PCBs AT MICROWAVE FREQUENCIES: DESIGN GUIDELINES

LAMINATE PRINTED-CIRCUIT BOARDS (PCBs) are a commonly used substrate for designing low-cost subsystems that can operate to 40 GHz. With their ability to support high-performance surface-mount technology packages (SMTs) containing RF integrated circuits (ICs) while supporting a wide range of interface connections, PCBs are ideal for many RF/microwave applications. However, significant considerations must be applied to every step of the design to ensure proper operation. Such considerations have grown due to the reduction in size of RF ICs, which has led to a reduction in parasitic capacitance and a subsequent increase in attainable frequencies of operation. In a seven-page application note titled "Technology Overview Designing Laminate PCBs at Microwave Frequencies," Plextek details some of these critical design considerations.

If appropriate measures are not taken, for example, grounding inductances can induce a series inductive feedback around an RF SMT IC. Two possible approaches to help reduce grounding inductances are the use of an array of tightly spaced vias within the groundplane of the SMT IC and selecting a suitably thin substrate height to reduce the individual via inductances. Knowing the level of tolerable grounding inductance and how to estimate the grounding inductance are necessary metrics to design with cost efficiency and timeliness.

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The exact material and sizes of the PCB substrate also are critical for effective RF PCB design. Modern RF PCB substrates are well suited to mass manufacture and generally have dielectric constants around 3.5. To ensure appropriate operation of on-PCB transmission lines or microstrip waveguides, the maximum substrate thickness should be less than one-tenth of the highest wavelength of operation.

The thickness of the copper metallization, known as weights of copper cladding, must be known to design according to the required direct-current carrying capability as well as the maximum skin depth. The exact dimensions of the pads and metallization of attached discrete components and printed components correlate directly to the parasitic elements within the circuitry. They must therefore be accounted for accordingly. Based on the frequencies of operation, connections made with external devices (which usually incorporate on-board coaxial connections) and adequate grounding and mechanic attachment strength also should be taken into consideration.

SURVEY PROVIDES IN-DEPTH OVERVIEW OF SPECTRUM ANALYZERS

MODERN SPECTRUM ANALYZERS have capabilities far beyond the frequency-selective and peak-responding voltmeters that are calibrated to display RMS values of their sine waves of origin. A swept-tuned spectrum analyzer uses a superheterodyne receiver to down-convert the spectrum of the input signal to the center frequency of a band-pass filter using a mixer and voltage-controlled oscillator. The 120-page application note by Agilent, "Application Note 150: Spectrum Analysis Basics," offers a rigorous walk-through of the capabilities and understanding behind the operation of swept-tuned superheterodyne spectrum analyzers. Analyzing electrical signal spectra can give the designer valuable information on the spectral components of a signal not easily detectable in time-domain waveforms.

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A spectrum is a properly combined collection of sine waves that produce a desired time-domain signal. The value of monitoring a spectrum lies in the ability to measure the energy throughout a frequency domain. For example, this knowledge is necessary in determining if signal energy is spilling into other frequency bands for cellular communications and to determine what interference with other electronics can be expected during device operation.

Spectrum analyzers are made from hundreds of high-precision and high-performing parts, which are carefully matched and tuned to maintain optimum performance. These complex parts all play a role in measuring the various aspects of the signal response of a device under test. To meet modern demands, spectrum analyzers have included many of the capabilities traditionally held by vector signal analysis and Fourier signal analyzers—for example, the all-digital intermediate-frequency operation, which Agilent claims to have implemented with many operational benefits. Some of these benefits include a combination of Fast Fourier Transform analysis for narrow spans and swept analysis for wide spans for a more optimal approach. Other modern spectrum analyzers also sport application-specific measurement functions such as vector signal analysis and adjacent channel power.

Overall, the note strives to provide an in-depth summary of the building blocks of spectrum-analyzer operation, covering amplitude/frequency accuracy, sensitivity/noise, dynamic range, and frequency range. Included is a special dedication to the note's original author Blake Peterson, who received the *Microwaves & RF* "Living Legend" award in June 2013.