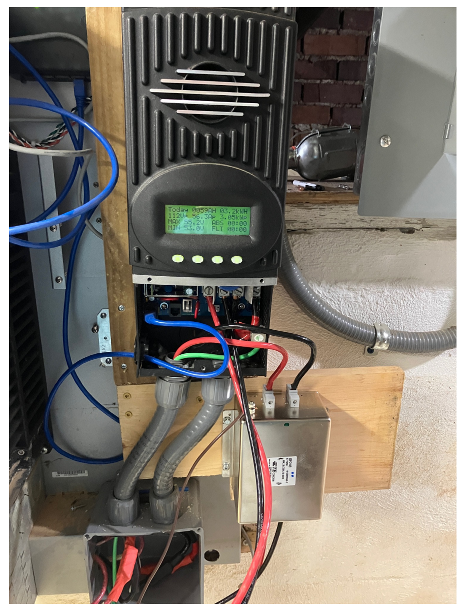
Filtering Solar Panel MPPT Charger with Industrial Filter: Initial Data on Amateur Radio Noise Improvement

by Gordon Gibby

Switching power supplies generate large amounts of harmonic signals, due to the Fourier Transform of abrupt level changes. The fast switching reduces heat dissipation and increases efficiency, but increases harmonic generation. The MPPT (maximum power point target) chargers currently favored for maximum efficiency in solar panel power systems not only use switching power supplies, but they vary the switching parameters often, tracking the maximum power transfer point as the solar radiation on the panels changes minute by minute. They are a significant part of the high frequency 3-30 MHz (HF) undesired radiations produced by solar power systems.

In this test, an industrial 50-amp single stage common- and differential-mode AC line filter was utilized to attempt filtering of the RF signals emanating from an Outback FM-80 MPPT controller through the heavy-gauge wiring to the solar panels. (https://www.mouser.com/ProductDetail/TE-Connectivity-PB/50FC10B?qs=3sBZtWOgbifJ3hS9Momjeg%3D%3D) The filter is the silver box in the lower right of the photograph. I was able to get AWG #6 stranded wires to insert into the screw-tightened connection points. In a permanent installation, the filter would need to be inside a protective box. As the switching system makes abrupt transitions, RF energy is transferred back to the input wiring from the solar panels. The lengthy wiring from the basement to the rooftop then appears as an "end-fed antenna" for the interference, with the mass of the solar panel equipment/inverter/batteries and ground connection as the counterpoise for this undesired antenna.



My physical situation in our Black Mountain NC family home is worse because the solar panels are only yards from the feed-end of an end-fed 135-foot amateur radio back yard antenna. There aren't many other options with the available space and roof.

The monitoring amateur radio station used for measurements utilized an HF Signals sBitx Version 2 transceiver, which presents signal levels in a "waterfall" with a graticule that approximates 10dB per vertical division, based on an examination of the underlying software. While absolute measurements aren't given, relative measurements to possible improvements are easily measured.

Background noise levels (between obvious true signals) were measured by observing the waterfall graph between local time 11AM and 12:15 PM during very sunny conditions on Dec 31 2024., for three conditions:

(1) solar panels disconnected from system;
(2) MPPT controller activated with solar panel input; and
(3) MPPT controller activated with industrial filter on input from solar panels.

The intermediate frequency amplifier gain was maintained constant at 100% for all bands; upper side band was utilized, with a bandpass of 2.8 kHz, and frequencies near the bottom of the 80, 40 and 20 meter amateur USA bands were studied. MPPT interference signals were easily recognized by their digital music type sound and the loudest signals were attempted to be measured.

Arbitrarily assigning "0" to the bottom visible graticule on the waterfall and positive dB numbers to the lines above, the following data were collected:

Approx Frequency	Background Noise without solar	Noise from MPPT controller with solar	Noise from MPPT controller with filtered solar	Improvement due to Filter (dB)
3.5 MHz	40-50 dB	90-110 dB	90-110 dB	minimal
7 MHz	20-30 dB	80-90 dB	60-70 dB	~ 20 dB
14 MHz	10-20 dB	30-40 dB	10-20 dB	~ 20 dB

Confirmation of typical receiving situation: The baseline noise measurements, when translated to generally match the published rural HF noise levels by the ITU-R, visually appeared to match the rate of decreased noise expected on the higher bands, suggesting the measurement system is sufficiently accurate.

DISCUSSION

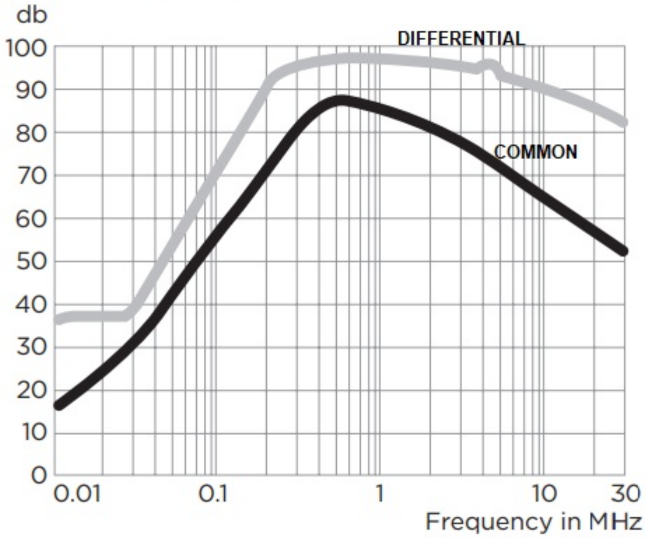
Little improvement was noted on the 3.5 MHz frequency, while a very significant 20dB improvement was noted on both 7MHz and 14 MHz bands. For the 14MHz band, which is popular during the daytime for long distance contacts, the effect was to virtually **eliminate all interference from the solar panel system**. On the 7 MHz band the improvement was not as dramatic. If one "S" unit is considered to be 6dB, the noise peaks on the 7 MHz band were reduced to approximately 6.5 S-units above the background noise, so strong signals would still be received even if they coincided with one of the harmonics of the MPPT noise. The MPPT harmonics can move around their frequencies as solar conditions change, e.g., as clouds go by.

The improved rejection of higher frequency undesired noise by the filter may be explained by higher reactance of its internal common mode choke, interacting with a potentially lower-valued end-fed impedance of the panel wiring, at higher frequencies. At lower frequencies, the noise filter inductor may have only modest reactance, while the input impedance of the end-fed wiring may be quite high, and therefore little reduction is obtained by the inductor. The ground connection provided to the bypass capacitors on each line in the filter may have undesired RF length due to wiring length of the AC ground in the house. An improvement might be to add a nearby ground rod and ground the filter to it.

Although frequencies above 14 MHz were not tested during this experiment, the generally improving performance with higher frequencies suggests the filter will be a substantial help for daytime communications on favored long distance bands. Happily, the prime usage time of the 3.5 and 7 MHz bands is nighttime, when the poor performance of the filter doesn't matter -- because the MPPT controller goes to sleep with no solar input. Thus the system can substantially improve the usefulness of an amateur radio station with a nearby solar panel system.

Published noise rejection of the industrial filter in a 50-ohm test environment:

50FC10B



db
100
90
80
70
60
50
40
30
20
10
0
DIFFERENTIAL
COMMON
0.01
0.1
1
10
30
Frequency in MHz