CMFB-VGMM (The Monster)

The Evolution of the MGD Common Mode Filter

Presented

by

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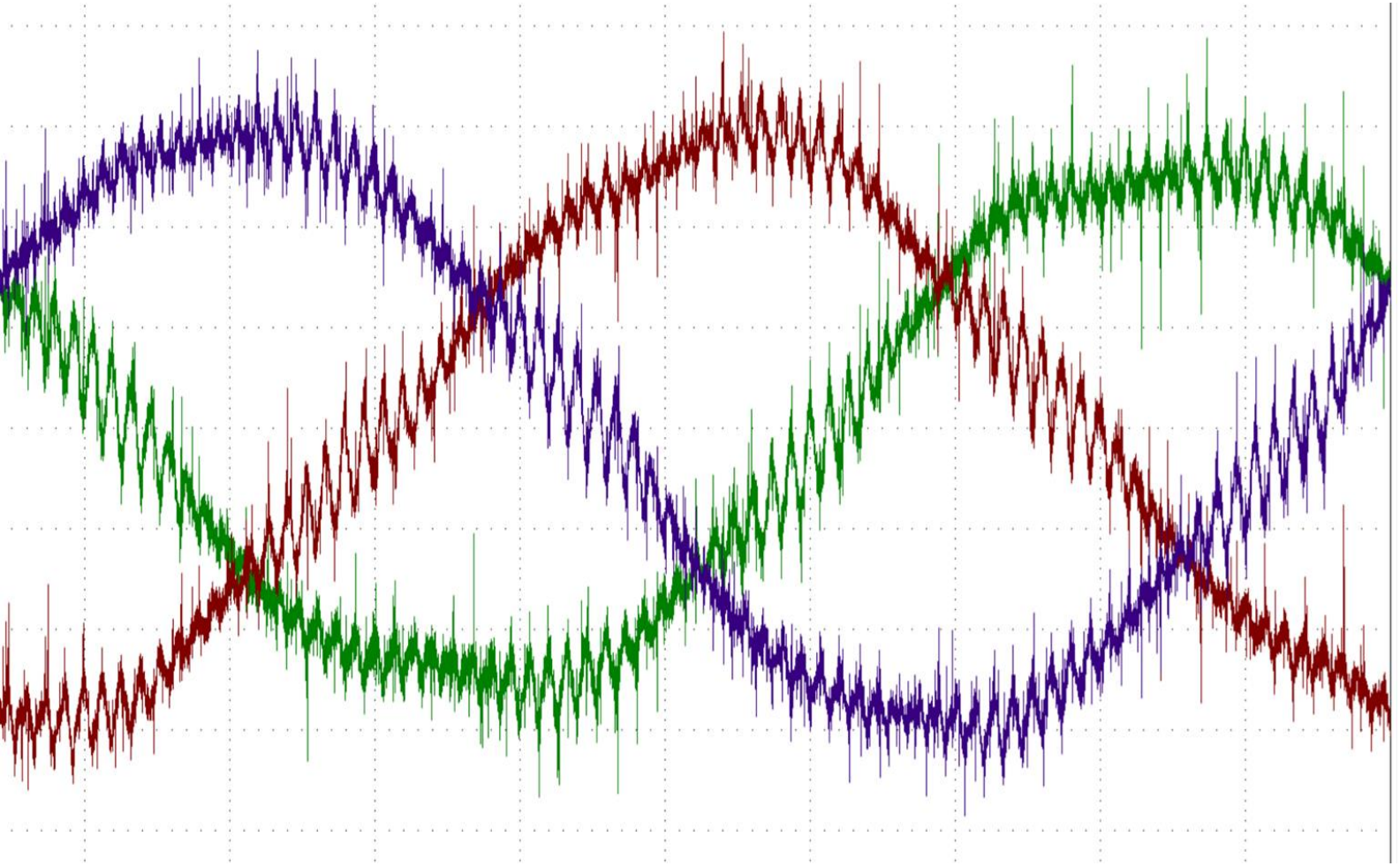
What the CMF isn’t and is

- The MGD Common Mode Filter is not a replacement for a properly designed and fully functional Sine Wave Filter.
  - The CMF is designed to mitigate the damaging effects of common mode noise that is a side-effect of the switching action of multi-phase, switch-mode power supplies.
  - The SWF is designed to recapture the intended sine wave from a train of pulses with varying duty cycles. This is usually referred to as Filtered Pulse Width Modulation.
    - Observation discovers variable degrees of success in this recapturing of the intended sine wave and a ripple with a period consistent with the PWM carrier frequency is usually observed riding the intended waveforms.
      - The resulting ripple is differential mode noise.

The Purpose of the CMF



- The CMF is intended to mitigate the damaging effect of common mode noise.
  - Common mode noise is of sufficient frequency and magnitude to cause the breakdown of insulation in the downhole circuit.
  - Essentially, the CMF is intended to keep this from happening.
    - Here we see an ESP system in its end stages just prior to the occurrence of a ground.
    - This is characterized by an excess of partial discharge and partial discharge-like events.

Why does CMF reduce the Ripple?

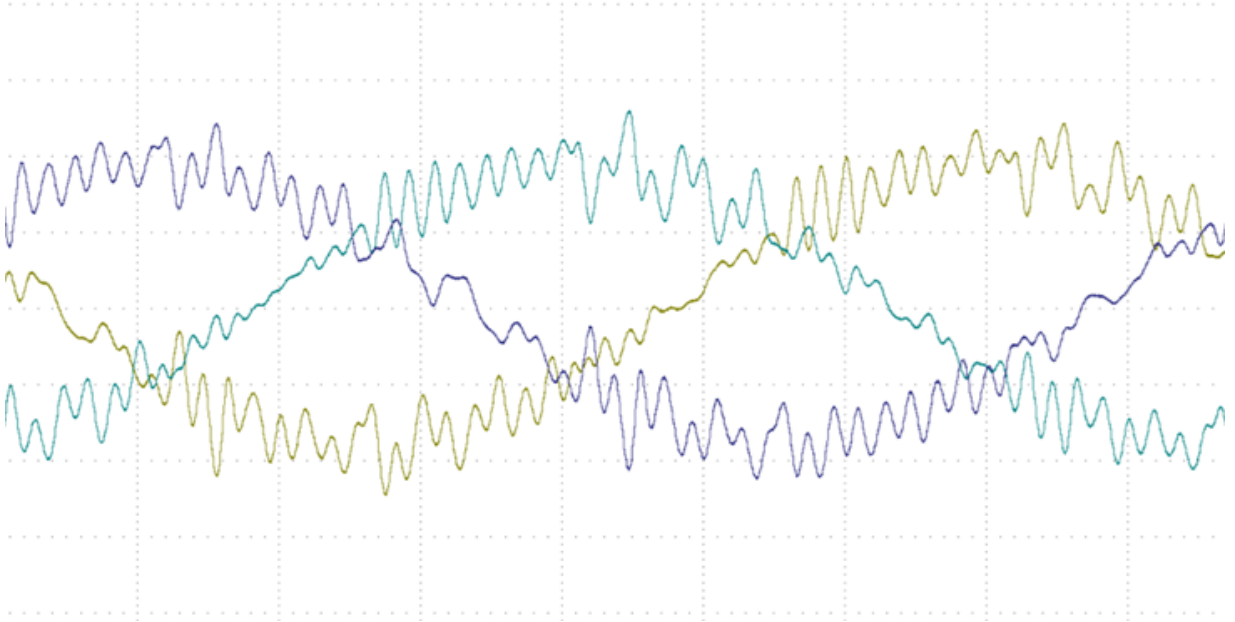
- The CMF is a Y-Connected, resistive-capacitive circuit . This allows it to pass high-frequency imbalances (common mode noise) to ground at the surface.
- The CMF still presents a small amount of phase-to-phase capacitance and resistance to high-frequency, differential mode noise such as the ripple.
  - This is the primary factor in the heat rise of the CMF resistors and CMF fuse opening events.
  - This also allows the CMF to function as an early warning system of SWF component degradation/failure.

Frequencies Present in an ESP System

- Each frequency, of sufficient magnitude, present in a voltage waveform affects the reactive elements in the ESP circuit differently.
  - Lower frequencies, such as the operating frequency, prefer loads that are inductive and resistive in nature such as the ESP motor.
  - Higher frequencies, such as the PWM ripple, prefer loads that are capacitive and resistive in nature such as the penetrator, cable run, and mle.
  - The highest frequencies, such as common mode, can exploit the previously listed and other, unintended capacitive paths in the circuit such as motor bearings.

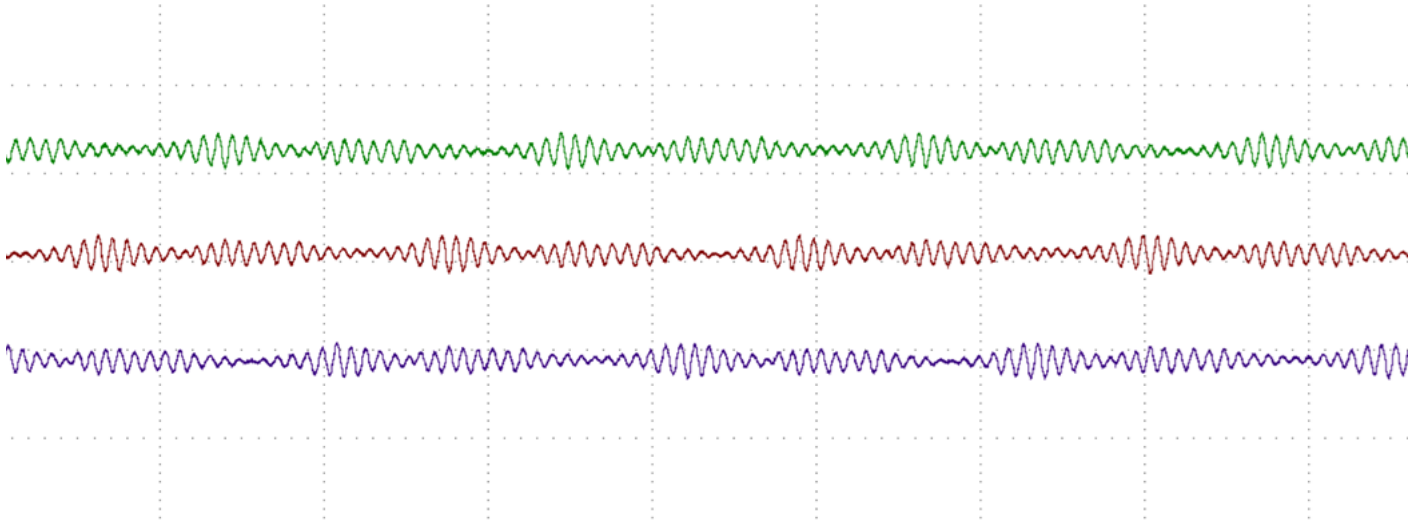
The Ripple

- The ripple in an ESP system is the remaining differential mode noise.
  - It is a side-effect of the action of PWM drives.
  - Multiple harmonics of the PWM carrier frequency may be present.

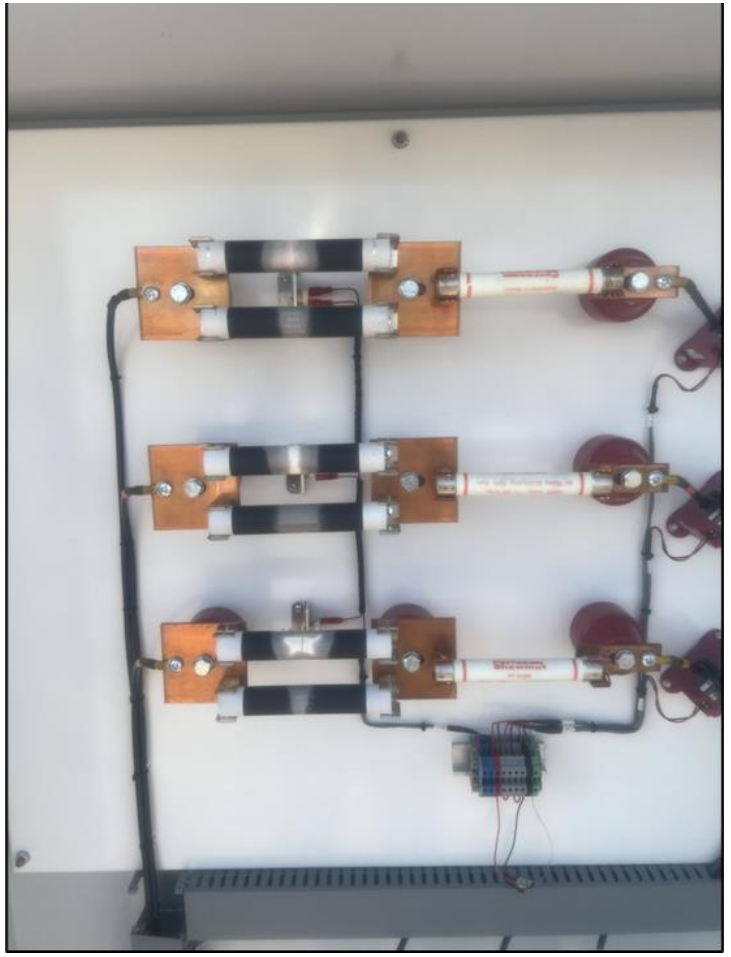


Ripple through the CMF

- The ripple is the primary source of resistor heating and fuse opening in the CMF.
- In this instance, the ripple through the CMF is over 3 Arms per phase, continuous.



The Challenge

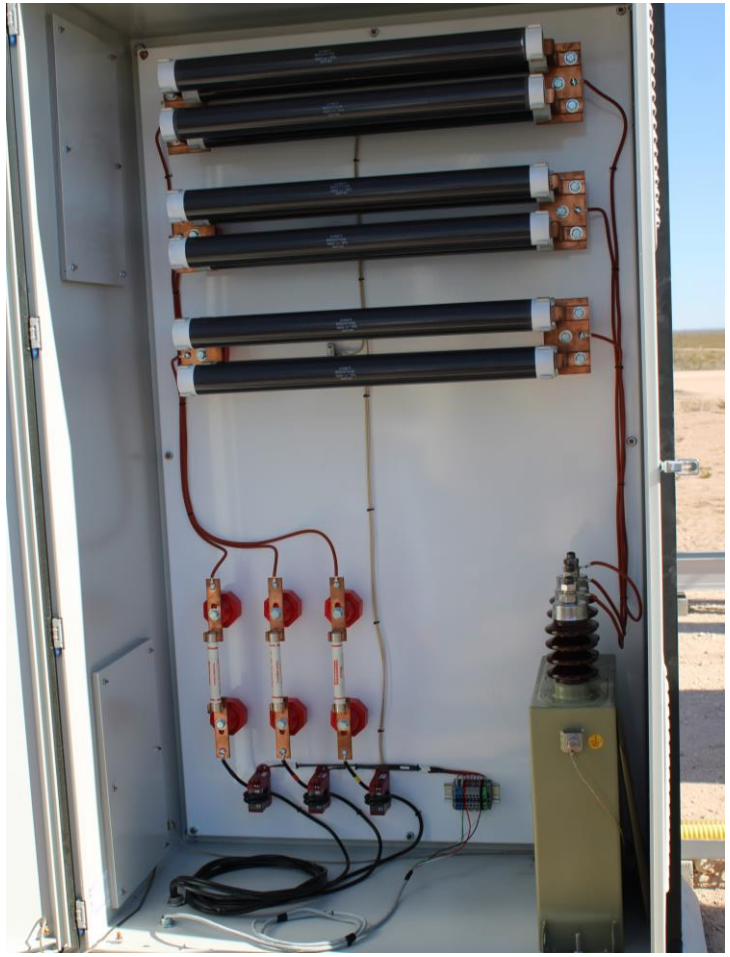


- The CMF operates in an application that presents a wide range of high-frequency differential mode noise magnitude and frequency.
  - This has resulted in CMF failures and fuse opening events.
  - This challenge has become more pronounced lately with higher magnitudes and higher frequencies of noise observed.

The Solution

- The challenge demands a new model of CMF that can sustain the effects of excessive differential mode noise while still accomplishing the CMF design goal of mitigating the effects of common mode noise.
- The CMFB-VGMM has been dubbed ‘The Monster’ and has been designed to sustain up to 5 Amps rms of high frequency per phase, continuously.
    - The VGMM is still a CMF in every respect, it is just designed to withstand punishment that would cause any other model CMF to prematurely fail.

How is the CMFB-VGMM Different?



- Larger enclosure
- Standard 5E fuses
- Dramatically increased resistor heat dissipation
  - The most obvious difference lies in the twelve resistors that are each 2’ long.
- Higher temperature rated components
- End-user selectable option for use of exterior vents with easily cleaned filters.

How do I Onboard the CMFB-VGMM

- The VGMM is easy to onboard for anyone already familiar with the MGD CMF.
  - The connections are identical.
  - The fuses will still open in the event of SWF component degradation/failure.
  - The temperature switches will still open in the event of overheating.
    - If field conditions allow, the plates isolating the vents may be removed.
  - As with all CMFs, it is recommended that the resistors should be removed during transport such as in reinstallation.
    - The resistors are ceramic and not designed to be transported in place.
  - It is recommended that MGD personnel attend initial onboarding of the CMFB-VGMM to provide a field overview and answer any questions.

When do I use a CMFB-VGMM?

- MGD recommends using the CMFB-VGMM for your more challenging CMF applications.
  - Drives operating in 6-Step (Square Wave) mode.
  - Drives producing an excess of high-frequency differential mode noise (ripple).
- The CMFB-VGMM may also be used as a catch-all for applications that may change such as reinstallation or when the drive style/size to be installed is not yet known.

CMF Application Guidelines

- CMFB-VGR2-2T: (2/Phase) 80 Ω Resistors, 2E Fuses, Temperature Switches
  - FPWM: 500 KVA and Less
- CMFB-VGC-T-3: (2/Phase) 80 Ω Resistors, 3E Fuses, Temperature Switches
  - FPWM: 501 - 750 KVA
  - FPWM operating PMM
- CMFB-VGC-T-5: (2/Phase) 80 Ω Resistors, 5E Fuses, Temperature Switches – Model Phasing Out
  - 6 Step ASD (Baker ESP Mode)
- CMFB-VGMM-T-5 (4/Phase) 160 Ω Resistors, 5E Fuses, Temperature Switches
  - 6 Step ASD (Baker ESP Mode)
  - SLB (Toshiba)
  - All Else

Questions?

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