EVLA Memo 92
L/S/C Converter Plate Phase Stability Test

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Abstract

A phase stability test of the L/S/C converter plates revealed a 12° shift in phase angle for an increase in temperature of 10° Celsius (C) from a temperature of 19° C and a 17° phase angle shift for a decrease in temperature of 10° C from 19° C at a frequency of 8 GHz. The lower temperature change (Δtemperature) was greater than an allowable maximum phase change of 12.5° @ 8 GHz per 10° C Δtemperature. This memo discusses the accuracy of the results. Another phase stability test will be performed to see if duplicate results occur.

Introduction

The maximum phase shift specification for a frequency of 8 GHz per 10° C Δ in temperature, as noted above, was detected between the median and upper temperatures, 29° C to 19° C, for the L/S/C converter plates. However, the same result was not noted during the Δtemperature from the median to lower temperature, 19° C to 9° C.

The phase stability test consisted of two parts. First, a reference graph of voltage versus phase angle was constructed. From that graph, a phase detector constant (peak voltage, V_P) was determined. Second, two temperature chambers were used to create a temperature difference for determination of dc voltage output from a mixer and thus phase shift between two separated L/S/C converter plates within each chamber. The methods and procedures are detailed with block diagrams for clarity.

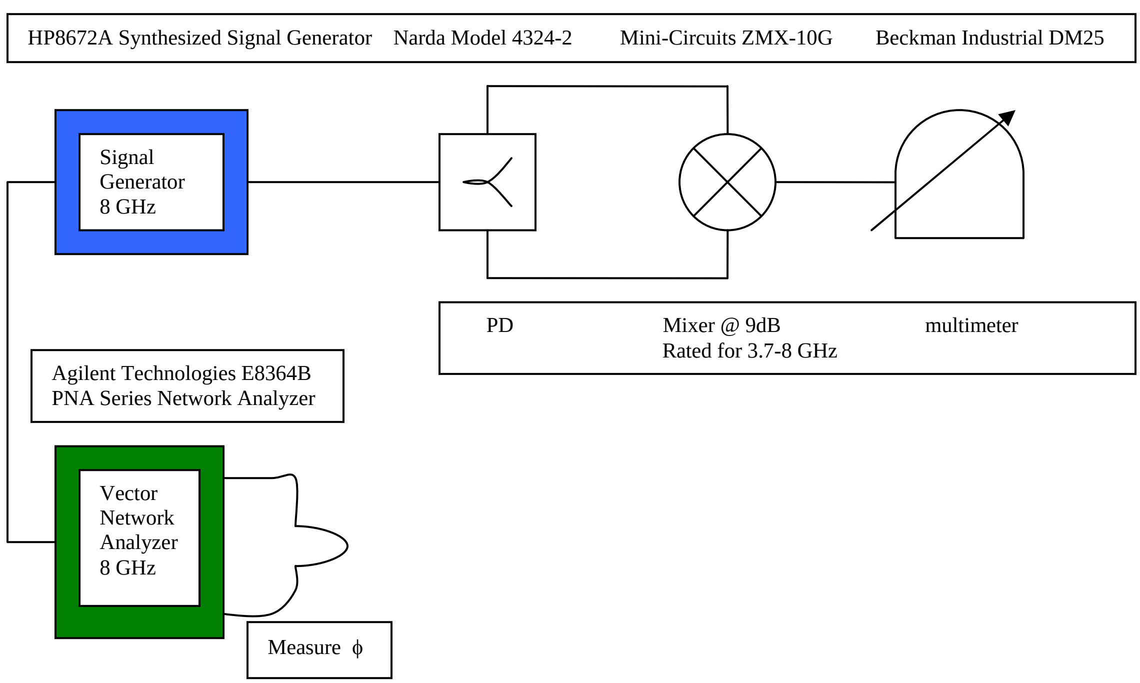
Methods

A voltage reference table was created using a voltmeter to measure dc voltage output from a Mini-Circuits Level 7 mixer receiving an 8 GHz at +9 dB power level signal for both RF and LO inputs from an HP8672A signal generator. The signal generator was referenced with a vector analyzer via its 10 MHZ reference output. Varying lengths of connectors and cables were placed in between the mixer RF input and one of the cables extending from a Narda model 4324-2 power splitter connected to the signal generator. Those varying lengths were measured on the vector analyzer to detect phase angle. Data was compiled on a spreadsheet to chart the phase angle versus voltage. The resultant graph was used, subsequently, for reference in the temperature chamber test.

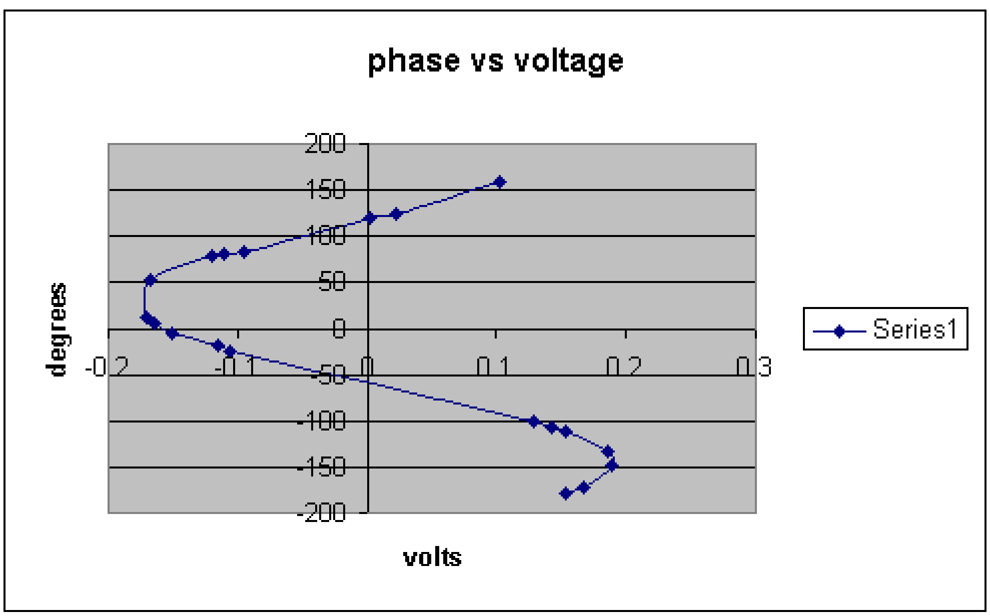
One of the temperature chambers held an L/S/C converter plate at a constant 19° C and the other temperature chamber with the second converter plate was varied by 10° C at, above, and below 19° C with a 1 hour stabilization time between each Δtemperature. The mixer dc voltage between the plates was recorded for the temperatures 9° C, 19° C, and 10° C after the 1 hour stabilization period was complete. A repeat run to determine accuracy/consistency was conducted and those values were recorded. The aforementioned reference chart, interpolation, phase detection constant, and measured voltages were used to calculate and determine phase angle shift.

Equipment used were: 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, 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.

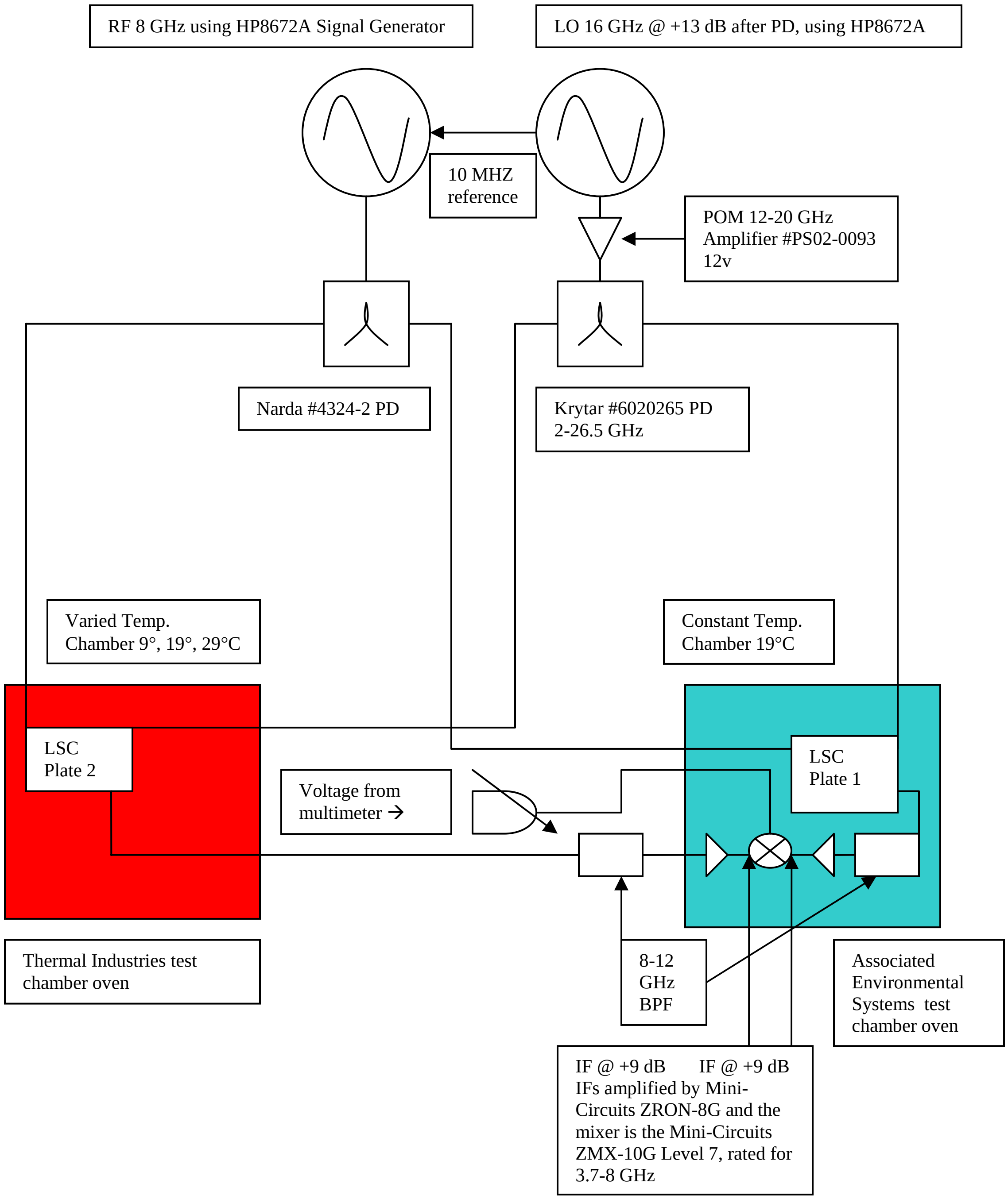
Setup #1



Description	voltage (v)	phase angle (degrees)
cables only	0.043	
brrl/xcrossbllt	0.154	-179
ESM-05/bllt	0.167	-172
bllt/ESM-05/smbllt/brrl	0.189	-148
bllt/minibnd-2.5	0.186	-133
smbllt/Tnslt-06	0.153	-112
bllt/minibnd/smbllt/brrl	0.143	-108
bllt/ESM-05/smbllt/minibnd-2.5	0.129	-100
bllt/brrl/nwbllt/Tnslt-04/xcrssbllt/brrl	-0.106	-24
bllt/ESM-03/smbllt/Tnslt-04/xcrssbllt/brrl	-0.115	-18
smbllt/minibnd-2.5	-0.15	-5
bllt/brrl/bllt/Tnslt-04/smbllt/brrl	-0.164	5
bllt/ESM-05/smbllt/Tnslt-04/xcrssbllt/brrl	-0.17	11
ESM-03/bllt/brrl/bllt	-0.168	53
brrl/bllt/brrl/bllt	-0.12	78
Tnslt-04/bllt	-0.11	82
ESM-05/bllt/brrl/bllt	-0.095	83
Tnslt-06/bllt	0.002	120
Minibnd-2.5/bllt/brrl/bllt	0.022	124
ESM-03/bllt	0.103	158



Setup #2


RF 8 GHz using HP8672A Signal Generator
LO 16 GHz @ +13 dB after PD, using HP8672A
10 MHZ reference
POM 12-20 GHz Amplifier #PS02-0093 12v
Narda #4324-2 PD
Krytar #6020265 PD 2-26.5 GHz
Varied Temp. Chamber 9°, 19°, 29°C
Constant Temp. Chamber 19°C
LSC Plate 2
LSC Plate 1
Voltage from multimeter →
8-12 GHz BPF
Thermal Industries test chamber oven
Associated Environmental Systems test chamber oven
IF @ +9 dB IF @ +9 dB
IFs amplified by Mini-Circuits ZRON-8G and the mixer is the Mini-Circuits ZMX-10G Level 7, rated for 3.7-8 GHz

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

Phase detector constant = .19 from phase versus voltage graph. Placing that value in the formula, V_P COS $\theta = V_{DC,}$ for the three different measured dc voltages, their respective phase angles were calculated. Inputting 0.18 volts dc yields a phase angle of 19°, 0.153 volts dc yields a phase angle of 36°, and 0.128 volts dc yields a phase angle of 48°. The respective phase angle for 9° C was calculated to be 19° and that difference from 36° is 17° (phase shift for the lower Δtemperature).   For the upper Δtemperature (19° to 29° C), the difference was 12°.

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). The percent error using for the lower Δtemperature is:

(17° - 12.5°)/12.5° x 100% = 36.5%

This is the phase shift percentage error for the Δtemperature between 19° C and 9° C.

Discussion

Ten voltages and their corresponding phase angles were plotted using a spreadsheet, initially. The curve produced by those plots provided a means to find combinations of connectors and cables whose resulting phase angle fit. By this method, voltages were plotted by their respective phase angles to "empty" locations on the curve with accuracy. (Empty is used to designate the open areas of the curve where no points had been plotted yet.)

The temperature chambers allowed room for error due to the distance between the chambers and the length of copper RF cables used as the signal transfer media inside of and outside of the "variable" temperature chamber. Both chambers use a heating/cooling see-saw effect to keep the temperature close to the set point. The temperature varied ± 1° C and from the set point, even after one hour of stabilization. A longer period for stabilization may have brought the error down and a two-hour period may be used in the next test.

Copper RF cables transferred LO and RF from the signal generators, external to the variable temperature chamber, into the chamber. From room temperature ~23° C to 9°, 19°, 29° C. Then, Copper RF cable transferred the IF signal through three temperature environments; from within the variable chamber (@ 9°, 19°, or 29° C), through room temperature (~23° C), and back into 19° C, the constant chamber. Another cause for concern is that attenuators were used to place a +9 dB power level at each input of the mixer. The +9 dB values were within ± 0.5 dB, approximately, of each other. External RF cables to/from one LSC plate are of a different material than the external RF cables to/from the other LSC plate which, more than likely, affected the outcome. As one can ascertain, due to the fluctuation of 1 ° C for each temperature at both chambers there is room for error even with "in-spec." readings. One can only create the best possible environment for this test that will minimize temperature differences between the three temperature scenarios so that there is as quick a change from one environment to the other.

Conclusion

In the next test, a repeat of the phase versus voltage curve will be graphed to see if values are duplicated and accurate/consistent at the +9 dB level going into the ZMX-10G mixer. During setup #2, the distance between the chambers will be shortened and stabilization time will be lengthened. Particular attention will be given to match each IF power level at the mixer via the combination of attenuators. Employment of identical external RF cables for both plates will be considered. Maybe, two sets of air-dielectric spline line for each plate will be used. After the original temperatures are tested, the constant temperature setting will be increased to 23° C (room temperature) to minimize temperature change in cables external to each temperature chamber. Consequently, temperature range will be ±10° C from 23° C. Hopefully, measurements will provide a maximum phase shift within specification.