

between 5 and 10 kHz, all is well. Running 3 – 6 dB “hot” is a time-honored technique in EMI testing, to sensitize the measurement a bit and make sure no subtle susceptibilities near the limit are missed. If a susceptibility is encountered between 5 and 10 kHz, then the actual limit at the failed frequency must be determined and that actual level injected, instead of relying on the 56 dB $\mu$ V reading. For example, a susceptibility is encountered at 8 kHz. The limit at 8 kHz is 4 dB down from the 136 dB $\mu$ V flat plateau at and below 5 kHz. That means our target reading on the spectrum analyzer/EMI receiver is 136 dB $\mu$ V – 4 dB – 80 dB = 52 dB $\mu$ V, instead of our “hot” setting of 56 dB $\mu$ V. Thus if the TOS (threshold of susceptibility) is between 52 and 56 dB $\mu$ V as measured using the PRD-240, the test sample actually meets the requirement.

<sup>ii</sup> Using a 3 Hz 6 dB BW allows injection within 5 Hz of the power frequency, which meets the 10% window for 50/60 Hz power. A 3 Hz BW is available on many modern EMI receivers, but is not a requirement in MIL-STD-461.



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## PEARSON ELECTRONICS POWERLINE RIPPLE DETECTOR MODEL PRD-240 OPERATING MANUAL



**Description.** The Pearson PRD-240 facilitates the measurement of power line AC ripple using a frequency selective voltmeter, i.e., EMI receiver or spectrum analyzer. In so doing, it greatly simplifies both the manual and automated measurement of injected ripple in such standards as MIL-STD-461 CS01/CS101, RTCA/DO-160 section 18 and MIL-HDBK-704-2 through -6.

**Features.** The PRD-240 is designed for use on AC or DC buses of 100 VAC or DC to 240 VAC and 270 VDC. For measurements on buses of lower potential, such as 28 VDC, the PRD-120 model should be used.

The PRD-240 provides the test engineer with the following built-in functions:

- Signal conditioning so that both power bus potential and ripple can be monitored on a sensitive frequency selective voltmeter

- Isolation between power bus and frequency selective voltmeter safety/chassis ground

- Capability to monitor ripple across both test sample and power source

- For MIL-STD-461 CS101, a switch selectable function which generates a constant output across the entire CS101 frequency range, even above 5 kHz where the limit changes with frequency

**Principle of Operation.** The PRD-240 is a passive signal conditioner, providing DC blocking, selectable AC attenuation, and transformer isolation to allow connection of a sensitive frequency selective voltmeter across the power bus in lieu of the traditional oscilloscope. See Figures 2a and b. Note that in Figure 2b, the spectrum analyzer/EMI receiver is not powered through an isolation transformer, because the required isolation is built into the PRD-240. The spectrum analyzer/EMI receiver operates with safety ground intact, while maintaining the isolation of the test sample power return above ground. Another difference between the Figure 2a and b drawings is that the PRD-240 connects across the test sample, as required in Figure 2a, and also across the power source. This added feature

domain viewing of injected ripple isn't necessary for DC-powered test samples, the device works just as well on a DC as an AC bus, and by providing isolation removes the need for an isolation transformer on the monitoring device. While the PRD-240 isn't necessary to monitor audio ripple injected on a DC bus, the fact that it can be used simplifies testing in that the set-up, software, and bookkeeping is identical between AC and DC-powered test samples.

**Fuse.** PRD-240 is protected by a 30 mA (40Ω) fuse, Bussman BK/S500-32-R. Correct calibration and frequency response requires the use of this specific fuse. A spare fuse is shipped with the PRD-240.

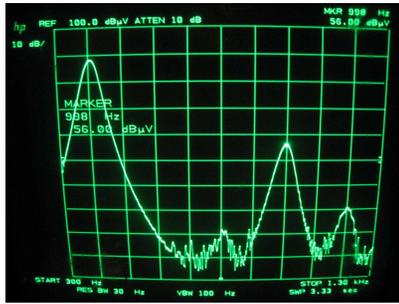
**Temperature.** In use, it is normal for the temperature of the PRD-240 to rise to about 125°F (52°C). Do not block the ventilation holes on the left side and bottom of the case.

**Warranty and return policy.** The PRD-240 is warranted to be free from defects in materials and workmanship for a period of one year after the date of purchase. Pearson Electronics will repair or replace a defective product. The product may be returned for full credit, or exchanged for up to 30 days, provided it has not been damaged by the customer. A restocking fee will apply.

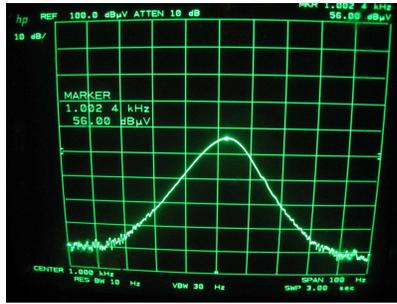
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<sup>i</sup> This technique works well except near the 5 kHz breakpoint frequency, because the CS101 limit is a Bode plot approximation to the actual response of a parallel RC network. A simple work-around is to use the flat frequency response switch position out to 10 kHz, and maintain 56 dBμV, and then at 10 kHz switch over to the "CS101" position, and continue to maintain 56 dBμV. This results in accurate testing up to 5 kHz using the flat setting, and accurate testing from 10 kHz up using the CS101 setting. From 5 to 10 kHz this technique results in testing a little "hot" - from 0 dB at 5 kHz to 6 dB at 10 kHz (before flipping the switch). If no susceptibility is encountered

available for audio frequency conducted susceptibility testing via use of the PRD-240.



**Figure 5a:** 1 kHz ripple in span to 1300 Hz

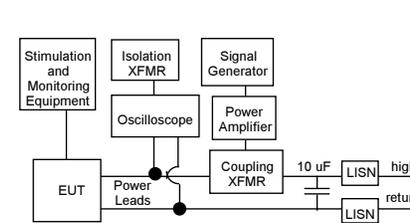


**Figure 5b:** 1 kHz ripple at center of 100 Hz span

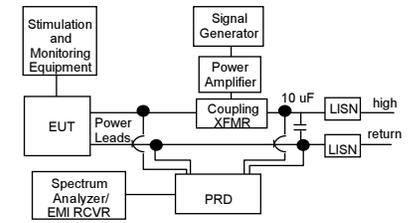
The only place this doesn't work well is very close to the power frequency. Prior to 1993, MIL-STD-462 CS01 had an exclusion zone within 10% of the power frequency. Using the MIL-STD-461E/F 6 dB bandwidth of 10 Hz, the closest "approach" to the power frequency at a level 25 dB below the bus potential is 15 Hz away. For 400 Hz or wild-frequency power, that is well within the 10% window cited above.<sup>ii</sup> Also, any span that includes the power frequency won't be able to use the marker-to-peak function to level on the test signal, because marker-to-peak will seek out the power frequency. If it is possible to have the injected signal at the span center frequency, a "marker-to-center-frequency" command could be used, and if that isn't available at very low frequencies, a zero-span command could tune the receiver to the test signal frequency, and exclude all else. This however relies on extremely accurate and stable tuning so that the peak of the test signal is captured.

**PRD-240 works on both AC and DC buses.** It should be noted that while the PRD-240's function allowing frequency

provides greater test control. By inspection, ripple injected by the coupling transformer must drop either across the test sample (desired), or across the power source (undesired). The 10  $\mu$ F capacitor is an attempt to force injected ripple to drop across the test sample, but it is ineffective below about 10 kHz. If the required ripple potential cannot be established across the test sample when driving the required power, a flip of the EUT-Power source switch allows the test engineer to measure the ripple potential across the power source. If the power source ripple level is such that added to the test sample ripple results in the required ripple level, then steps may be taken to reduce the power source impedance, allowing enough of the injected ripple to fall across the test sample to meet the requirement.



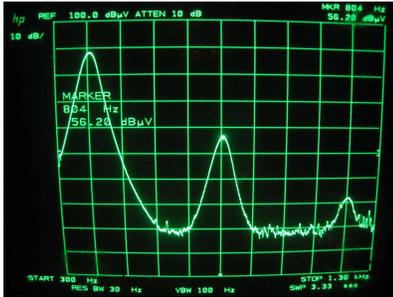
**Figure 2a:** Traditional audio frequency injection test set-up



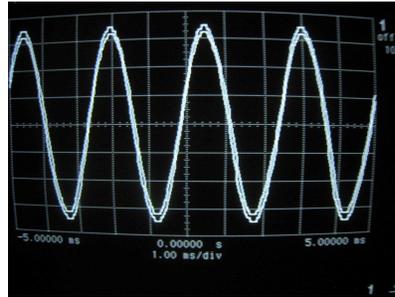
**Figure 2b:** Audio frequency ripple injection using PRD

Figures 3a and b demonstrate that with the PRD-240, ripple is visible on the frequency selective voltmeter display as an entirely separate signal, rather than low-level superimposed ripple riding on the AC bus potential waveform. The PRD-240 has a nominal -80 dB transfer function, meaning that 80 dB must be added to the signal levels shown in Figure 3a to properly interpret them. Each PRD-240 is individually calibrated and the actual transducer factor supplied with an

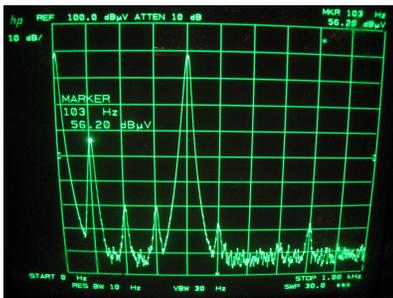
individual serial number unit must be applied. The PRD-240 makes available not only frequency domain selection and discrimination, but also the higher dynamic range (~80 dB) of the typical frequency selective voltmeter with logarithmic amplitude display. This is in contrast to about 40 dB of usable



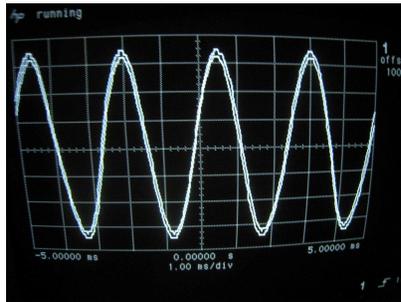
**Figure 3a:** View of 6.3 Vrms 800 Hz ripple on a 400 Hz 240Vrms bus, using the PRD-240



**Figure 3b:** View of the same ripple on the same bus, using an oscilloscope



**Figure 4a:** View of 6.3 Vrms 100 Hz ripple on a 400 Hz 240 Vrms bus, using the PRD-240



**Figure 4b:** Envelope of the same 100 Hz ripple on the same bus, using an oscilloscope

on-screen dynamic range with an oscilloscope. Figures 4a and b illustrate that it is just as easy to inject ripple below the power bus fundamental frequency as above. This is immediately useful for MIL-HDBK-704-2 through -6 testing, and restores to MIL-STD-461 a capability that was lost in 1993. The PRD-240 transducer factor can be either frequency independent, or, at the flip of the right-hand switch visible in Figure 1, the attenuation above 5 kHz rolls off at 20 dB/decade, to match the slope of the MIL-STD-461D/E/F CS101 limit. With this switch position selection, the output of the PRD-240 into the spectrum analyzer/EMI receiver is independent of frequency across the entire CS101 test frequency range, at a nominal 56 dBμV, or 0.6 mV if testing to MIL-STD-461F Figure CS101-1, Curve 1. This allows for very easy testing, even in manual mode, with a cursor or threshold set at the 56 dBμV target.<sup>i</sup>

#### Automation of Audio Frequency Conducted Susceptibility Testing.

Figure 5a shows 6.3 Vrms ripple at 1 kHz using a sweep from 300 Hz to 1.3 kHz. The power frequency and second and third harmonics are visible in addition to the injected ripple. If the span is modified to be centered on the ripple frequency, and just wide enough to display the injected waveform, as in Figure 5b, then the same test automation routine that is used with MIL-STD-461 requirement CS114, or RTCA/DO-160 section 20 conducted rf susceptibility, may be applied when automating audio frequency ripple injection. The routine commands both signal source and spectrum analyzer/EMI receiver to the desired frequency, with a specified and fixed span for the analyzer/receiver. With only the injected frequency visible, the analyzer/receiver “marker-to-peak” function is invoked, and then the leveling feedback loop adjusts until the marker is at the desired level. This is how existing automation for RF conducted susceptibility testing is made