MARK 5 MEMO #068

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February 26, 2008

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To: Mark 5 Development Group

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Subject: Measurements of Times Microwave Phase Track II 240

Times Microwave sent me a 255 foot (314 ns) sample of their Phase Track II 240 cable. I cycled the temperature from 75 F to 125 F using an insulated box with internal air circulation. The air temperature in the box was raised by supplying warm air at the bottom and letting air escape at the top. The air temperature was brought back to room temperature by continuing to supply air with the heat source turned off.

The Cable temperature was measured with a digital thermometer. The home made chamber set-up is shown in figure 1.

The delay through the cable was measured by two different methods:

A] Splitting the power from a signal generator, into 2 parts and then recombining the paths again. Figure 2A shows the set-up. The attenuation in the direct path is adjusted to equal the attenuation in the cable path so that a sharp null is observed which the frequency corresponds to an odd number of half-wavelengths through the cable. The mathematics for this method is given in memo #066.

B] Using the Timing solutions TSC 5115A phase comparator as shown in Figure 2B. Initial measurements were somewhat confusing until it was realized that the thermal time constant was significantly longer than expected and the cable change lags the temperature indicted by the thermometer which was embedded in the cable. In practice, it was found that at least 2 hours were required for the cable to reach the final temperature of about 125 F and another 3 hours for the phase readings to reach a constant value after the heat was turned off and the cable allowed to cool to the room ambient of about 75 F. In some cases I managed to get readings at an intermediate temperature of about 100 F by applying about half the heat, waiting 2 hours and then applying full power to reach 125 F. After allowing for adequate time for the cable to reach equilibrium with the environment there was no evidence of hysteresis and the cable electrical length returned to the same value upon cool down to the initial temperature.

Measurements were made at 1 GHz, 30, 10 and 5 MHz. A lot of time was spent trying to understand the frequency dependence of the temperature coefficient. Initially it was thought (see memo #67) that the change in temperature coefficient at frequencies of 30 MHz below was the result of standing waves but this could not be confirmed. Next it was thought that the increasingly positive temperature coefficient is the result of resistive loss which become more and more dominant at low frequencies. The theory (see memo #67) predicts the trend but fails to predict a large enough coefficient.

Temperature coefficients

Frequency MHz	Temperature coefficient ppm/˚C	Method used
1011	-7±1	A
30	-1±1	B
10	+6.5±1	B
10.7	+6.0±2	A
5	+13.0±2	B

Notes:

1] A negative coefficient means that the electrical length decreases with increasing temperature.

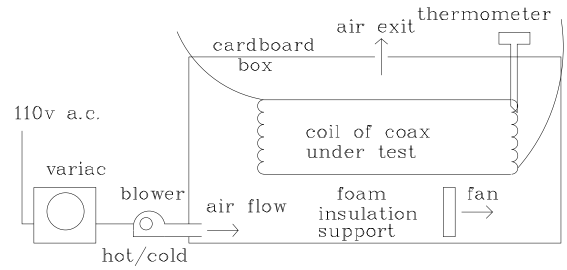

Figure 1. Test "oven"

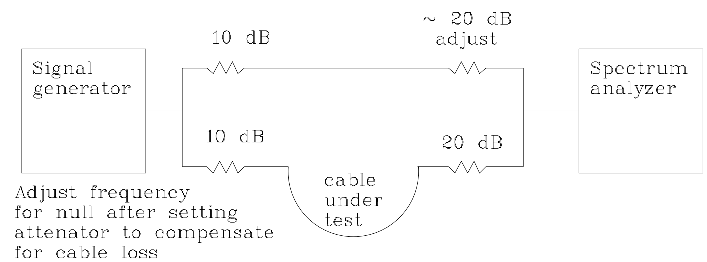

Figure 2A. Measurement method "A"

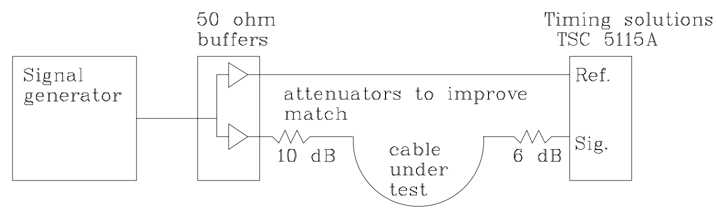

Figure 2B. Measurement method "B"