RSMS-4 Design and Development — RF and Measurement Hardware

Outputs

- RF and Measurement System Requirements document that defines the design parameters.
- Conception, selection, and acquisition of instrumentation for a measurement system.
- Design of an ITS-built 0.5-26.5 GHz preselector.
- Design of an ITS-built 0.1-1000 MHz preselector.

The RF and Measurements project was a part of the ITS program to upgrade the Radio Spectrum Measurement System (RSMS) to a fourth generation system. The primary goals included identifying and acquiring the instrumentation and accessories needed to create a modern state-of-the-art measurement capability. The need to measure the wider range of RF technologies present today, that is expected to expand even more in the future, demanded a system design that has more versatility, adaptability, and measurement capability. Future measurement needs were compared with current instrument capability to identify what could be achieved with Commercial-off-the-Shelf (COTS) equipment and what would require ITS-designed and -built devices. The result is a new generation RF and Measurement system.

The design effort started with the Functional Measurement Requirements document, which describes the functions that the RSMS-4 shall perform. This set of requirements was global to the entire program. To provide this project with more specific guidance, an RF and Measurement System Requirements document was created. This document applied quantitative specifications to the functional requirements, providing a practical set of measurement parameters for the RSMS-4.

A major task involved the system design and the selection and acquisition of instrumentation for the RSMS-4. The designer had to define a collection of instruments that would satisfy the system requirements shown in Figure 1. Signals enter the measurement system and depending on the frequencies of interest, the High or Low frequency preselection stage is enabled. After preselection, the signal enters the measuring instruments. The Spectrum Analyzer is used primarily to make frequency-domain and time-domain-envelope measurements. The chosen unit is faster, more accurate and has a modern detection capability (root mean square or RMS) that is critical to future spectrum management challenges. Measurement bandwidths up to 8 MHz are available and an IF output provides a downconverted signal with a 30-50 MHz bandwidth. The vector signal analyzer is used to analyze magnitude and phase properties of the signal. It is also capable of analyzing the modulation format and modulation parameters. This "vector" look at signals is a powerful new enhancement that allows for a more thorough characterization of unknown signals. The digital oscilloscope can capture signals directly (in the time domain) for frequencies up to 1 GHz and indirectly beyond 1 GHz using the IF output of the Spectrum Analyzer. Since the RF spectrum is, for the most

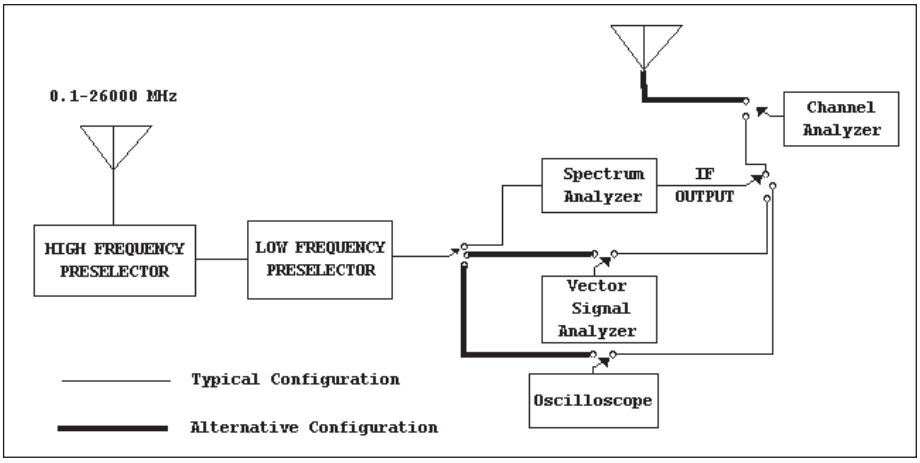

Figure 1. High-level block diagram of an RSMS-4 measurement system.

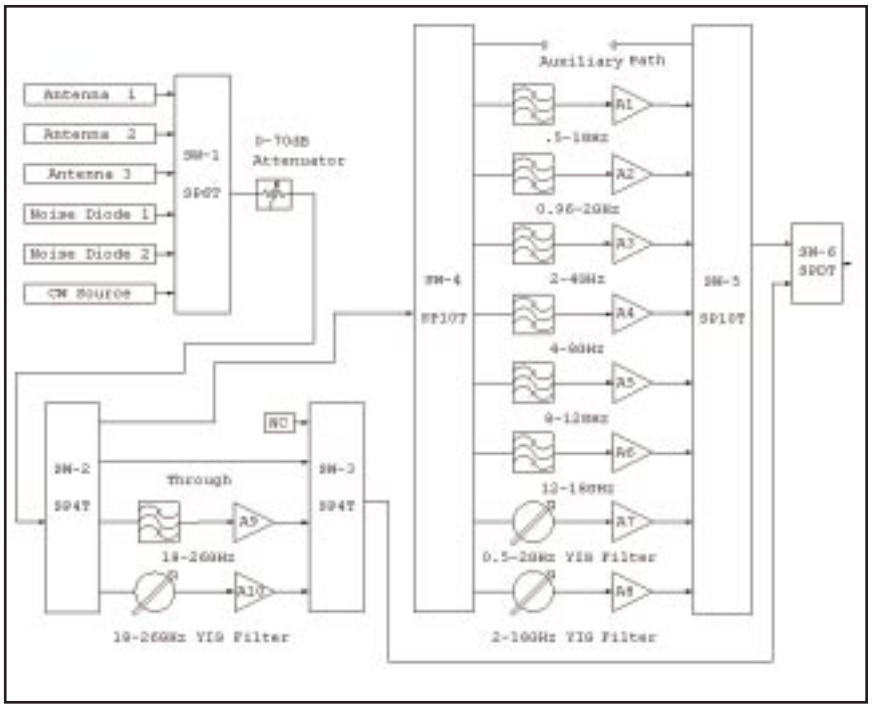

Figure 2. Block diagram of the ITS designed 0.5-26 GHz preselector.

part, divided up into individual channels which are assigned to individual users, the channel analyzer is used to examine the transmissions within these channels. This analyzer is extremely quick at categorizing various parameters of a signal within a channel as well as processing many channels per second to provide accurate statistics. This collection of instruments was chosen to meet the measurement needs of today and the future.

Preselection is the processes of selecting the signal (or a portion of the signal) for measurement, from an environment of multiple signals, and can be used to enhance the measurement system's sensitivity and dynamic range. The block diagram of the 0.5-26.5 GHz Preselector (High Frequency Preselector) is shown in Figure 2. On-board noise diodes and a port for a CW signal are available to calibrate the measurement paths. A stepped attenuator is used to prevent front-end overload and increase the measurement range of the system. Bandpass filtering with amplification is used to optimize sensitivity, selectivity and the dynamic range of the measurement system. A noise figure as low as 3.5 dB was achieved with noise figures under 10 dB available for all frequencies under 18 GHz, providing for a very sensitive measurement system. To handle signals with large amplitude excursions, the dynamic range was kept above 94 dB, rising to 108 dB for some frequencies.

A 0.1-1000 MHz Preselector (Low Frequency Preselector) was designed with similar goals as the 0.5-26.5 GHz Preselector except that it contains some additional functionality. The lower frequency filtering and amplification stages provide noise figures under 10 dB reaching as low as 3.6 dB. In addition to RF preselection, this unit provides some intelligence to the system through the use of a single board computer (SBC) which can accept commands from a controlling computer to set its own and the other preselector's configuration. The SBC is responsible for keeping the tunable filters tracking the measuring instrument while automatically compensating for changing temperature effects and tracking hysteresis to improve the quality and accuracy of future measurements.

Overall, the RF and Measurement team has created a new generation measurement system that will improve the quality of measurements, increase the speed at which information can be gathered, and add new measurement capability, while providing growth potential to meet the future needs of spectrum management.

Recent Publications:

"RF and Measurement System Requirements," http://www.its.bldrdoc.gov/home/programs/rsms-4/rf_meas_sys_req_v4.pdf

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