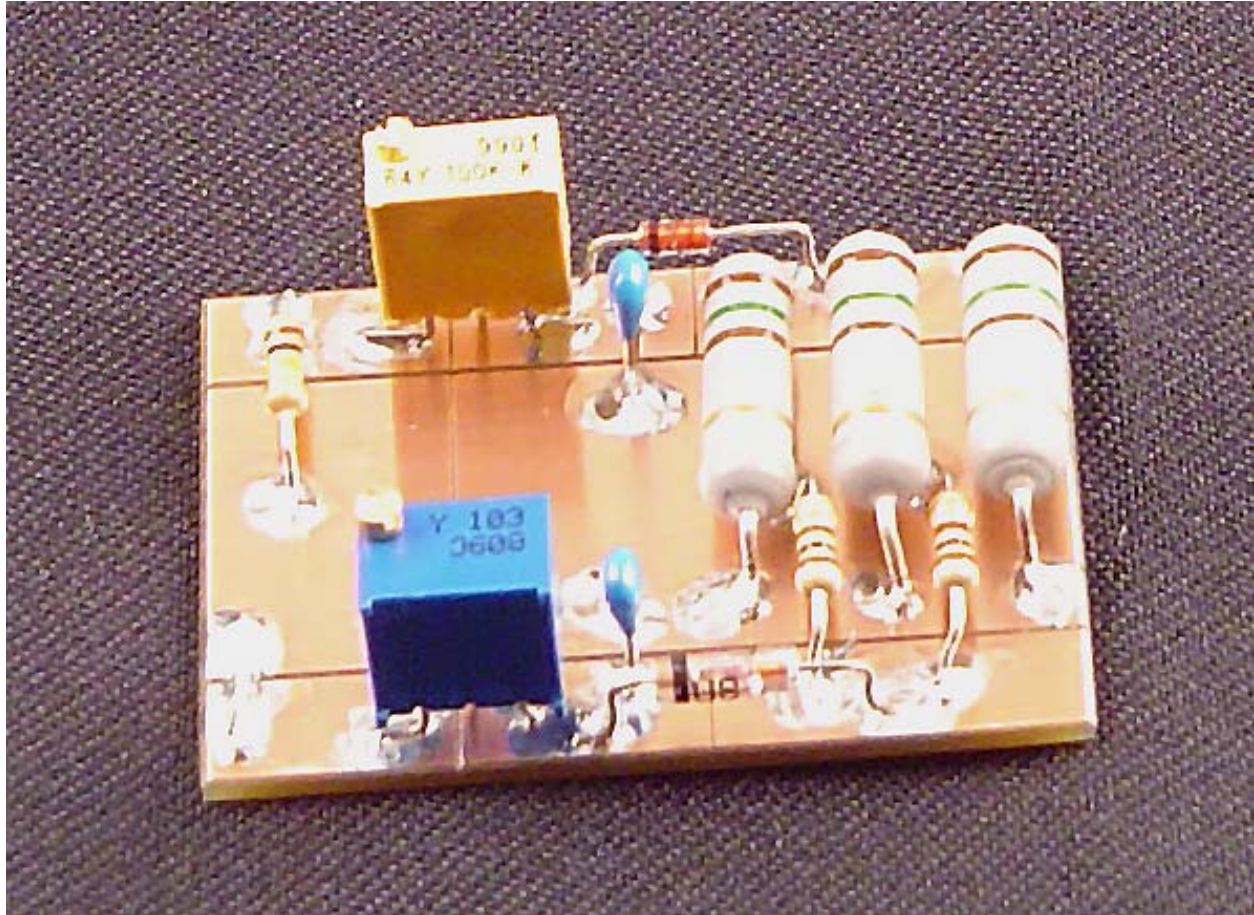
Everything seems to fit up nicely so we will move on to the next stage of construction which will be the pc board component assembly.

PC Board Assembly

The dummy load resistors, diodes, caps and calibration pots are added to the etched pc board. There is one sorta “gottcha” here that I would like to remind you of if you follow the board layout from the NorCal downloadable assembly manual. You will notice from the pc board dimensions in the manual that the board layout is quite small. This didn't seem to pose a problem until Bill, WB0LXZ, in our builders group tried to assemble his power meter pc board. The resistors in the package are rather large for the area they need to be installed in and it does require a little planning, as Bill discovered. It is not a big deal and the resistors have to be large (2 watts each) to handle the power they will be subjected to on the 6 watt side of the board.

After listening to Bill mutter something under his breath and seeing rosin rising from his soldering iron, the problem was solved by interlacing the 3 large 2 watt resistors with the 2 half watt resistors similar to what is shown in the image below. It seems to work out nicely and there is room for the two dummy load assemblies but you just have to plan ahead a little. If I had

known this before the boards were etched and sheared, it would have been an easy fix by changing the pad size and layout. There are other options such as standing the resistors on end “Manhattan Style” to gain the required room for them. Below is my version of solving the minor space problem, thanks to Bill’s early discovery of a potential assembly problem.



My final assembly of these components looks like it was meant to be this way. If this were going to be a production run of many hundreds of boards, then I would make the necessary changes to the artwork to make it easier for kit builders who follow. Beings this is a *roll your own* project it was decided to just leave the boards the way they are and continue on with the project.

One last suggestion before we move on and that is using the *“glued punched solder land”* and build your power meter with solder points anywhere you desire on a blank piece of circuit board. It has also been suggested in the manual on the NorCal website that the grooves in the circuit board could be cut with a high speed rotary cutting tool and a diamond or dental drill type bit. It takes a steady hand or a jig to hold the tool and the board. For me it was a faster alternative to do the photo pc board etching process. I can’t justify the time or the expense to make the boards but I just like doing it. There is something magic about watching the image appear on the pre-sensitized board in the development process. Additional excitement occurs when the tiny

bubbles in the etch batch start to create your little circuit board by carrying away the copper where it is unprotected by the photo image.

Enclosure Finishing

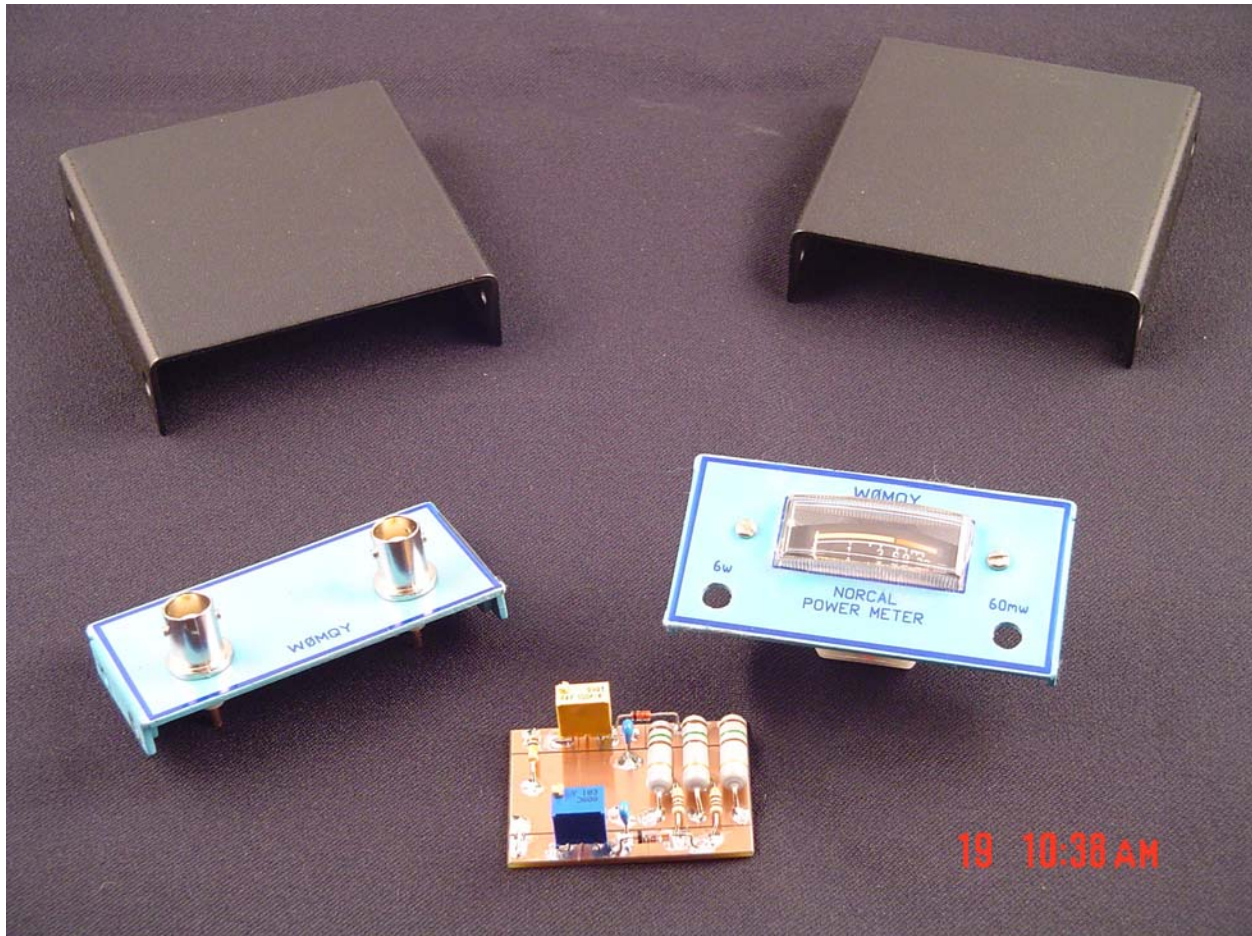
Another one of my obsessions is making the enclosure look somewhat like the professional ones. Since Doug has such a nice little box for his famous “**BLT Tuner**” and has graciously made these available to our builders group, it would not be fitting to not do something special for the “**NorCal Christmas Power Meter**”. A survey of the local hardware and discount stores provided some interesting materials for treating the little box housing the power meter. Below is an image of the paints I used with varying degrees of success and you might want to try them sometime on one of your pet projects.



One of the problems with finishing aluminum cases is that there is usually an oil residue left from the manufacturing process and this must be removed before painting. A good solvent such as Acetone seems to work for me but I am sure there are many other processes that could be used to clean the aluminum. I follow the cleaning process with an automobile primer which provides a nice base coat with a tooth to it for the final color coat adhesion. This brings to mind a note I was asked to place on a drawing for metal preparation at a company I used to work for. This

note read ***“abrade surface to enhance adhesion”*** and since this created some confusion during the manufacturing process, it was changed to read, ***“sand it so the paint will stick better”***. The latter note seemed to get the point across much better. The finish coat on the front and rear panel was done with the light blue plastic model paint (an attempt to match my power meter with my Sierra color scheme) but when the paint dried, I noticed a change in color that didn’t match the Sierra. Well, you win some and you lose some but the panels were still attractive I thought.

The finished panels are shown in the image below and you can judge for yourself the results of my effort.

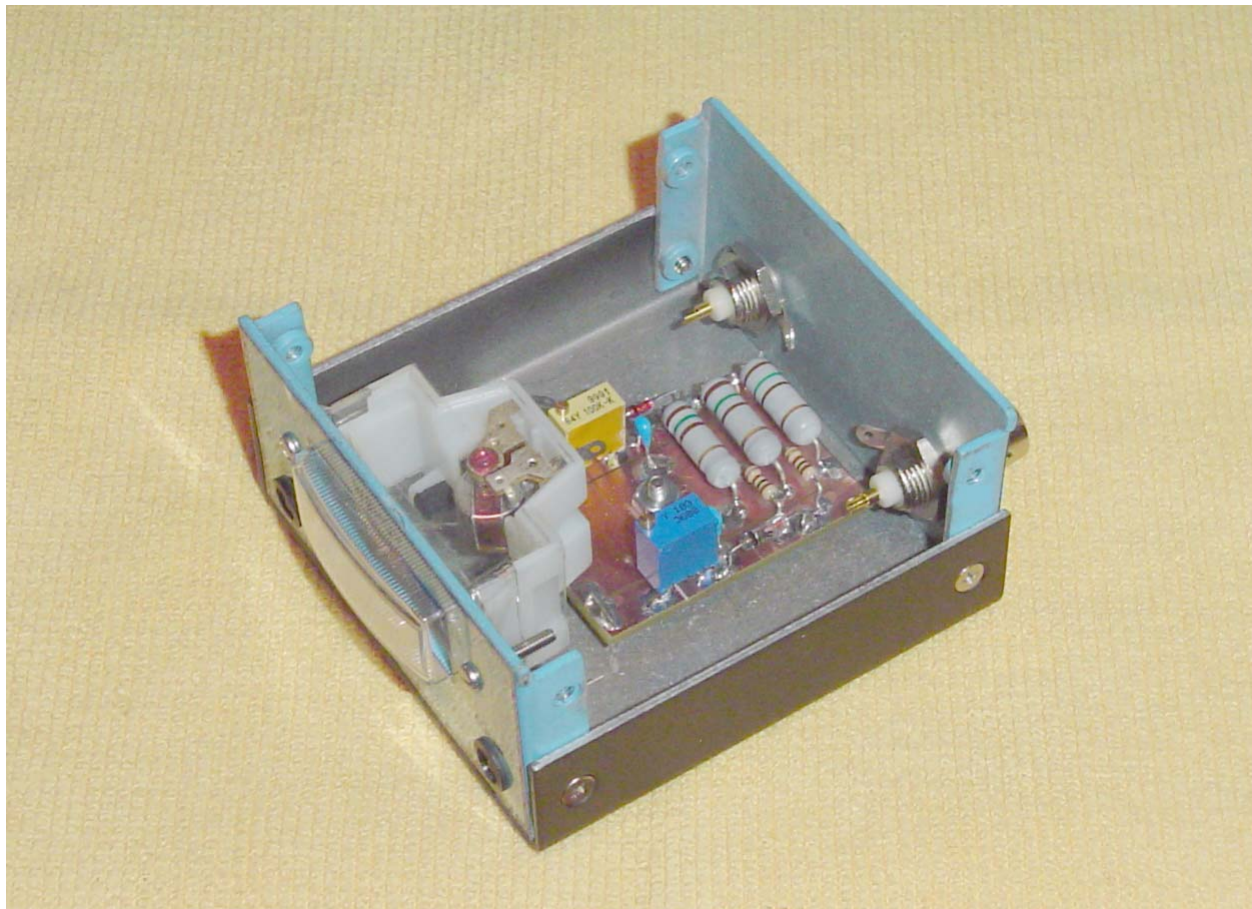


The bottom and top covers were painted with a paint that was designed for outdoor lawn furniture and seems to provide a quite nice textured finish. It looks and feels very much like the old standard black crinkle finish that has been used for many years on ham equipment. It does, as does any paint, need sufficient drying time to prevent that proverbial finger print on your panel when you chose to pick it up to admire before it was completely dry. One trick some builders use is, baking in the xyl’s oven for a few minutes to give additional toughness to the finish. One word of caution is warranted here though and that is, xyl’s can become hostile with the smell of the paint drifting throughout the house from the kitchen. Maybe the label on the paint can should have a warning to this affect, ***“Baking this paint in your xyl's oven can be hazardous to your health...”*** You can also spray the top and bottom cover with an additional

coat of a clear polyester type spray as a safer alternative. I did not bake the finish or clear coat it and therefore the case finish is not impervious to dings and chips. If you plan to use your power meter in the field and it is going to take some abuse, you might choose to just leave the case in its raw aluminum finish.

Final Assembly

The final product is starting to take shape now with the mounting of the meter, pc board and the bnc connectors into the painted enclosure. This image shows everything done but the meter, LED, and the rf input connector wiring.



I am sure the question will arise “why the LED’s?” Well, another of our builders group, Max, KC0MAX, made the comment one time in a building session “if it doesn’t have lights, push buttons, or switches, then it is not something he wants in his arsenal of qrp equipment. The LED’s bring on a lot more questions than answers but here is my reasoning. First of all, I agree with Max, and second, a red and green LED seemed fitting to distinguish between which power level was in use. Also, the meter was given the title “The NorCal Christmas Power Meter” making the red and green LED almost mandatory. So, two extra holes were drilled in the front panel with labels of 6 watts and 6 mw which seemed to satisfy both Max and I about bells and whistles. After all, isn’t doing something different on your project necessary to set it apart

from someone else's. I have yet to meet a qrper/builder who does not want to add their own special touch and design changes to make it personal.

I am sure some of you are thinking about the voltage drops of the LED and current limiting resistor affecting the calibration of the meter. You are absolutely correct but the meter was supplied with calibration pots so let's go for it. The meter has a graduated S meter type face and will require a replacement label if the meter is to read accurately and directly without conversion. This requires taking the meter apart by separating the case and exposing the very delicate meter movement. The reason I know about taking the meter apart is that when you place a 5 watt handheld on the 6 mw bnc connector, there will be meter movement adjustment required. If there is a disadvantage to having the input connectors on the rear panel, I have discovered the hard way what it is. Unless you turn the box around and watch which connector you hook the rf source to, you can expect to do the same thing I did. There is no more sickening sound (other than dropping a telescope mirror) than when a meter movement tries to exit the right side of the case at a very high rate of speed. It requires the touch of a brain surgeon to get the meter to work again but we managed to get it back where it belonged with a minimum of trouble. The calibration pots seem to allow for enough adjustment that Max and I can have our bells and whistles in addition to a properly calibrated meter.

The Finished Project

There is always a certain amount of pride that goes into every qrp project and I think that is good. This causes bragging but most of our builders group has learned to just put up with me until I get it out of my system. I hope some of my ideas (however trivial) will inspire you to make that next project of yours something special but adding that personal touch when you build. After all, the joy of building encompasses all of the failures and successes and hopefully will culminate in a very joyful learning experience for you. ***"The NorCal Christmas Power Meter"*** is a fantastic little project for anyone wanting to try out his or her building skills and in the end you will have a very useful little tool for the bench or the field. A big thank you goes out to Doug and the NorCal bunch for sharing this little jewel with us.

To make the panels have somewhat of a professional look, I used clear transparency material to print the text and borders in color for the front and rear panels. The nice thing about this is that you can create panels with very exacting dimensions in circuit board CAD software and then print them on transparency film or mailing labels. My good friend and cohort in crime, Terry Fletcher WA0ITP, is a master at creating equipment labels. You can take a look at his website for information concerning his process.

http://4sqr.com/ats-3_labels/ats-3_labels.htm

The important thing is that you experiment and see what works best for you and your projects. I am probably the king when it comes to having a lot of projects that look pretty but don't work worth a hoot electronically. The upside of this is that I have gained a lot of experience on what works good and what doesn't. A case in point is the way I attached the transparency labels to the panel of the power meter. I got the wild idea that "photo matt adhesive" would be a good way to apply the clear artwork over my freshly painted front and rear panels. You can always

get some panel mounted device such as switches, bnc connectors, meters, or whatever, to hold the clear transparent label in place. I discovered, unfortunately, that the photo adhesive did not stick as well as I had hoped and the labels you see on my finished project had some places that the adhesion did not take place. This caused me some grief with reflections into the camera and therefore you don't see any photos in this write up looking straight into the front or rear panel. This image pretty well shows what I am talking about.



It has been a lot of fun and when the rest of the builders group finishes their project, I hope they will share their experiences as well with the qrp community. Designing, building, creating, and sharing, has been a cohesive glue that keeps our little builders group focused and a fun reason to attend those building meetings. Using this little meter as an incentive to get guys to come to the meetings was another excellent contribution to the qrp world by Doug Hendricks KI6DS.

72/73 Joe W0MQY
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