State of the Art, Inc.

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8 January 2013

Temperature Variable Attenuators

Temperature variable attenuators (TVAs) decrease attenuation with increasing ambient temperature. TVAs passively compensate temperature sensitive components without generating any signal distortion. For example, TVAs can be used to compensate an amplifier's drop in gain as temperature increases, producing a linearly regulated signal output as a function of temperature (see Figure 1). This passive signal compensation with temperature can be used for various amplifiers (power amplifiers, low noise amplifiers, MMIC amplifiers, and gain block amplifiers), circulators, mixers, power dividers, and other temperature sensitive devices.

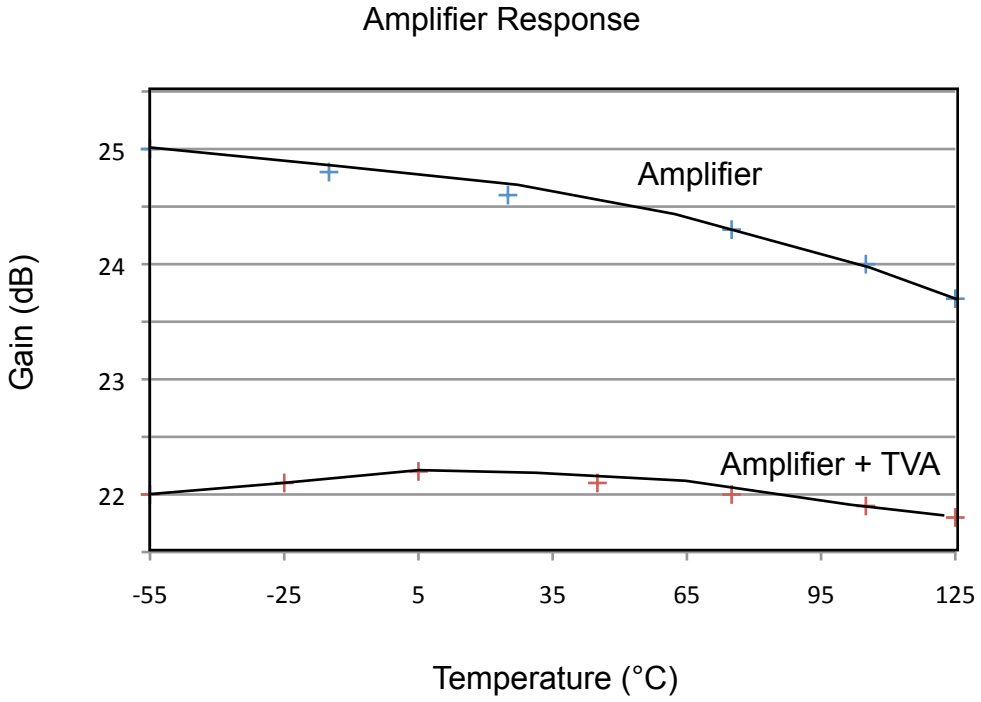

Figure 1. Amplifier gain with and without a TVA.

State of the Art, Inc. has developed temperature variable attenuators in the 1512 case (0.150" x 0.125") size suitable for use from DC to 6 GHz. These S1512AT temperature variable attenuators are available with SN60(40% Pb) over nickel barrier termination finish suitable for surface mount reflow solder attachment and wire bondable gold termination finish for chip and wire applications. These devices are equivalent mechanically and electrically to the incumbent supplier's devices.

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Mechanical

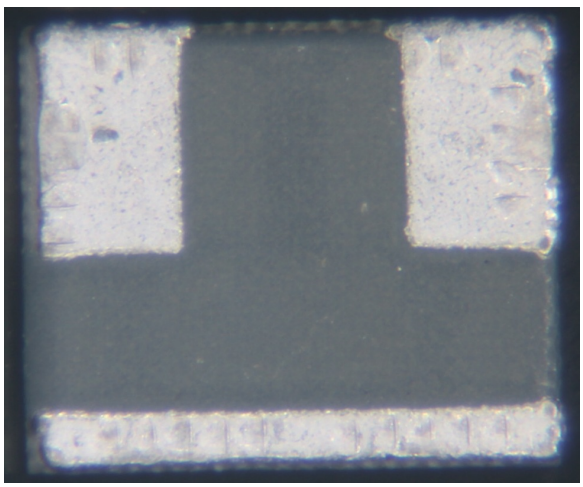
State of the Art, Inc.'s TVAs have equivalent mechanical layouts to the incumbent supplier's product as can be seen in Figure 2 and Tables 1 & 2. Tables 1 & 2 present mechanical data for the incumbent's TVA devices and State of the Art, Inc. S1512AT TVAs. The mechanical dimensions are very similar. The input and output pad length and width are both about 0.040" and 0.060". Similarly, the input/output gap are both about 0.066" for both suppliers products. There are some minor differences in the dimensions of the ground pad width but these differences will not preclude the use of either device on existing board layouts.

Table 1. Mechanical dimensions of the incumbent supplier's TVA (inches).

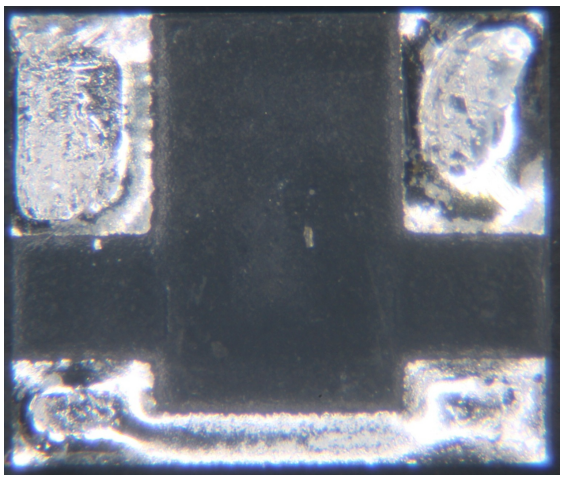
Case Length	Case Width	Case Thickness	Input Length	Input Width	I/O Gap	Output Length	Output Width	Ground Length	Ground Width	I/Ground Gap
0.147	0.125	0.037	0.038	0.062	0.069	0.042	0.062	0.144	0.029	0.033
0.146	0.124	0.026	0.038	0.062	0.068	0.040	0.062	0.144	0.028	0.033
0.146	0.124	0.026	0.038	0.062	0.068	0.040	0.059	0.144	0.029	0.034

Table 2. Mechanical dimensions of State of the Art, Inc. S1512AT… TVAs (inches).

Case Length	Case Width	Case Thickness	Input Length	Input Width	I/O Gap	Output Length	Output Width	Ground Length	Ground Width	I/Ground Gap
0.150	0.126	0.017	0.039	0.061	0.065	0.039	0.062	0.140	0.015	0.046
0.150	0.127	0.017	0.039	0.060	0.064	0.039	0.062	0.142	0.016	0.047
0.150	0.126	0.017	0.038	0.062	0.065	0.039	0.061	0.141	0.015	0.046



State of the Art, Inc. S1512AT… TVA.



Incumbent supplier TVA.

Figure 2. State of the Art, Inc.'s S1512AT… TVA and the incumbent supplier's TVA.

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Electrical Performance

The electrical performance of our TVAs is similar to the incumbent's products. Attenuation vs. temperature for SOTA's TVAs and the incumbent supplier's devices are presented in Figures 3 - 7. The resistance value of the series and shunt resistors are monitored at temperatures between -55°C and 125°C. DC attenuation was calculated and plotted. The slope the attenuation as a function of temperature curves for SOTA's TVAs and the incumbent supplier's are very similar from 25°C to 125°C, but the slope of the incumbent supplier's product increases at the colder temperatures between -55°C and 25°C. This increase in slope at temperatures <25°C can result in misleading TCA values.

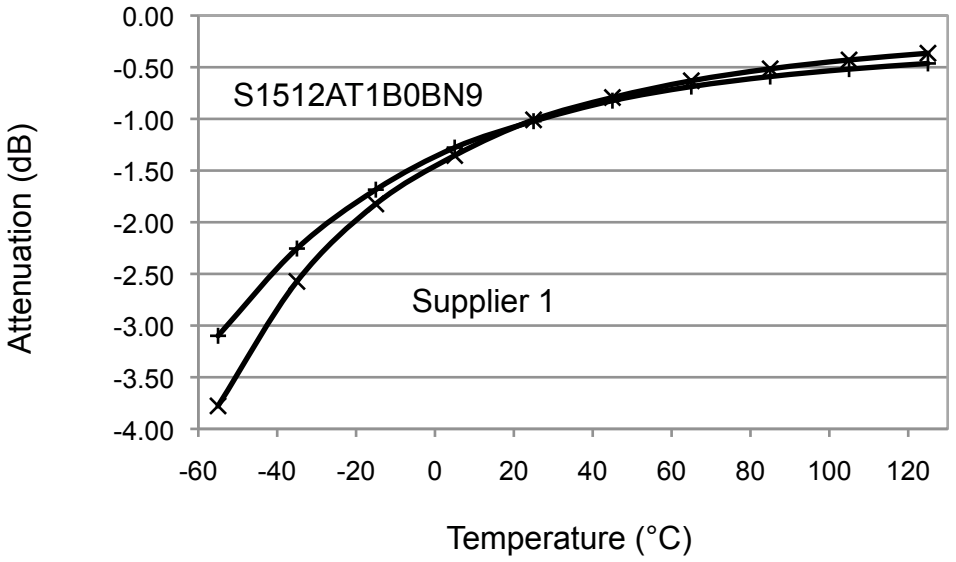

Figure 3. DC attenuation vs. temperature for SOTA and the incumbent supplier's 1 dB temperature variable attenuators with a TCA slope of -0.009 dB/dB/°C.

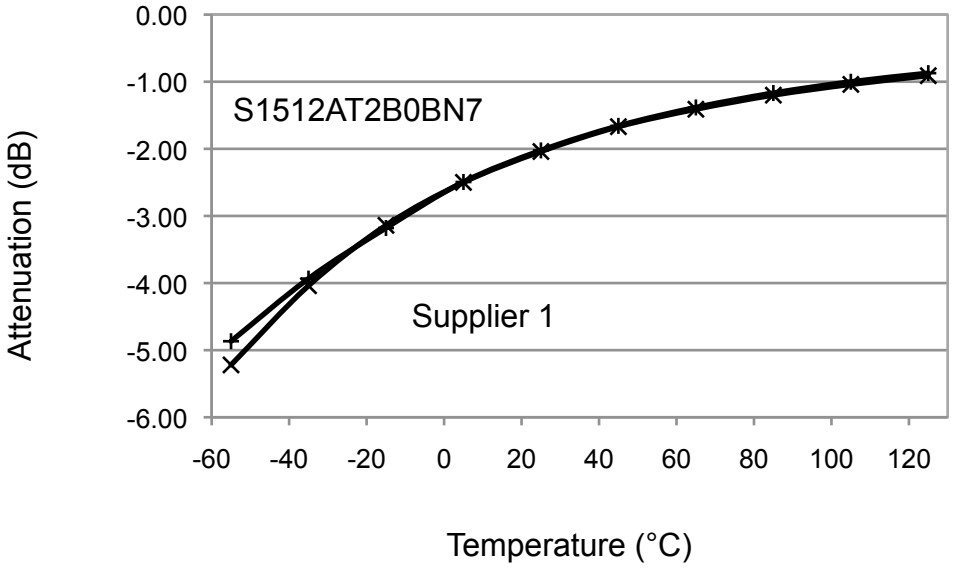

Figure 4. DC attenuation vs. temperature for SOTA and the incumbent supplier's 2 dB temperature variable attenuators with a TCA slope of -0.007 dB/dB/°C.

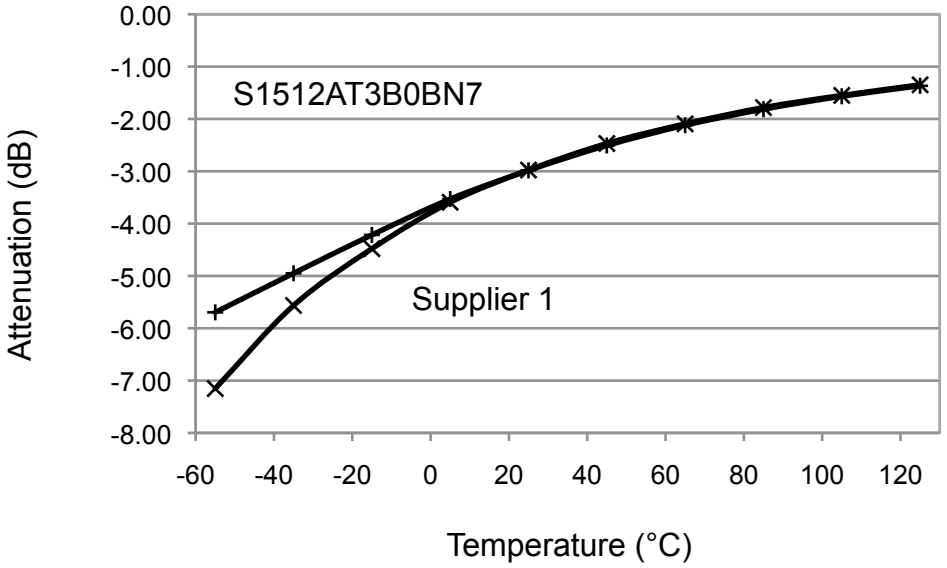

Figure 5. DC attenuation vs. temperature for SOTA and the incumbent supplier's 3 dB temperature variable attenuators with a TCA slope of -0.007 dB/dB/°C.

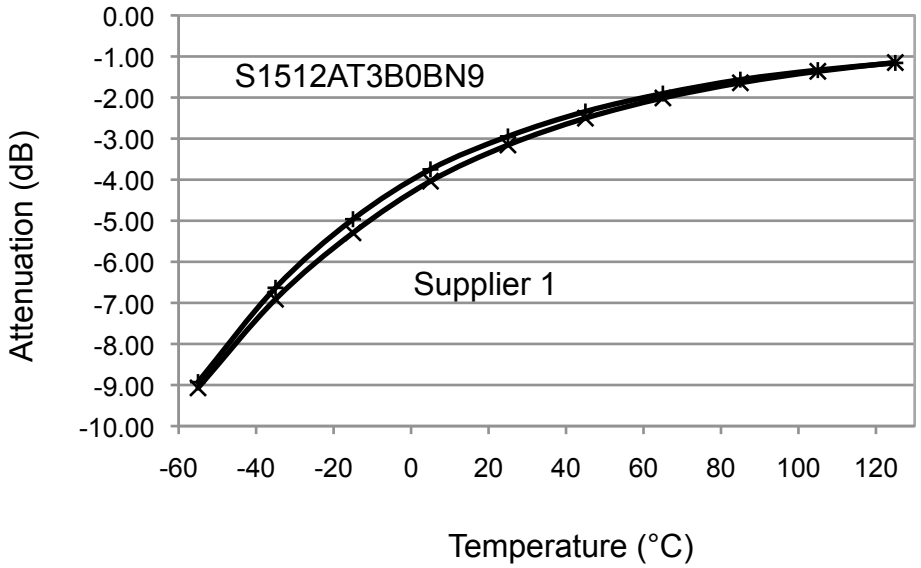

Figure 6. DC attenuation vs. temperature for SOTA and the incumbent supplier's 3 dB temperature variable attenuators with a TCA slope of -0.009 dB/dB/°C.

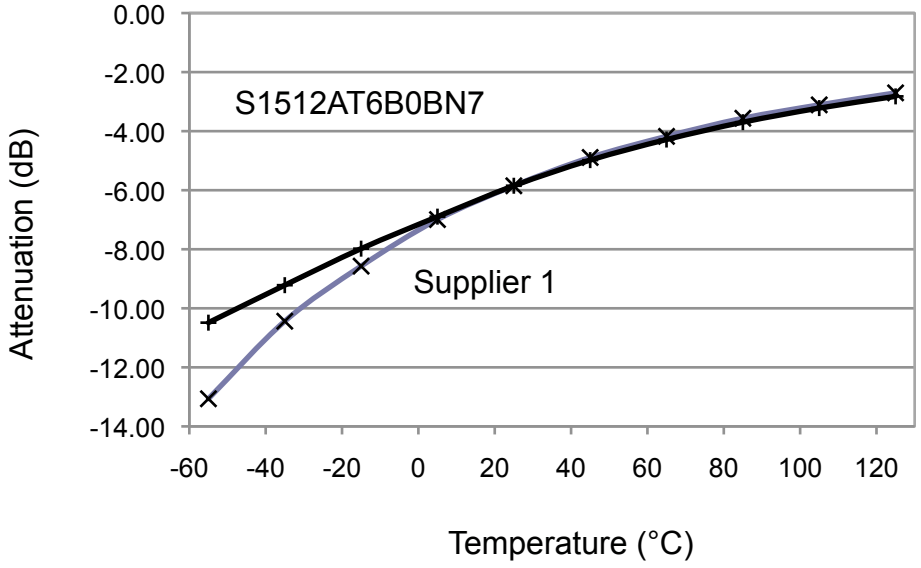

Figure 7. DC attenuation vs. temperature for SOTA and the incumbent supplier's 6 dB temperature variable attenuators with a TCA slope of -0.007 dB/dB/°C.

Attenuation at 6 GHz was measured at various temperatures using a vector network analyzer and is presented Figures 8 – 10. The attenuation at 25°C remained within +/- 0.5 dB for the SOTA TVAs, but that was not the case for the incumbent supplier.

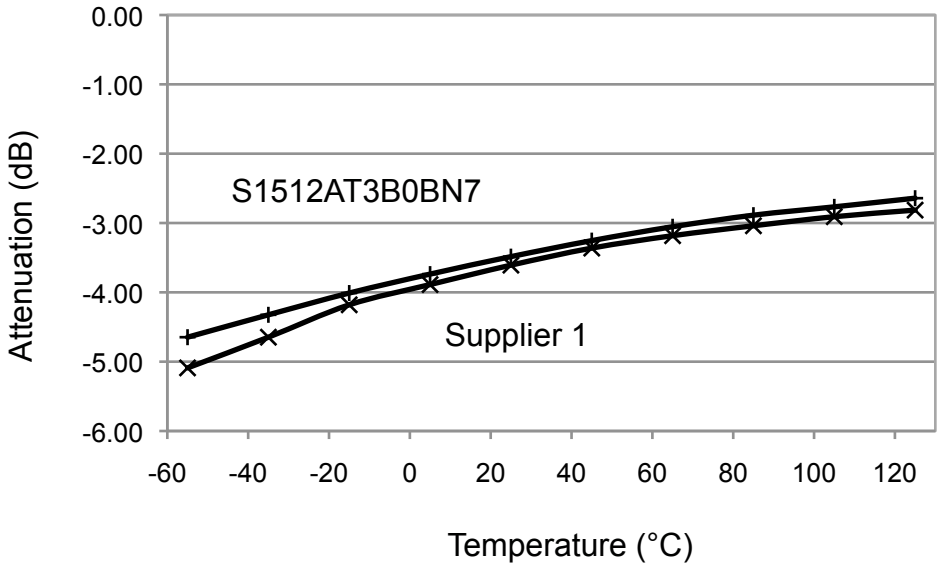

Figure 8. Attenuation vs. temperature at 6 GHz for SOTA and the incumbent supplier's 3 dB temperature variable attenuators with a TCA slope of -0.007 dB/dB/°C.

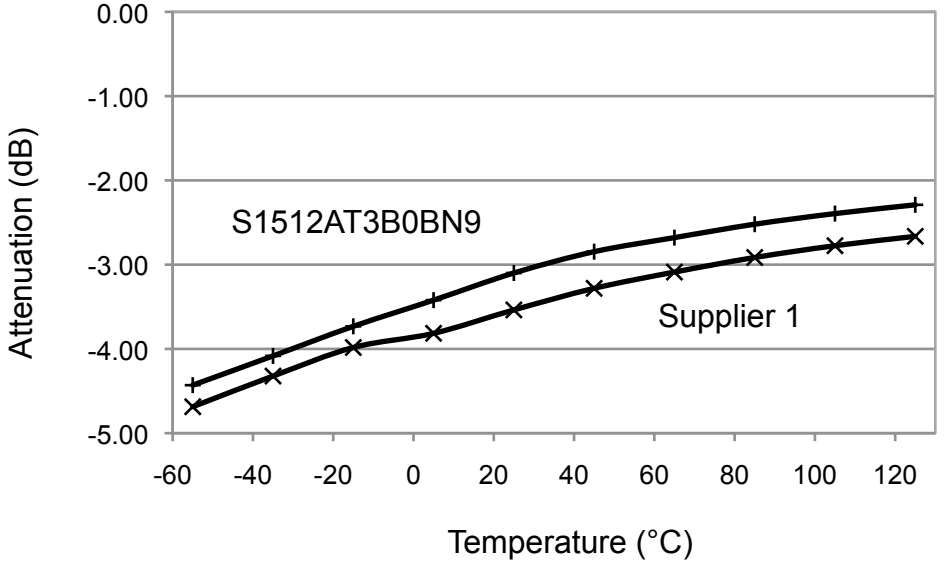

Figure 9. Attenuation at 6 GHz vs. temperature for SOTA and the incumbent supplier's 3 dB temperature variable attenuators with a TCA slope of -0.009 dB/dB/°C.

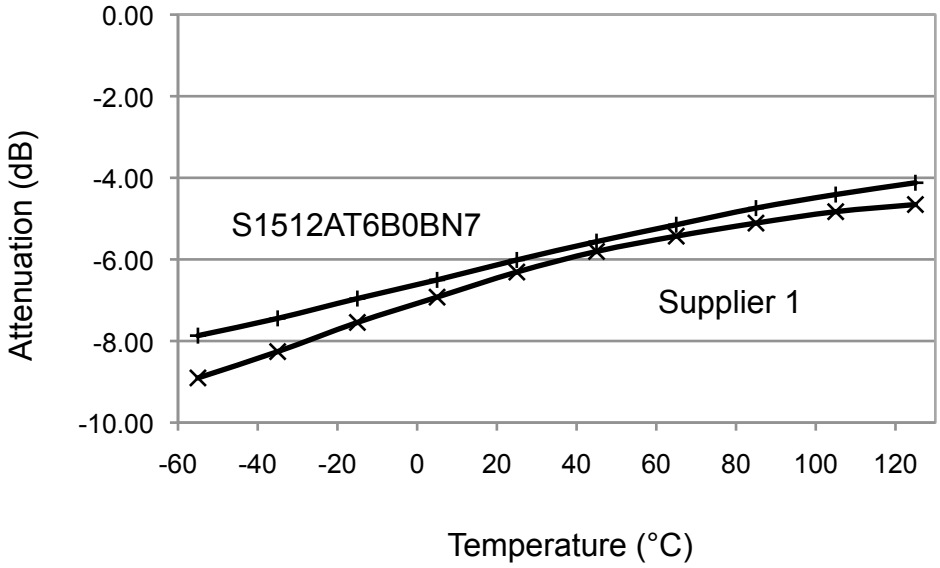

Figure 10. Attenuation at 6 GHz vs. temperature for SOTA and the incumbent supplier's 6 dB temperature variable attenuators with a TCA slope of -0.007 dB/dB/°C.

The relationship between attenuation and temperature is nonlinear yet a linear regression fit is used to determine the temperature coefficient of attenuation (TCA). This determination of TCA varies with frequency. The TCA at low frequency varies significantly from the TCA at higher frequencies. An example is shown in Figure 11. The TCA of the SOTA device is closer to N9 than the incumbent supplier's devices. TCA also drops as a function of frequency.

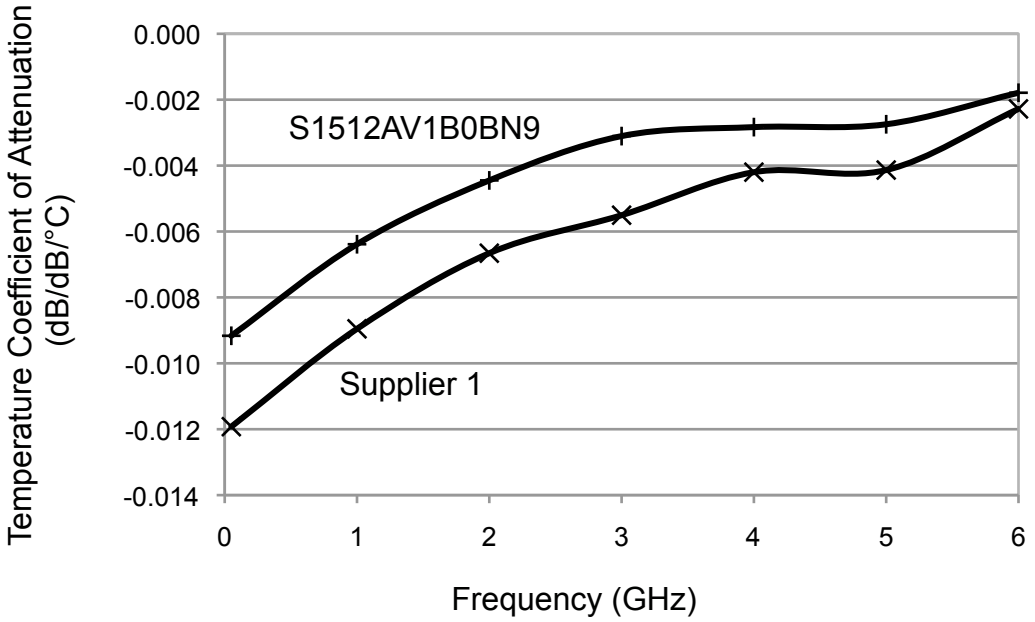

Figure 11. Temperature coefficient of attenuation vs. frequency for SOTA and the incumbent supplier's 1 dB temperature variable attenuators with a TCA slope of -0.009 dB/dB/°C.

State of the Art, Inc. has developed temperature variable attenuators (TVAs) which have equivalent mechanical and electrical performance to the incumbent suppliers products. State of the Art, Inc.'s S1512AT… devices are a suitable replacement for the incumbent supplier's products with top surface terminations.