TangiTek CleanSignal™ Technology for Circuit Boards – Test Results Part I

Testing of Resonant Planar Coiled Structures on Printed Circuit Boards (PCB)

1. Introduction

TangiTek LLC develops and licenses novel high performance composite materials. In this application, the electromagnetic qualities of TangiTek's **CleanSignal**™ composite material are evaluated for use in FR-4 printed circuit boards (PCB). The following informal tests illustrate how **CleanSignal**™ technology reduces unwanted electromagnetic interference in electronic circuits.

The test results illustrate the gains feasible when **CleanSignal**™ technology is used to enhance circuit board performance. We tested the LRC characteristics of resonant planar coiled structures on different circuit board substrates. These investigations were performed in-house and the results presented are the uncontrolled bench test results.

2. CleanSignal™ Technology

Electromagnetic signals are widely used to transmit and receive information through circuit boards, cables, and wirelessly between antennas. Every electronic device (sensor/actuator) uses electrical signals to send, receive, process, and transmit information. Electrical currents within a device and those nearby generate extraneous electromagnetic fields which can produce unwanted background interference and distortion, combined with noise generated by devices within the circuit, leading to degraded signal quality.

A common approach to reducing background interference and improving signal quality typically center on boosting the source signal which increases the power demands of the circuit. The **CleanSignal**™ technology focuses on reducing electromagnetic interference and noise by using novel and improved ground plane isolation techniques.

We anticipate that this technology can be applied to almost any type of antenna, circuit board, cable, or enclosure to reduce unwanted electromagnetic interference and noise. The technology can reduce background noise and improve signal quality in addition to being relatively low cost, light weight, strong, and easy to manufacture.

3. Test Procedure and Circuit Design

Several printed circuit boards - 1/32” FR-4, 1 oz. copper (Cu) substrate PCB - with planar coiled microstrip structures were designed and manufactured, in-house, to test the performance of the **CleanSignal**™ technology.

Two 0.020” (0.508mm) wide circuit traces spaced approximately 0.070” (1.778mm)apart, and 36.12” (917.44mm) long were constructed in an intertwined spiral pattern to test resonant LRC characteristics of different circuit board substrates (Figure 1). A picture of one such circuit board manufactured in-house is shown in Figure 2.

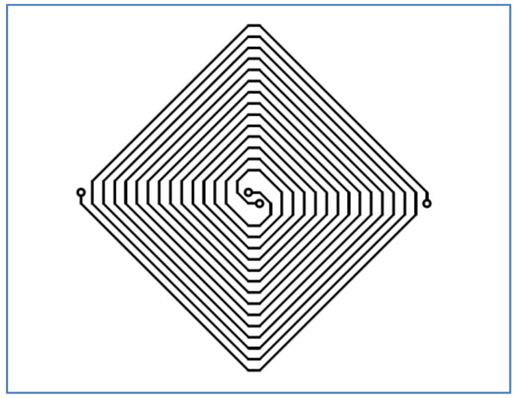

Figure 1 - Circuit trace pattern

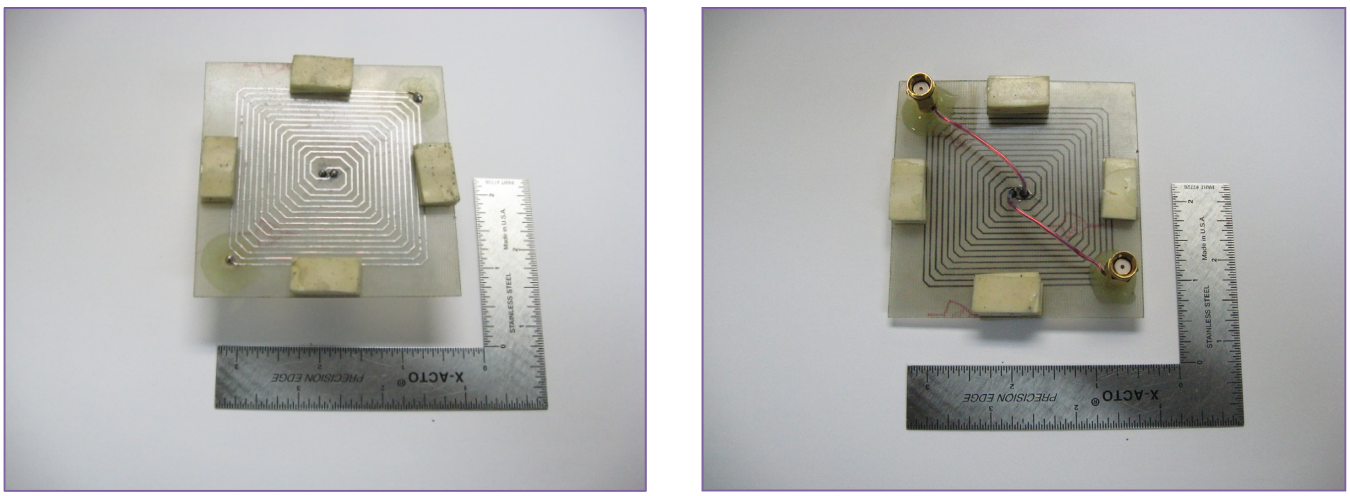

Figure 2 Front and back (left and right images respectively) of sample circuit board with planar coiled microstrip structures.

Three sets of tests were performed as follows:

- Test Case 1 – 3.00 MHz sine wave at approximately 3V p-p (peak to peak)
- Test Case 2 – 3.00 MHz square wave at approximately 3V p-p
- Test Case 3 – 3.00 KHz square wave transition at approximately 3V p-p

For each of the above cases the following tests were performed:

- Lead Test with no circuit board attached
- Circuit board without ground plane
- Circuit board with ground plane (1oz. Cu)
- Circuit board with composite ground plane

- Circuit board with **CleanSignal**™ ground plane
- Circuit board with **CleanSignal**™ (*inverted*) ground plane

The signal source was a Tektronix TM 503 (FG 503 3 MHz) signal generator running at 3MHz at 3V p-p. A FLUKE 123 ScopeMeter was used to monitor the source signal and response.

Channel A on the scopemeter was used to monitor the wave form from the input terminals (signal/primary side). Channel B was used to monitor the parasitic output (response/secondary side). The actual test data from these tests are presented below.

3.1. CASE 1: 3.00 MHz sine wave at approximately 3Vp-p

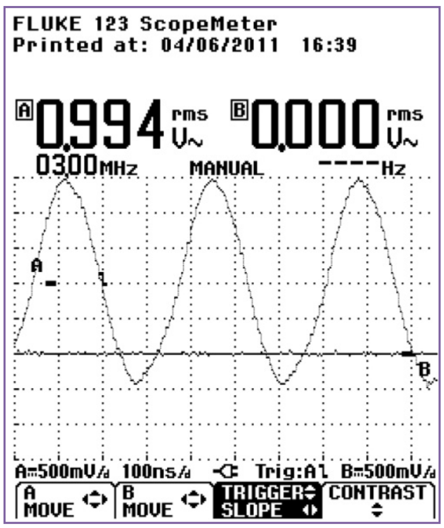

Figure 3 - Lead test – NO PCB attached

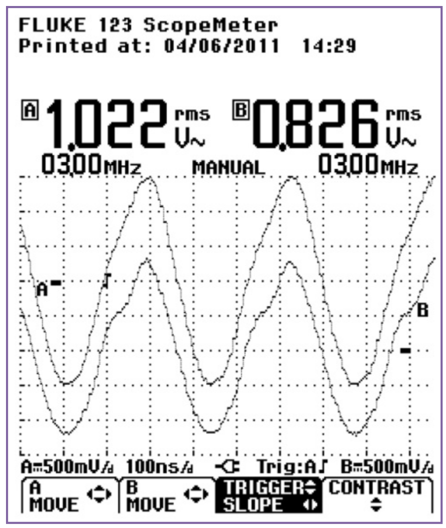

Figure 4 - PCB w/o ground plane

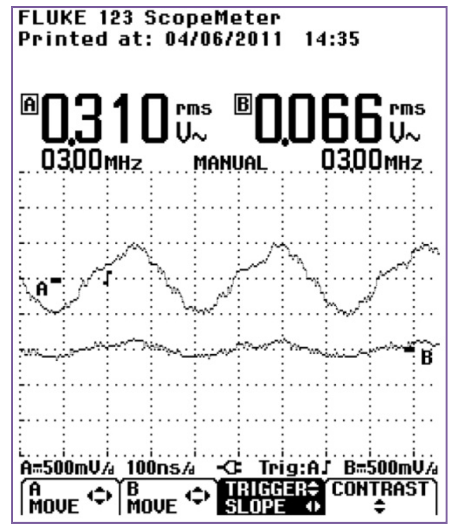

Figure 5 - PCB with Cu ground plane

In the first output above (Figure 3), without any test circuit attached, the scopemeter's display shows that the input wave form is a 3MHz, 3 volt peak to peak (3V p-p) sine wave. The output wave form is almost flat, exhibiting low inherent channel cross-talk.

The second output (Figure 4) shows the test setup connected to 1/32" FR-4 PCB without any ground plane. The input wave form (Channel A) shows little loss of amplitude and slight distortion while the output signal (Channel B) is slightly distorted but almost as large. This test demonstrates without effective shielding, cross-talk can pose a challenge.

In the third setup (Figure 5) a 1 oz (approx 2.8mil) copper ground plane was applied on the rear side of 1/32" FR-4 PCB. The input wave form amplitude was reduced from 3V p-p to 1V p-p. Coupling between the input and output circuits has been greatly reduced as evidenced by the lower RMS value for the output (Channel B), while at the same time introducing no appreciable phase error.

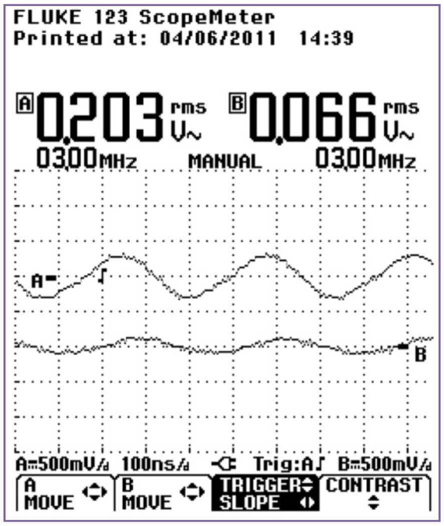

Figure 6 - PCB with composite ground plane

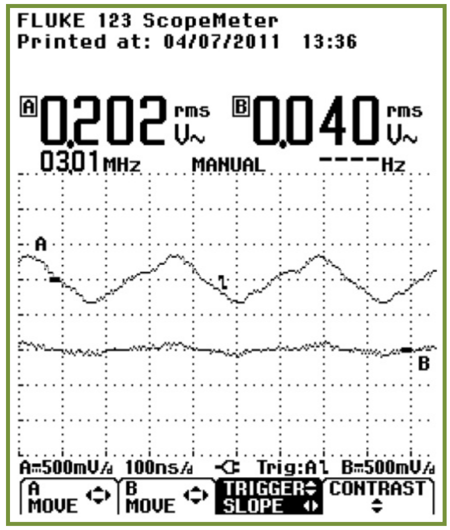

Figure 7 - PCB with CleanSignal™

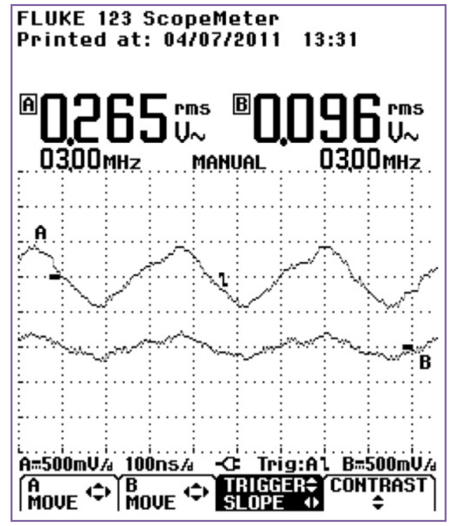

Figure 8 – PCB with CleanSignal™ Inverse

Replacing the copper ground on the back of the PCB with a conventional composite dampens some radiated high frequency interference, (the RMS values on Channel B are the same), but at the expense of some additional input amplitude reduction as well as introducing significant output phase lag (Figure 6).

Figure 7 shows the scope output for the FR-4 PCB with **CleanSignal**™ ground plane. The RMS output voltage is attenuated more than in any of the other ground plane configurations. The **CleanSignal**™ difference means minimal input attenuation and no discernible phase shift in the output wave form when compared to the conventional copper ground plane PCBs, while providing the best output attenuation.

Figure 8 shows the response when using the **CleanSignal**™ - ***Inverse Configuration*** ground plane. It can be observed that the output signal is degraded. This is rectified in the previous example (Figure 7) which utilized **CleanSignal**™.

3.1.1. Case 1 Test Results

The series of tests in Case1 clearly show (Figure 7) that the **CleanSignal**™ technology for PCB provided the least attenuation of the source sine wave signal, and the maximum attenuation of the output signal and no discernible phase shift in the output wave form when compared to other conventional copper ground plane PCBs.

3.2. CASE 2: 3.00 MHz square wave at approximately 3Vp-p

In Case 2 the same set of tests are repeated, but now using a 3 MHz square wave 3V p-p as the input wave form (Figures 9 to 14).

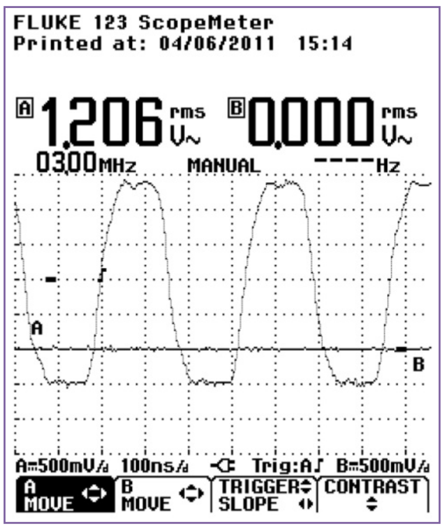

Figure 9 - Lead test – NO PCB attached

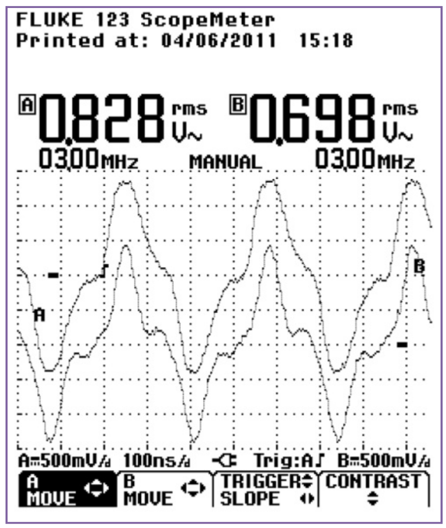

Figure 10 - PCB w/o ground plane

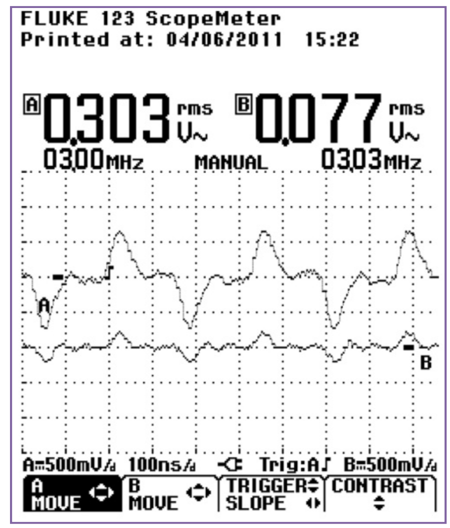

Figure 11 - PCB with Cu ground plane

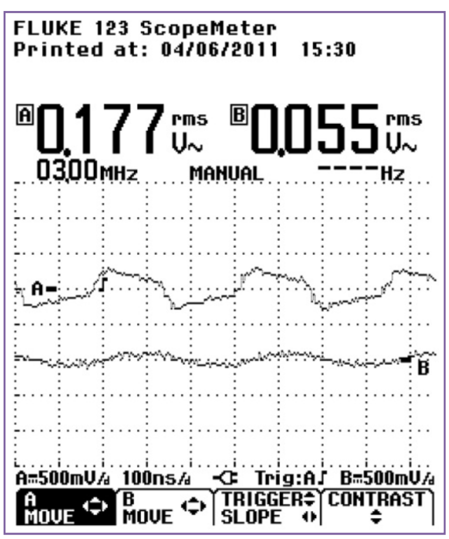

Figure 12 - PCB with composites

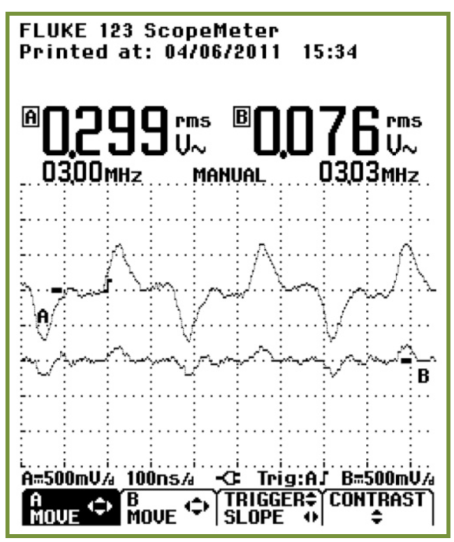

Figure 13 - PCB with CleanSignal™

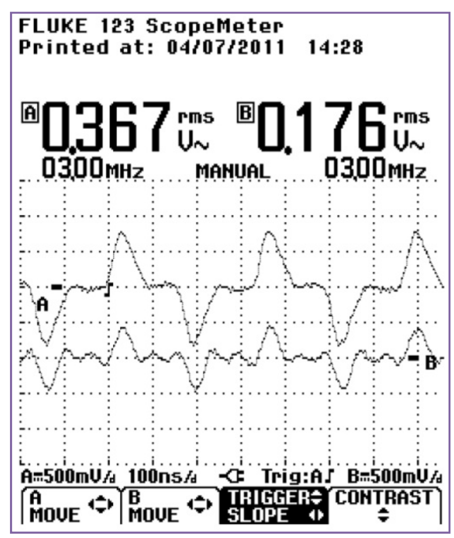

Figure 14 – PCB with CleanSignal™ Inverse

In Figure 10 the cross-over distortion of both the input and output wave forms becomes apparent. The addition of a ground plane reduces cross-talk (Figure 11).

The composite only test (Figure 12), shows the greatest attuentation to the input signal. Additionally, the overall shape of the incoming wave form (square wave) is the most accurate. The output wave form has the lowest amplitude but the greatest phase shift.

In the FR-4 circuit board enhanced with the **CleanSignal**™ ground plane, the input and output wave forms are the closest to a convential ground plane PCB, while offering a "*cleaner signal*" on the output (Figure 13).

If the **CleanSignal**™ **- *Inverse Configuration*** ground plane is used - the output signal exhibits a significant amount of cross-talk.

3.2.1. Case 2 Test Results

The series of tests in Case2 show that the **CleanSignal**™ technology for PCBs provided the better attenuation of the source square wave signal (Figure 13) when compared to other conventional copper ground plane PCBs. Additionally, the output signal has no discernible phase shift in the output wave form.

3.3. CASE 3: 3.00 kHz square wave transition at approx. 3Vp-p

In Case 3 the same set of tests are repeated, but now using a 3.0 kHz square wave 3Vp-p as the input wave form (Figures 15 to 20). A pulse generator was not available so the trailing edge of 3.0 kHz square wave form is examined.

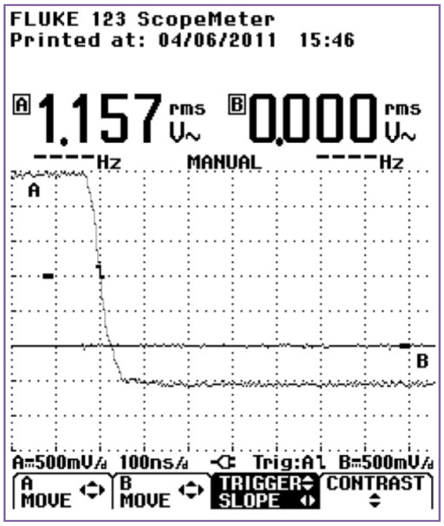

Figure 15 - Lead test – NO PCB attached

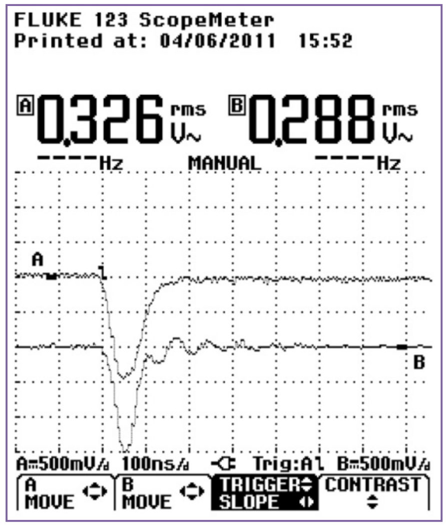

Figure 16 - PCB w/o ground plane

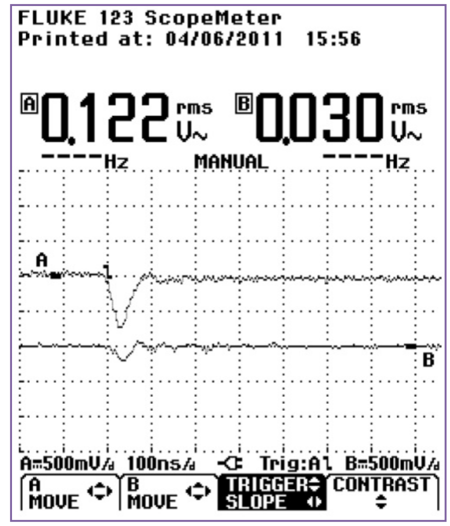

Figure 17 - PCB with 1oz. Cu ground plane

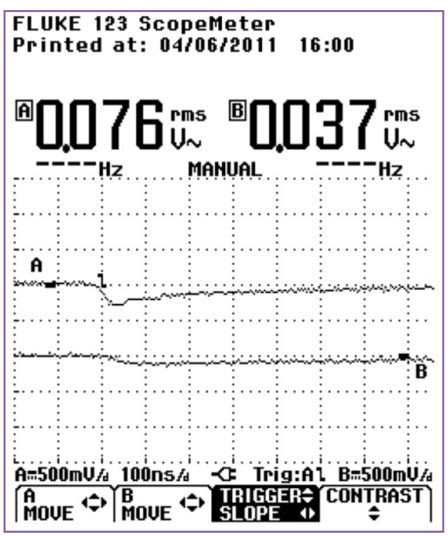

Figure 18 - PCB with composite ground plane

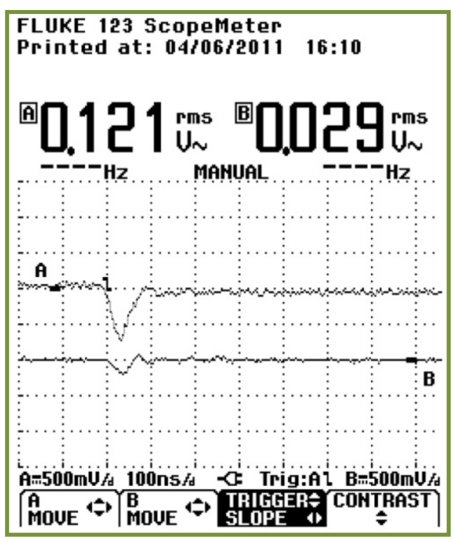

Figure 19 - PCB with CleanSignal™

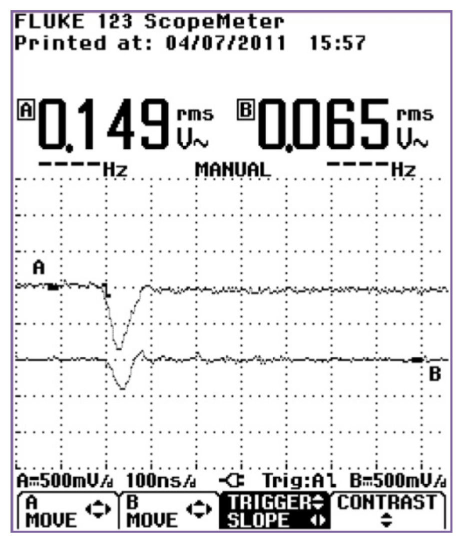

Figure 20 - with CleanSignal™ Inverse

3.3.1. Case 3 Test Results

In Figure 16 the cross-over distortion of both the input and output wave forms becomes apparent. The addition of a ground plane reduces cross-talk (Figure 17).
The composite only test (Figure 18) shows the attuentation to the input signal. However the output wave form exhibits phase shift.

The FR-4 circuit board with the **CleanSignal**™ ground plane, the input and output wave forms are the closest to a convential ground plane PCB, while offering a "*cleaner signal*" on the output (Figure 19) with additional attenuation.

4. Conclusions

Several circuit boards (1/32" FR-4, 1 oz. Cu substrate) with planar coiled microstrip structures were designed and manufactured, in-house, to test the performance of the **CleanSignal**™ technology. We tested resonant LRC characteristics of different circuit board substrates – FR-4 PCB without a ground plane, with a conventional copper ground plane, a ground plane made of composite material, and ground planes in two different **CleanSignal**™ technology configurations.

The series of uncontrolled, bench tests performed in-house show that the **CleanSignal**™ technology for PCBs provides better attenuation of the source sine and square wave signals when compared to other conventional copper ground plane PCBs. There is less cross-talk between the two circuit elements. Additionally, the output signal has no discernible phase shift when compared to the input wave form.

We conclude that the **CleanSignal**™ technology can likely be applied to almost any type of circuit board to reduce unwanted electromagnetic noise and interference. The technology reduces background interference and noise and improves signal quality. Because less power is needed to boost signals when there is less interference, **CleanSignal**™ technology has the potential to improve energy efficiency in many applications.

5. Contact

TangiTek, LLC
1033 SW Yamhill St.
Ste. 301
Portland OR – 97205. USA
Ph: 503-222-1022
E-mail: info@tangitek.com
http://www.tangitek.com