The Wireless

August 2024

The Garden City Amateur Radio Club

PO Box 482 • Garden City, MI 48135-9998

Next Meeting:
Tuesday, September 17, 2024, 7:00pm
Garden City Presbyterian Church

Congratulations to our newly licensed Technicians:

Shane, KF8BWN	Stephen, KF8BWP
Bruce, KF8BWM	Jesse, KF8BWK
Robert, KF8BWL	Corey, KF8BWW

Wishing you la lifetime of enjoyment in Amateur Radio.
We'd love to have you join us at our next club meeting on Sept. 17th.

The Garden City Presbyterian Church has treated us very well over the years. They not only have provided us with a meeting space, they have allowed us to hold several special events In their building and/or on their grounds. They have even given us a room to set up as a "radio room" for the club station and equipment storage . Did you know that we have an HF antenna installed in the attic of the church building?
On **August 24th**, the Church is hosting a classic car show, with proceeds to benefit Focus Hope. They have asked our club if we would help out with parking and possibly other areas. This is a good opportunity to come enjoy the day with friends, chat on our HTs, and help our benevolent hosts with a very worthwhile cause. If you'd like more information, please contact Scott, WT8S.

Attention VE's:

Our next scheduled exam session will be Thursday, November 14, at 7:00pm, at Schoolcraft College. Please plan to be there by 6:30.
Interested in becoming a VE?
If you have a General Class or higher license, we can use your help. Contact Don at gcarc.wireless@gmail.com for more information.

SPECIAL SERVICE CLUB

Best of Matmatics
- Isolation Transformer Patch Panel
- Mat Breton, AB8VJ

I often use an isolation transformer when working inside equipment. Many pieces of equipment do not have an internal isolating transformer (especially some modern switched mode power supplies, and old radios): you can get a nasty (or fatal) shock if you touch the wrong thing and the current takes a path through you and ground (or you can similarly ruin test equipment if you hook it up wrong). An isolation transformer will protect you from this (although you can still get shocked if you touch both lines coming out of the transformer): this was thoroughly covered in the June-2013 Wireless Article "*A Policy of Isolation (Isolation Transformers)".*

A personal annoyance is the fact that I have to pull the isolation transformer out of storage and hook it up when I want to use it (see picture below). It uses bench space, storage space, and the annoyance factor means I probably don't use it as often as I should. I started with the idea of making it super easy to use, and the project started getting a little bigger bit by bit. I added the desire to be able to connect and disconnect the transformer in case I wanted to move it somewhere other than my bench. I wanted the ability to monitor the power and current being drawn (so I wouldn't have to dedicate one or more of my multi-meters). I wanted a 15A circuit dual pole circuit breaker: 15A so the local breaker would blow before my 20A lab breaker went if there was a short or problem and dual-pole so that it would completely disconnect the equipment (both hot and neutral).

Available isolation transformers

Because the transformer it power limited (to 250VA), I wanted an additional higher-power GFCI outlet in addition to the isolation transformer outlet. GFCI outlets can also protect you from current passing through you and ground, although in a different way. GFCI (called RCD, or Residual Current Devices in Europe) outlets will disconnect power if they detect any current leakage (greater than about 4mA). Because it takes a finite amount of time to detect and trip, you can still get quite a jolt from a GFCI protect circuit … but it is unlikely to be fatal. You are also dependent on the GFCI electronics and switch to work correctly … something you don't have to worry about with an isolation transformer.

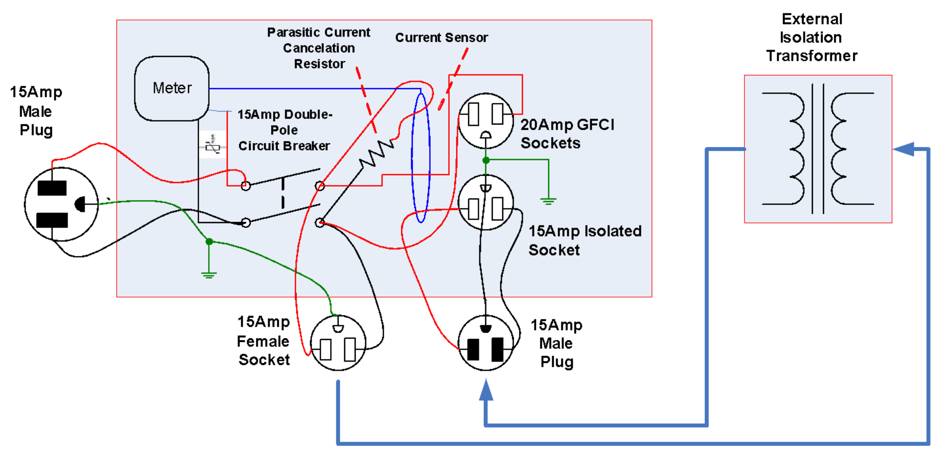
Isolation transformers are therefore preferred because they prevent the current from flowing in the first place (intrinsic safety) while GFCI/RCD devices detect and switch off dangerous current flow after it has started. Additionally, working with RF can cause problems with GFCI/RCD devices as the RF can cause them to inadvertently trip: the transformer coil inside each of them can pick up stray RF and interpret it as leakage current. Finally, devices that have significant hot-to-ground capacitance can cause them to falsely trip when the device is turned on, as the displacement current through ground is interpreted as a safety leakage (no way for the device to tell the difference).

Project Goals: The following are the goals that I ended up designing the system for: Easy/Convenient access; The isolation transformer needs to be easily connected/disconnected; Local Circuit Breaker; measurements for voltage, current, power, power factor; separate higher-capacity GFCI Outlet; and fits in a 2U rack space (what I had available on my bench rack)

I was able to purchase a meter module on eBay for $17.50 (including S&H). The meter module advertises to measure voltage, current, power, power-factor, energy usage, and frequency. This easily covered what I wanted. The unit importantly used a transformer to measure current (and not a shunt), which allowed me to run a couple of wires through the transformer such that the leakage power from the isolation transformer would impact the measurements. Documentation for the meter module was sparse, and there were no accuracy specifications (only maximum limits and ranges).

Circuit: The circuit is pretty simple and is shown below. Two notes:

1. I need to route the wiring such that the parasitic power for the isolation transformer (12.8mA) and the meter module (41.4mA) is not detected: this was done by running two wires through the current transformer, one for the GFCI-only current, and one for the isolation transformer secondary winding current.
2. I added a big 250Vac MOV across the hot/neutral of the meter module. While the meter is supposed to work at up to 250Vac, I wanted to protect it if the breaker blew when under a heavy inductive load (resulting in an unequal voltage difference between hot and neutral as both sides of the breaker arced). Of course, the breaker will only blow when it is over maximum load, and since I don't know how much protection is inside the meter module I thought this was a wise and inexpensive piece of insurance.



Schematic showing the separate isolation transformer

Fabrication: Other than the meter module ($17.50) and the MOV ($0.95), I was able to obtain everything I needed from my junk drawers. I started with a blank 2U rack panel: I measured, drilled, and cut the necessary holes to mount the equipment. I then wired everything up and tested it (made sure grounding was correct, isolation was correct). There were two “gotchas” I discovered during testing.

GFCI devices use a small amount of current for their internal electronics … about 6.6mA for my unit. This showed up on the meter whenever the panel was on as a 0.9W load. I had a number of options to fix this:

1) Take the GFCI apart and power the electronics from an external feed: Probably not easy to make it reliable and safe
2) Use an external circuit to cancel the power through the current detector coil: probably difficult to make it exact, as a resistor might vary with voltage/temp differently than the GFCI electronics.
3) Use the GFCI as a "hidden" backside unit, and put a secondary normal outlet on the GFCI load terminals (and watch the current on the load): Unfortunately the reset/test buttons would not be easily accessible
4) Put in a switch to turn off the GFCI when it isn't needed (most of the time I would probably use isolation transformer outlet instead)
5) Remove the GFCI and put it into a wall outlet (where it could be accessed): Steve (WQ8T) noted this would solve the issues.

I decided to add a resistor in the circuit (option 2) to cancel the parasitic current through the current sensor. The exact resistor was about 18.8kOhm, and the closest value I could get in a large wattage was 18.7kOhm. The resulting reverse current nicely cancels the GFCI parasitic current, and the meter module displays zero watts at rest.

Side notes Rich (W8DOW) asked if the GFCI drew any current when it was tripped. If it didn’t, then I could just trip it when I was only using the isolated receptacle and there wouldn’t be any leakage current. Unfortunately the unit had an LED that lights when tripped, and the receptacle still draws 2.2mA (to light the LED).

Steve (WQ8T) noted that this parasitic power drain results in a yearly cost of about $1.25 per year per GFCI in your house (at an electric rate of about $0.16/kw-hr).

Readings before resistor added (left), and after (right)

For the second "gotcha" my first design measured current on the secondary side of the isolation transformer and voltage on the primary. Unfortunately the transformer winding was not exactly 1:1 … it was actually 0.94:1. This caused a significant error in the power and power factor measurements for the isolation transformer outlet. My options were limited: if I put the current measurement on the primary, I would have the transformer losses figured into the power figures. I decided to add a switch to swap the meter measurement between the primary side (for the GFCI outlets) and the secondary side of the transformer (for the isolated outlet). Not ideal, but better than living with the significant amount of error. After adding this switch the results were corrected.

Performance: The finished panel behaves as designed (once the two "gotchas" were corrected). The isolated outlet is truly isolated. The GFCI outlet trips when leakage current is detected. I had a couple of question regarding the meter module performance.

> Question #1: Is the power measurement "True" (aka Resistive), or does it include reactive components? Since the meter unit has "W" (Watts) as a unit, it should be "True" power. To determine this I put a reactive load and measured the power with a power analyzer and the meter unit. The meter displays True power like it should. It was very accurate until the power factor dropped below 0.5, where the error began to increase.
>
> Question #2: Are the voltage and current "true RMS" measurements or adjusted-average calculations? To determine I made numerous measurements with a number of different loads (varying currents, power factors, and current/voltage phase shift). The measurements were nearly exact compared to an accurate true-rms meter I used to compare.

For the accuracy measurements I borrowed a Magtrol Model 4612 power analyzer: it measures current, voltage, and real power with a significantly higher accuracy than I needed. I tested with a variety of loads with both the Magtrol and the meter unit. The table below shows the results. Remember that my measurements were taken with a new unit (no aging), at one single (moderate) temperature, on one single meter (not a larger number or across multiple batches), and did not cover the entire range (voltage, current, power) that the meter is said to be able to handle: the true worst-case error for the model is sure to be much higher.

Measurement	**Error**	***Comment***
RMS Voltage	-1.8 to 0.1%	*0.2-13A, 0.1-0.99 PF, 1V Resolution*
RMS Current	-0.8 to 0.9%	*0.10-12.0Arms, 0.1-0.99 PF, 10mA Resolution*

Measurement	**Error (PF = 0.5-0.99)**	**Error (PF = 0.1 to 0.99)**	***Comment***
Real Power	-0.8 to 1.1%	-0.8 to 12.5%	*.003-1.3KW, 10mW Resolution*
Power Factor	-1.2 to 1.0%	-1.2 to 5.2%	*.003-1.3KW, 0.01 Unit Resolution*

The meter gives surprisingly accurate readings, especially for current and voltage: it appears that the accuracy is higher than the meter's display resolution (not the case in most measurement systems). The fact that you can get True RMS measurements with this accuracy at that price is incredible. Additionally, as long at the Power Factor is not too low, the Real Power and Power Factor measurements are also quite accurate.

Interesting side notes (thanks to John Schneider for these): You can't use a standard "Electrical Receptacle Tester" to test a socket with an isolation transformer: there are no current paths for the ground/neutral checks. Adding a GFCI in series with an isolation transformer (either the input or the output) will not increase the protection: the isolation transformer will prevent the ground fault currents that the GFCI needs to trip.

Summary: For $18.45 (the cost of the meter and the MOV) I was able to make an easily accessible, easy-to-use, fully metered, isolated line supply for use when I'm working on equipment. This was a neat project that only took a couple of days (part time) to build … most of it in the metal work and painting. Most of the parts came from the junk drawer. Since I've completed this project I've also been using to help detect and minimize parasitic power from various devices in the house. I really like this project.

Finished panel/transformer on the table (left), and in the "tower of power" rack (right)

Be sure to visit and use our repeater:

KK8GC
146.860 MHz
-600Hz offset (input on 146.260)
100 Hz PL tone

And be sure to join us for our Sunday Night Social Net, at 9:00pm on the KK8GC repeater.

Also, please join us for breakfast, every Saturday morning at 9:00 am at Big Boys, on Ford Road at Harrison in Garden City. Everyone is welcome.

MI ARRL Section Hamfest, Meeting and Event Calendar

Sep 7, 2024	Branch County ARC Trunk Swap, Coldwater, MI
Sep 14, 2024	GMARC Trunk Swap, Shelby Twp, MI
Sep 15, 2024	Adrian Swap & Shop, Adrian, MI
Oct 5, 2024	Kalamazoo Hamfest, Kalamazoo, MI
Oct 6, 2024	USECA Hamfest, St Clair Shores, MI
Oct 8-13, 2024	USA ARRL Radio Orienteering Nat'l / IARU Reg. 2 Championship, Chelsea, MI
Oct 12, 2024	Muskegon Color Tour Hamfest, Muskegon,MI
Dec 1, 2024	L'Anse Creuse Hamfest, Troy, MI