Detection Systems that Register Electromagnetic Disturbances

The process of registering electromagnetic wave phenomena, which have both a large dynamic range along with broad frequency coverage, is accomplished with specialized, but typically quite costly and bulky, laboratory equipment.

With a practical sensing solution, designers should be able to accommodate tight budget constraints of site operators.[3] This is why designers must endeavor to maintain the total hardware costs to a minimum that will be well within the targeted performance profile.

Component Hardware for a Detection System

Analog signal processing

- *Antenna:* A compact loop antenna design with the ground plane seated flush with the aluminum walls of the detector casing. Basic requirements include:
  - Capability for a broadband signal acquisition over the relevant frequency range (ranging from a few hundred MHz to 10 GHz)
  - Using a flat frequency response over a high gain.
  - Having no voltage breakthrough, even at field strengths in the kilovolt ranges
  - A compact antenna design having mobility as a design goal.
  - Having sensitivity to all wave polarizations such as vertical, horizontal, or circular regardless of either left or right handedness.
- *Attenuation:* After the antenna acquires the signal, it will need to be attenuated to avoid damage when entering the low-level RF electronics. Three components are included in each of the eight initial signal paths—two attenuators that are sandwiching a limiter. Their properties will determine the measuring range of the overall system.
- *Demodulation:* This follows the attenuation of the signal. Subsequently, the signal processing moves into a separate module that's shielded—the inner printed circuit board (PCB). Since there's the possibility of any disruption attempts, which may span orders of magnitudes in field strength, a logarithmic detector is now employed to demodulate the signals that have a high dynamic range. Next, output reactivity will enable sampling of signal envelopes on a time scale of a few ns for even more digital data processing.
- *Frequency detection:* Two loop antennas will be mounted atop a detection device to acquire signals of all polarizations to determine the carrier frequency of any narrowband signals. Then their superimposed signals are input into a limiter and further attenuation is performed. Next, a limiting amplifier will normalize the signal amplitude to the frequency-detection circuitry. After that, a frequency divider will compress the system input frequency range to fit the specification of two 8-bit frequency counters. The counters are alternately gated with a bit of overlap that will prevent acquisition downtime.

Digital data processing

- *FPGA for raw data processing:* To be able to sample the raw data stream from the four signal channels plus the frequency information, an FPGA will have the outputs of four analog-to-digital converters (ADCs) as well as those from the frequency counters. Subsequently, a custom core will arrange for the raw data to be preprocessed and then sent into a FIFO downlink.
- *A single-board computer for additional processing:* All of the further processing will take place in a Raspberry Pi compute module that's also used to load a core into the FPGA at system startup. Then it will host the backend process handling system control and perform corrections to the amplitude values.

General casing and power supply

All of the hardware components in the sections above will reside within the RF-proof outer cubical aluminum housing of the detector, which is 19 cm in edge length and mounted on a tripod base. The cube base has a mark for locating the internal magnetic power switch, a few status LEDs, and the optical-fiber connections for network access.

Another connector for an external custom power supply may be used to charge the internal $LiFePO_4$ battery pack, which occupies almost half of the space within the cubical outer housing.

Summary

EMPs have been known to be a serious national security threat since the 1960s. On March 26, 2019, President Donald Trump issued an Executive Order to enable the United States to prevent and even respond to any EMP attack or "geomagnetic disturbance" (GMD).

References

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2. "The Emerging Threat of Tactical Electromagnetic Interference & Its Spread into Non-Defense Sectors," Paul Currie, January 29, 2020.
3. "A forensic detection system for intentional electromagnetic interference (IEMI) attempts," Thorsten Pusch, Christian Adami, Sven Ruge, Michael Suhrke, IEEE 2023 International Symposium on Electromagnetic Compatibility—EMC Europe, IEEE 2023.