EVLA Memo 94
L/S/C Converter Plate Phase Stability Test II

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Abstract

In reference to EVLA Memo 92, an inaccuracy in acquiring the phase detector constant resulted in erroneous phase shift values. Using the correct phase detector constant with original measured voltages in the phase angle formula produced within-specification phase shifts. The voltages recorded from the second temperature chamber test and used in the phase angle formula generated better results. At an IF of 8 GHz, phase shifts of 11° and 9°, for a change in temperature (Δtemperature) from 9°C to 19°C, and from 19°C to 29°C, respectively, were realized for the initial test. For the same IF, in the second test, a 1° phase shift and 5° phase shift for the same lower and upper Δtemperatures, respectively, were obtained. The corrected procedure and improved results will be discussed in this memo.

Introduction

The maximum phase shift specification for a frequency of 8 GHz per 10° C Δtemperature, as noted previously in EVLA Memo 92, was satisfied for both 10° C increase and decrease from 19° C in the initial temperature chamber test. The discrepancy found in the first test was corrected while conducting the phase detector constant measurement for the second temperature chamber test. The initial phase detector constant (peak voltage, V_P) was acquired inaccurately due to a misread power measurement leading to the Mini-Circuits Level 7 mixer. Power levels at the mixer were not at the +9 dB reference level for the temperature chamber test, resulting in the 'out-of-spec.' results. For the second phase detector constant measurement, the +9 dB reference power level was measured at both LO and RF mixer inputs. The new resulting phase detector constant was found to be .22, a change of +.03 from the initial.

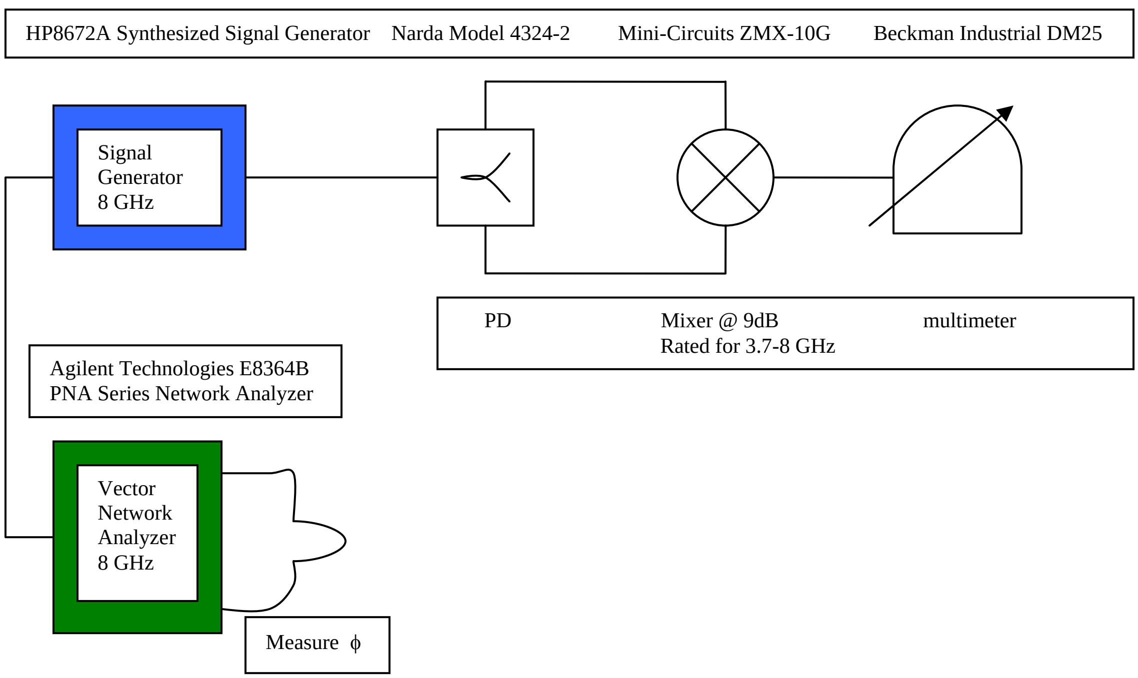
One other incongruity in the initial test occurred during the temperature chamber test. The holes (cable entry/exit holes) in the wall of the temperature chamber, itself, for the cables to and from the L/S/C converter plates were not insulated. During the second temperature chamber test, cable entry/exit holes were insulated well.

Methods

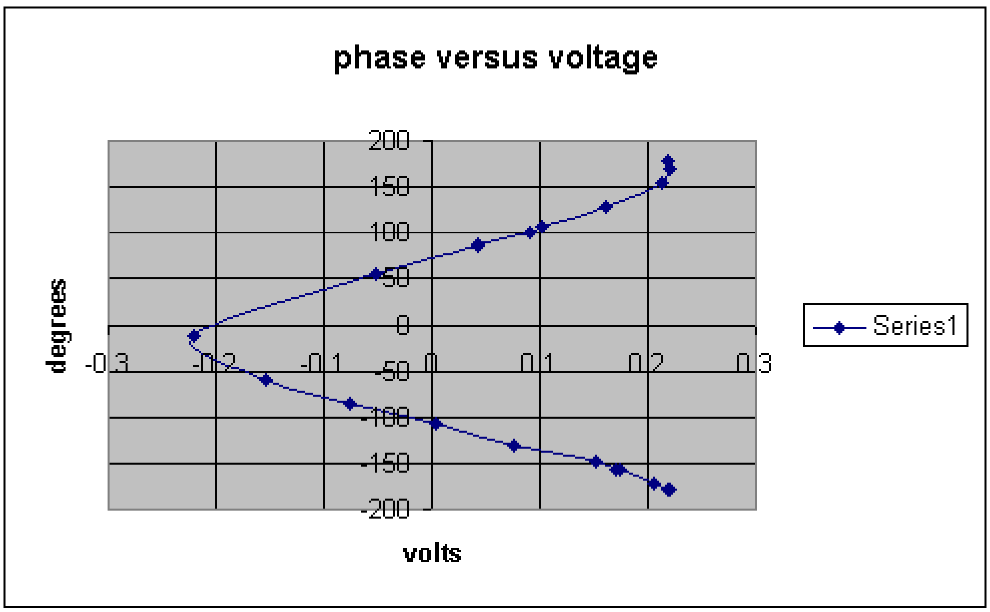
The same methods as those described in EVLA Memo 92 were repeated here except that extra attention was given to ensure +9 dB was present at the mixer inputs from the RF signal generator. Setup #1 measured results were improved. Temperature chamber tests were the same except that the time was lengthened for stability and chamber holes were insulated.

Equipment used included: Several barrels and bullets, a Minibend-2.5 cable, ESM-03, -05, and Tensolite-04, -06 cables, copper air-dielectric spline line (copper RF cables) for the “varied” chamber signal connections and 2 Storm cables for the constant chamber signal connections, foam insulation pads, 3 power supplies for the amplifiers, 2 Mini-Circuits ZRON-8G amplifiers rated for 2-8 GHz, attenuators varying from 1 to 10 dB, an HP E4418B EPM Series power meter, plus components noted in setups 1 & 2.

Setup #1

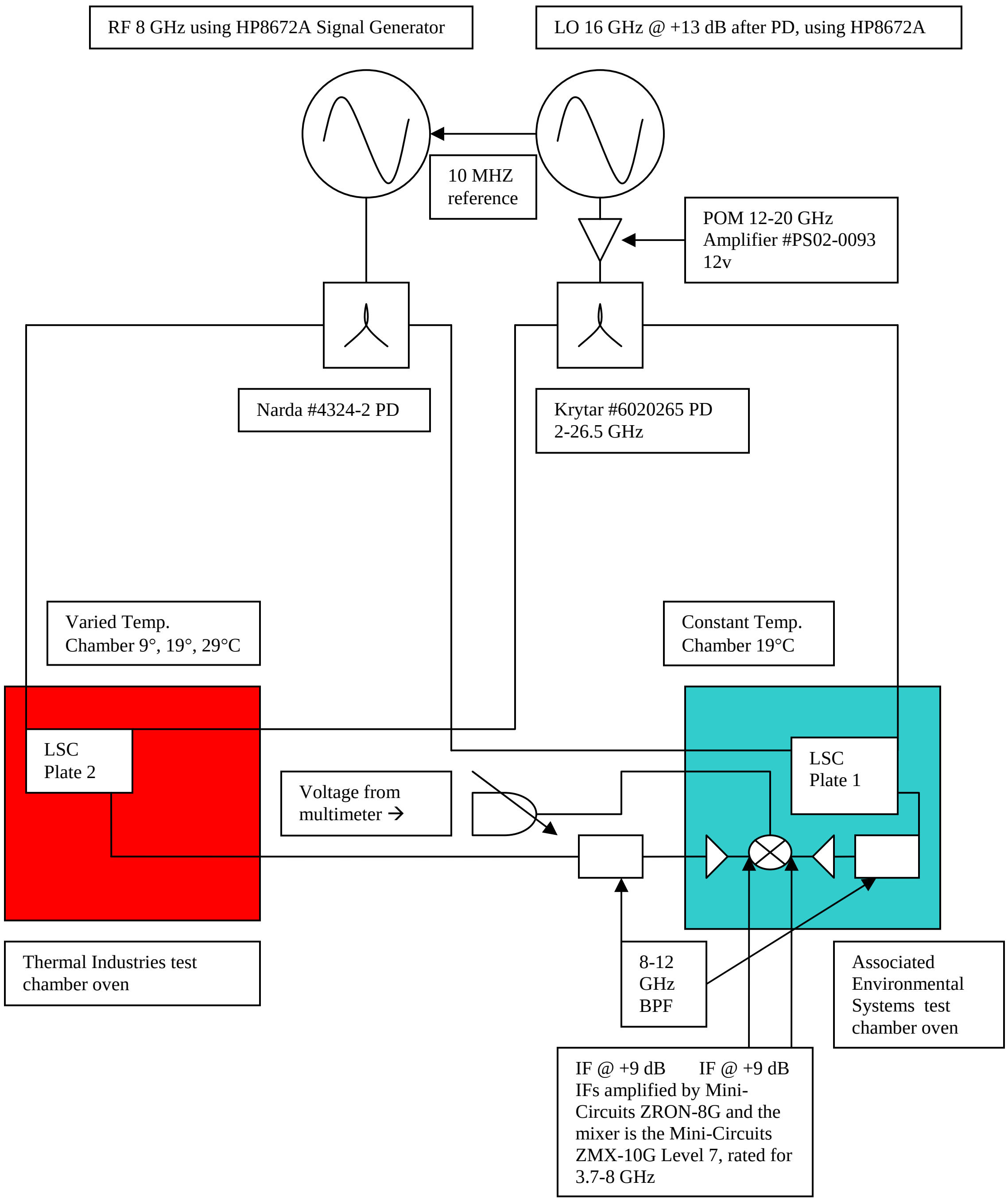


Description	voltage (v)	phase angle (degrees)
nwbllt/tnslt-004/bllt/esm-03	0.218	179
nwbllt/esm-03/xcrssbllt/brrl/bllt/brrl	0.221	169.7
esm-03/xcrssbllt	0.213	155
nwbllt/tnslt-004/xcrssbllt/mb-2.5	0.161	129
brrl/bllt/tnslt-004/xcrssbllt	0.101	108
nwbllt/tnslt-004/xcrssbllt/brrl/bllt/brrl	0.09	101
nwbllt/tnslt-004/xcrssbllt/esm-05	0.042	87
tnslt-004/xcrssbllt	0.043	85
nwbllt/tnslt-004/xcrssbllt/esm-03	-0.051	56
nwbllt/mb-2.5/bllt/brrl	-0.221	-12
nwbllt/brrl/bllt/brrl	-0.154	-60
nwbllt/esm-03/bllt/brrl	-0.076	-85
brrl/bllt/mb-2.5/xcrssbllt	0.003	-107
mb-2.5/xcrssbllt	0.075	-131
brrl/bllt/esm-05/xcrssbllt	0.152	-149
nwbllt/esm-05/xcrssbllt/brrl/bllt/brrl	0.171	-157
brrl/bllt/brrl/xcrssbllt	0.174	-157
esm-05/xcrssbllt	0.205	-171
brrl/bllt/esm-03/xcrssbllt	0.22	-178
brrl/xcrssbllt	0.218	-179



phase constant is .22

Setup #2



From setup #2, the measured voltages were used to find the upper temperature phase shift and the lower temperature phase shift. Below are the following initial measurements and the follow-up measurements:

temp (degrees Celsius)	DC volts	2nd pass
9	0.18	0.18
19	0.154	0.153
29	0.128	0.127

A new correct Phase detector constant = .22 from the phase versus voltage graph produced accurate and satisfactory results. Using the phase angle formula, $V_P \cos\theta = V_{DC}$, for the three initial dc voltages, their new respective phase angles were calculated:

At 9° C, an angle of 35° was calculated. At 19° C, an angle of 46° was calculated. And, at 29° C, an angle of 55° was calculated. Phase shift for the temperature decrease was 11° and phase shift for the increase was 9°. Both shifts are within the specified parameter of <12.5° phase shift for a ±10° C Δtemperature.

The second temperature chamber test provided a phase angle of 80° at 9° C for a shift of one degree from the 19° C phase angle of 79° and a phase shift of 5° for 29° C with a phase angle of 75° C.

temp (Celcius)	voltage	phase angle
9	0.04	80
19	0.041	79
29	0.057	75

LO/IF systems phase/delay stability is specified in the NRAO EVLA Project Book, chapter 6.14.3.3. A requirement of .0013°/min/GHz and maximum average temperature slope of 0.25° C/(30 min) are listed. This provides a 12.5° phase shift for 8 GHz over a temperature change of 10° C: .0013°/min/GHz x 30min x 40 x 8 GHz = 12.48° (note: since observation is a 10° Δ, 0.25° C/(30 min) has a factor of 40.

Discussion

While setting up for the first half of the second test, it became apparent that the power level for the RF going into the Mini-Circuits level 7 mixer had been lower than +9 dB during the initial test. It was corrected and a new phase detector constant was produced from the resulting graph. For the second half of test number two, the entry/exit holes for the cables were plugged with foam pads for temperature chamber insulation. Three different temperature tests were run and each produced similar results in phase shift. Data from the first two were not included in this memo because a loose cable connector was discovered after measurements were taken. Minor problems had to be resolved before the third and final temperature chamber test was completed. A new copper RF cable was made to replace the one being used for the IF from the L/S/C converter plate in the variable chamber to the mixer in the constant temperature chamber. A loose connection on the LO amplifier broke off during the second trial of the second temperature chamber test and had to be re-soldered. When everything was checked and double-checked, the final test was run and completed without incident.

Conclusion

Graphing the phase versus voltage curve a second time brought about a value that ensured accurate results. Not plugging the entry/exit holes for the initial test was an oversight that when corrected effectively reduced phase shift. The tests were run at the same temperature intervals for consistency. In the previous memo, the median temperature of 23° C was considered for a trial run. However, after three days of completing the second temperature chamber test and observing successful measurements with initial settings, the test was completed. The distance between the temperature chambers was not shortened because the copper RF cables could not be bent nor shortened. The RF cables were kept straight and the distance between the chambers was kept as close as the cables would allow. All of the cables were not homogeneous. The constant temperature chamber employed Storm cables and the variable temperature chamber used copper air-dielectric cables. Particular attention was given to the mixer inputs to ensure that power levels were as close as possible to +9 dB for each. Overall, the tests were successful and the L/S/C converter plates can be used confidently, at an appropriate temperature, to achieve L/S/C band conversion with a phase shift within specification.