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Surface-Mount Amps Span 0.1 To 40.0 GHz

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cover story

Surface-Mount Amps Span 0.1 To 40.0 GHz

These tiny amplifiers measure 0.52 × 0.44 × 0.14 in. but provide high gain and wideband performance to 40 GHz without the limitations of chip and wire and connectors.

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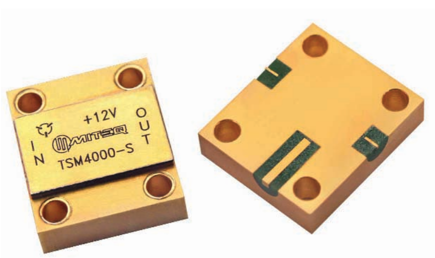
Broadband amplifiers serve an endless list of applications, from amplitude adjustment in commercial and military systems to signal driving signals in test equipment. Adding an amplifier to an application usually requires a trade-off between size and effort: The simplicity of using a connectorized amplifier is offset by its large package size, while the small size of a chip-and-wire amplifier is balanced by the labor involved with this approach. Fortunately, MITEQ (Hauppauge, NY) offers a better solution: the TSM series of true surface-mountable amplifiers that cover frequency bands from 0.1 to 40.0 GHz and are actually usable to 45 GHz. In fact, if proper surface-mounting practices are followed, the gain flatness of these broadband amplifiers is superior to the performance of much larger cascaded connectorized amplifiers.

The TSM Series surface-mount-technology (SMT) amplifiers **(Fig. 1)** numbers five different standard models **(see table)** with bandwidths adding up to coverage from 0.1 to 40 GHz. Model TSM1800, for example, operates from 100 MHz to 18 GHz with 22 dB gain and ±2.5 dB gain flatness. In spite of the wide bandwidth, it maintains a low noise figure of 3 dB and delivers +10 dBm output power at the 1-dB compression point. It exhibits input/output VSWRs of 2.50:1 and draws 175 mA current from a +15-VDC supply.

Model TSM1840 provides 22 dB gain from 18 to 40 GHz with gain flatness of ±3 dB. It achieves a noise figure of 4.5 dB with output power of +5 dBm at 1-dB compression. It draws 200 mA current from a +15-VDC supply. Additional models cover 0.1 to 26 GHz (model TSM2600), 18 to 26 GHz (model TSM1826), and 26 to 40 GHz (model TSM2640).



1. The TSM Series surface-mountable amplifiers provide broadband coverage over bands from 0.1 to 40 GHz in a package measuring just 0.52 × 0.44 × 0.14 in.

Optimum performance from these amplifiers requires proper care and handling, given their small size (0.52 × 0.44 × 0.14 in.). In a typical microstrip surface-mount installation **(Fig. 2, top)**, the microstrip is imbedded in a ground slot equal to the substrate thickness, thus making the ground connection and center strip coplanar. (This configuration should not be confused with normal coplanar waveguide that has no ground under the strip and uses a smaller gap on each side of the center conductor to maintain a 50-ohm impedance.) The ground-slot width is usually chosen to prevent dielectric surface waves at the highest operating frequency from bypassing energy on the microstrip center conductor, thus preventing a feedback path from the SMT amplifier output to the input with resulting gain ripples.

As an example of a typical application for mounting the amplifiers, 10-mil-thick Rogers (www.rogerscorp.com) 5880B printed-circuit-board (PCB) material was selected for its low loss. The material has a dielectric constant of 3.5; a strip width of 20 mils was used for the TSM amplifiers. The graph in **Fig. 2** shows theoretical data for two coaxial line diameter ratios in glass (100/20, 40/8) mils embedded in a 150-mil width channel, with the smaller-diameter line clearly yielding better results. In both cases, the coaxial center conductor should have minimum protrusion over the microstrip. The plot beneath that graph shows the nearly proportional phase constant and frequency relation of the microstrip line.

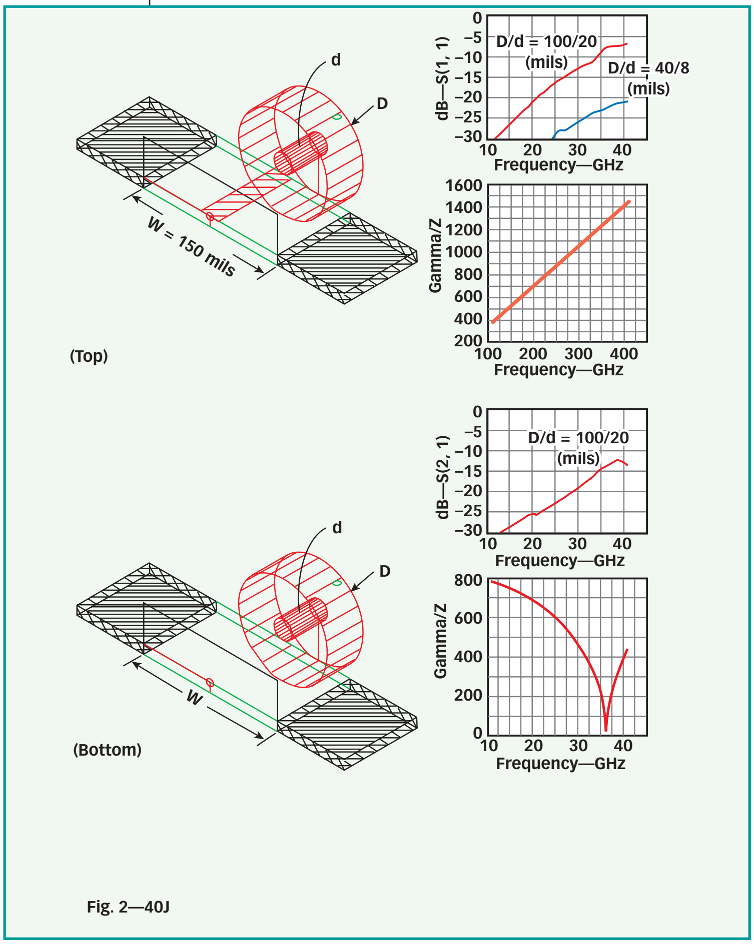
Fig. 2 shows the contribution of the dielectric surface mode to phase velocity in the absence of the microstrip conductor. It is the same microstrip-to-coaxial transition, except without a center strip. In this case, the transverse-magnetic (TM) mode begins to propagate above the cutoff frequency (36 GHz), yielding a highpass filter characteristic. The 150-mil slot width is too large for mode-free operation at 40 GHz. Consequently, a ground wall spacing of 62 mils was used to stop TM surface-wave modes above 55 GHz. The special split glass bead of the TSM Series amplifiers is designed to span a 62-mil groove width for operation to 50 GHz.

Most substrates are not embedded in the baseplate, but instead provide top ground connection points by means of "ground islands" made with closely spaced viaholes. These islands are also used to define mode-suppression side walls similar to an ideal groove. Caution is necessary when grounding the TSM amplifiers with viaholes to ensure that ground island series inductance above ground does not develop a voltage proportional to the amplifier output ground current. The ground island inductance through the viaholes can be quantified by observing the reflection and transmission of a surface rectangular land (300 × 200 mil) that is large enough to secure the surface-mountable TSM package. An ideal "ground island" would have a reflection coefficient of –1 (a short circuit) at its edge and infinite insertion loss when connected between 50-ohm test lines.

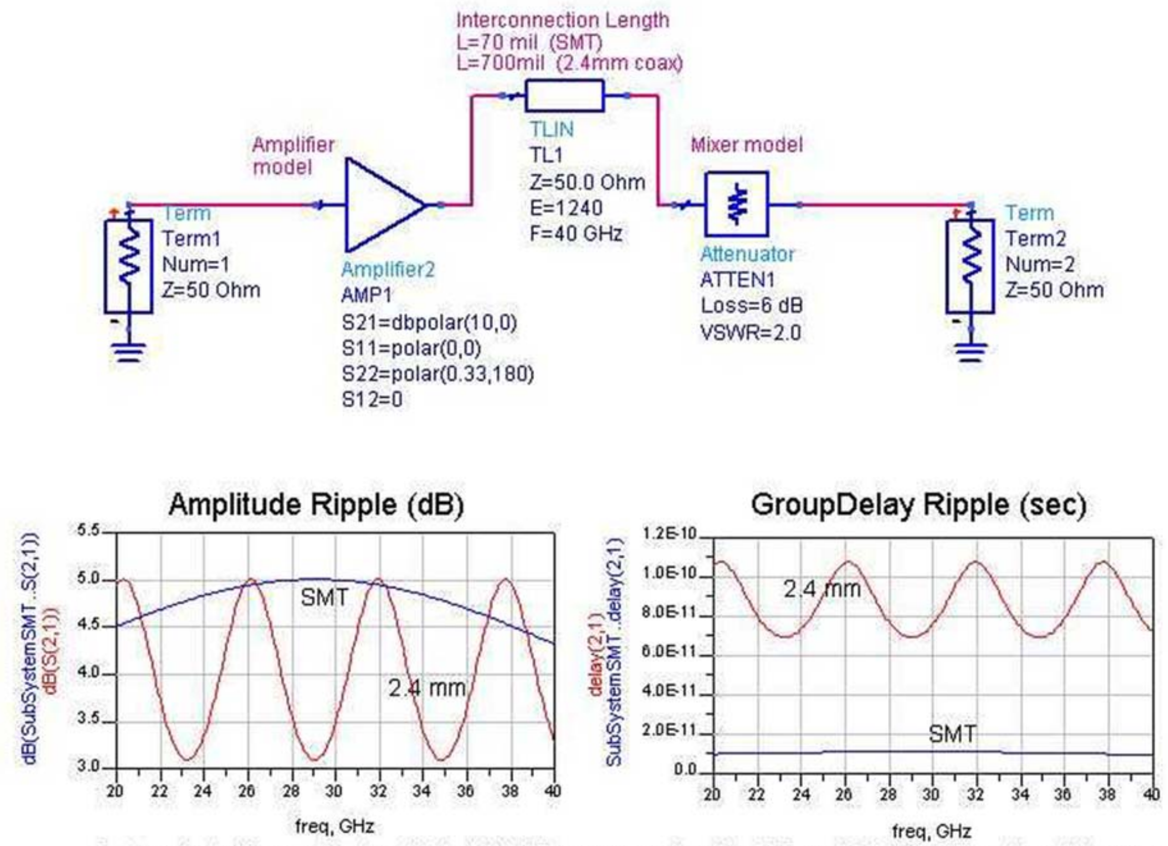
In tests performed to 40 GHz, it was found that a few viaholes spaced a quarter wavelength apart will yield

The TSM amplifiers at a glance

MODEL	FREQUENCY RANGE	GAIN	NOISE FIGURE	OUTPUT POWER
TSM1800	0.1 to 18 GHz	22 dB	3 dB	+10
TSM2600	0.1 to 26 GHz	22 dB	4 dB	+8
TSM1826	18 to 26 GHz	24 dB	3.8 dB	+8
TSM1840	18 to 40 GHz	22 dB	4.5 dB	+5
TSM2640	26 to 40 GHz	24 dB	4.0 dB	+5



2. A standard microstrip-to-coaxial transition (top) was analyzed for a 1-mil-thick glass substrate with dielectric constant of 3.8 and coaxial diameter ratios (D/d) of 100/20 and 40/8. The transition was also analyzed without the strip (bottom) for the effects of dielectric surface-wave leakage (HFSS software).



3 Amplitude/Phase Ripple of 2.0:1 VSWR components with 700 and 70 mil connection distances

bandpass filter like characteristics. A safe design rule would be to use less than one eighth-wavelength spacing between viaholes at the highest operating frequency, including the distance from the pad edge to the first row of viaholes.

One advantage to cascading amplifier chips is their small physical size, making it possible to minimize the spacing (and electrical phase lengths) between amplifiers. This results in the least gain ripples due to interstage VSWR addition and subtraction. Conversely, cascading components with connectors that suffer from poor VSWR performance can yield many amplitude and group delay ripples over wide bandwidths because of the larger physical distance between components. Of course, components with connectors can more easily be rearranged during the design stage compared to chip/wire construction. **Figure 3** shows amplitude/phase ripple of two components each with 2.0:1 VSWR, when connected by long and short transmission lines that simulate connectors or surface mount construction (Agilent ADS software).

The company also offers a three-connector version of the TSM surface-mount package. The firm is investigating the TSM amplifiers at frequencies above 40 GHz and thermal profiles for compatibility with standard SMT production machines.

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