

APP NOTES

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# Making Antenna Phase Change Measurements with the IQgig TFC

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## Background

The IQgig-RF, IQgig-5G, and IQgig-IF contain specialized hardware to support phase measurements and phase shift measurements when measuring the antenna array of mmWave devices. A TFC (Test Flow Controller) library has been created to optimize the user implementation on the phase shift calculation.

This applications note describes the implementation using a TFC named "phase\_shift\_tfc.js." Ensure that this TFC is preloaded in the test system before implementing the examples that follow. Refer to the test system documentation for instructions on how to load TFC libraries into LitePoint test systems.

## SCPI commands

### PHASe:CHANge:LIBRARY:VERSion?

Purpose:

To query the TFC version

Example:

```
:TX=ROUT1>>PHAS:LIBR:VERS?  
:RX=0 error>>"1.0.2"
```

### CONFigure:PHASe:CHANge:CALCulation

meas\_offset\_time, interval\_count, jump\_threshold, guard\_interval, user\_phase\_change\_time

Purpose:

To configure the phase change calculation.

Input parameters:

meas\_offset\_time: type: DOUBLE, unit: second.

To assign the calculation offset time in each GPRF measurement interval

interval\_count: type: UINT.

To indicate the total measurement intervals.

jump\_threshold: type: DOUBLE. Unit: degree.

To indicate the threshold to judge as a phase change. Set to 0 to disable.

guard\_interval: type: UINT.

To indicate the number of measurement intervals to be discarded nearby the phase change interval.

user\_phase\_change\_time: type: DOUB. Unit: second

To indicate the user-specified phase change location in a capture. Set to 0 to disable.

Example:

```
CONF:PHAS:CHAN:CALC 1e-6,40,20,1,50e-6
```

## EVALuate[:SEGMENT#]:PHASe:CHANge?

Purpose:

To calculate and fetch the phase change.

Output parameters:

Status\_Code: type: UINT.

0 means no error. Others means an error occurred in this SCPI command.

Phase\_change: type: DOUBLE. Unit: degree.

Calculated phase change.

Phase1 RMS Error: type: DOUBLE.

The RMS error of the each measurement interval in Phase1.

Phase1 Peak Error: type: DOUBLE. Unit: degrees.

The Peak error of the each measurement interval in Phase1.

Phase2 RMS Error: type: DOUBLE.

The RMS error of the each measurement interval in Phase2.

Phase2 Peak Error: type: DOUBLE. Unit: degrees.

The Peak error of the each measurement interval in Phase2.

Example:

```
EVAL:PHAS:CHAN?  
:RX=0 error>>0,-34.383,1.622,4.249,2.369,5.579
```

In this example, the result returns Phase2 - Phase1 is -34.383 degrees.

The RMS error in Phase1 is 1.622.

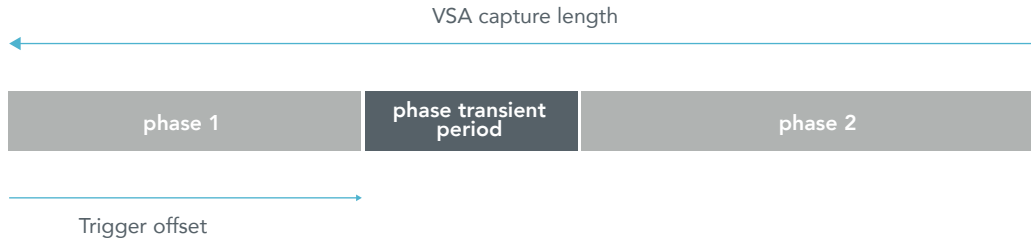
The peak error in Phase1 is 4.249.

The RMS error in Phase2 is 2.369.

The peak error in Phase2 is 5.579.

## Implementation Example

### Setting the VSA



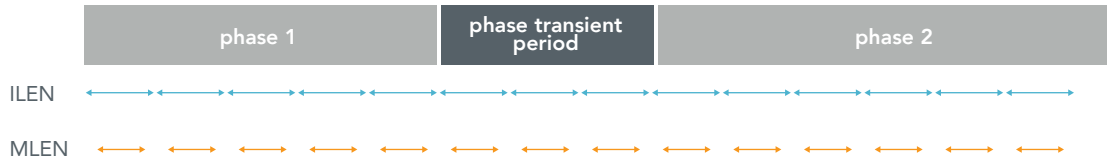
```
CAPture:TIME 1ms;  
TRIGger:SOURce PSHift;  
TRIGger:OFFSet:TIME -50us;
```

Note the VSA trigger offset MUST be a negative number to let the capture include phase1 period.  
In the above example SCPI the phase1 period in this capture is 50us.

### GPRF setting

ILEN: interval length

MLEN: measurement length in each interval



```
GPRF;  
CONF:ILEN 5 us;  
CONF:MLEN 4 us;
```

If the VSA TRIGger:OFFSet:TIME -5.000000e-05; and GPRF;CONF:ILEN 5 us; that means there will be 10 phase measurement intervals in the phase1 period.

If the VSA TRIGger:OFFSet:TIME -5.000000e-05; and GPRF;CONF:ILEN 10 us; that means there will be 5 phase measurement intervals in the phase1 period.

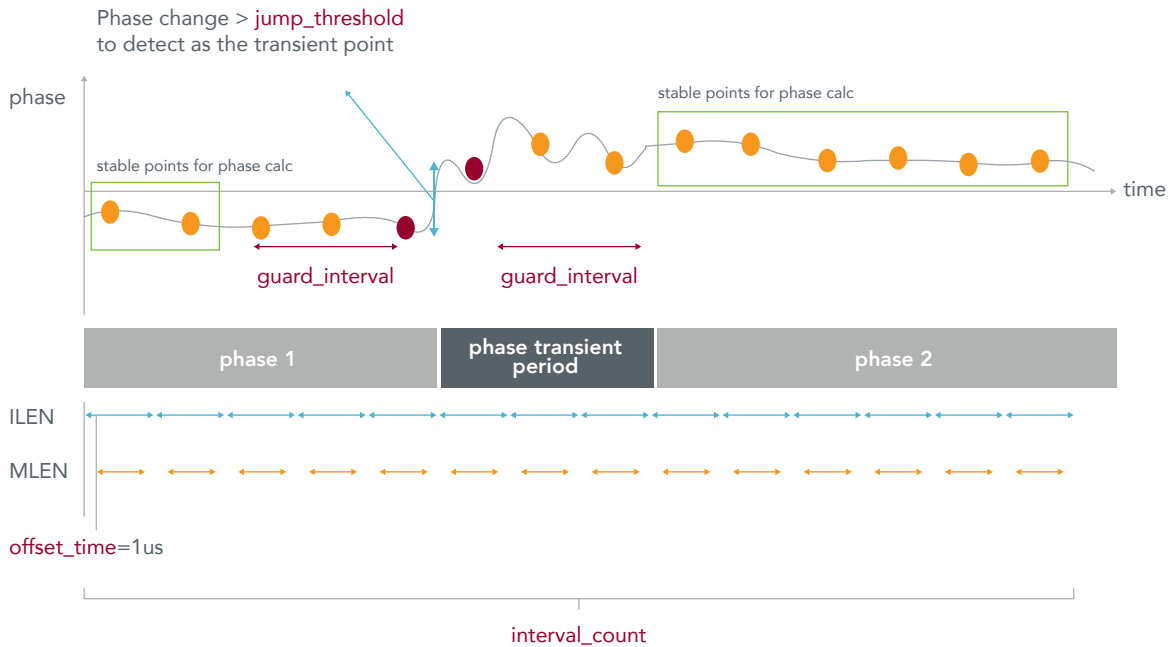
The MLEN means the measurement period in each interval, Frequency Error Correction will be more accurate at longer MLEN.

The total step (interval) numbers is calculated as the Capture time divided by Interval Length (ILEN). Phase Error will be more accurate at more steps. When Capture Time is fixed, the user must find a MLEN to balance FEC and Phase accuracy.

## Three methods to calculate phase change

### Case #1: User to specify the expected phase jump (jump\_threshold)

In this case user\_phase\_change\_time = 0 us.



```
CONFigure:PHASe:CHANge:CALC 1e-6,20,50,2,0
```

```
offset_time = 1 us
```

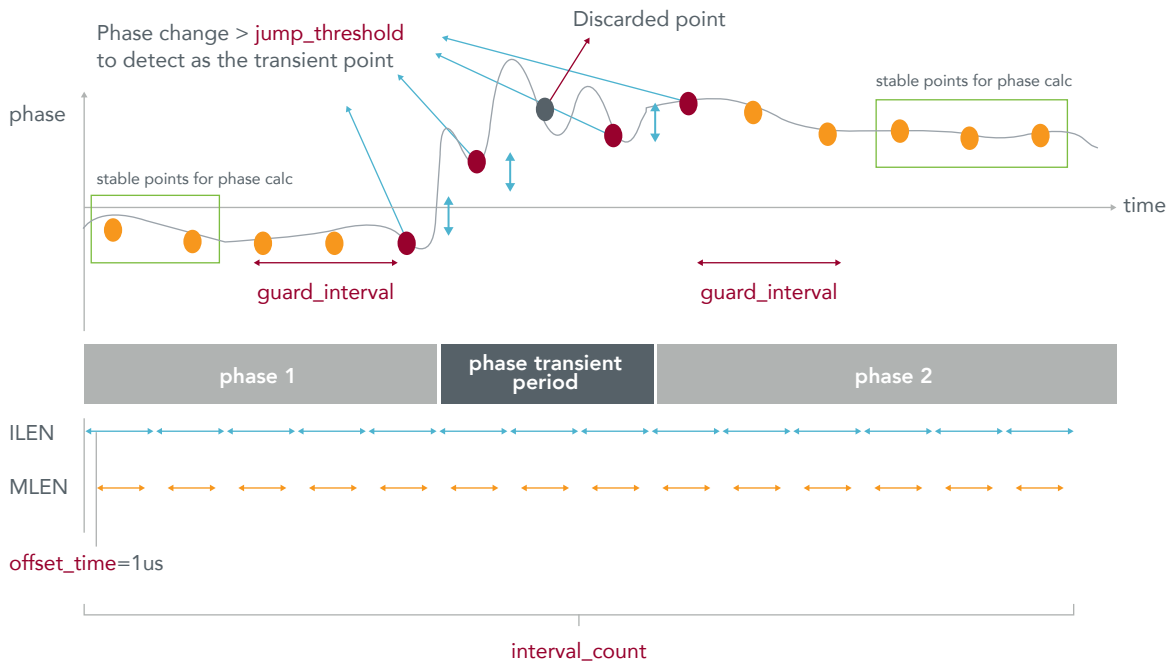
```
interval_count = 20
```

```
jump_threshold = 50
```

```
guard_interval = 2
```

```
user_phase_change_time = 0 us
```

If multiple points are detected to exceed the jump\_threshold, the points during those jumping points will be discarded when doing phase calculation.

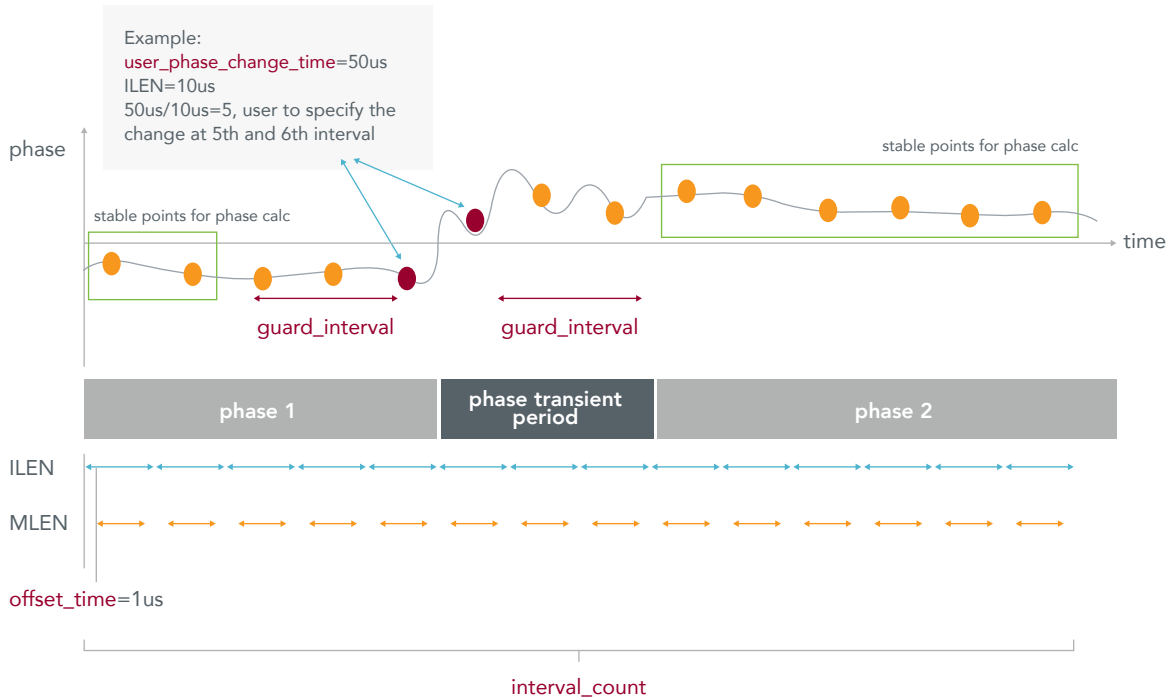


```

:TX=GPRF>>capt:load "/capture/AIP2-e01-to-e02-test12-20190410.iqvsa"
form:read:data asc
aprf
mrst
aprf
aprf
conf:ilen 5 us
conf:milen 4 us
CONF:PHAS:CHAN:CALC 1e-6,20,500,2,0e-6
EVAL:PHAS:CHAN?
:RX=0 error>>0,-349.432,1.436,2.419,1.872,4.194
  
```

## Case #2: User to specify the expected phase change time location

In this case `jump_threshold = 0`.



```
CONF:PHAS:CHAN:CALC 1e-6,20,0,2,50e-6
```

```
offset_time = 1 us
```

```
interval_count = 20
```

```
jump_threshold = 0
```

```
guard_interval = 2
```

```
user_phase_change_time = 50 us
```

```

:TX=GPRF>> capt:load "/capture/AIP2-e01-to-e02-test12-20190410.iqysa"
form:read:data asc
qprf
mrst
qprf
qprf
conf:ilen 5 us
conf:mle 4 us
CONF:PHAS:CHAN:CALC 1e-6,20,500,2,50e-6
EVAL:PHAS:CHAN?
:RX=0 error>>0,-349.432,1.436,2.419,1.872,4.194

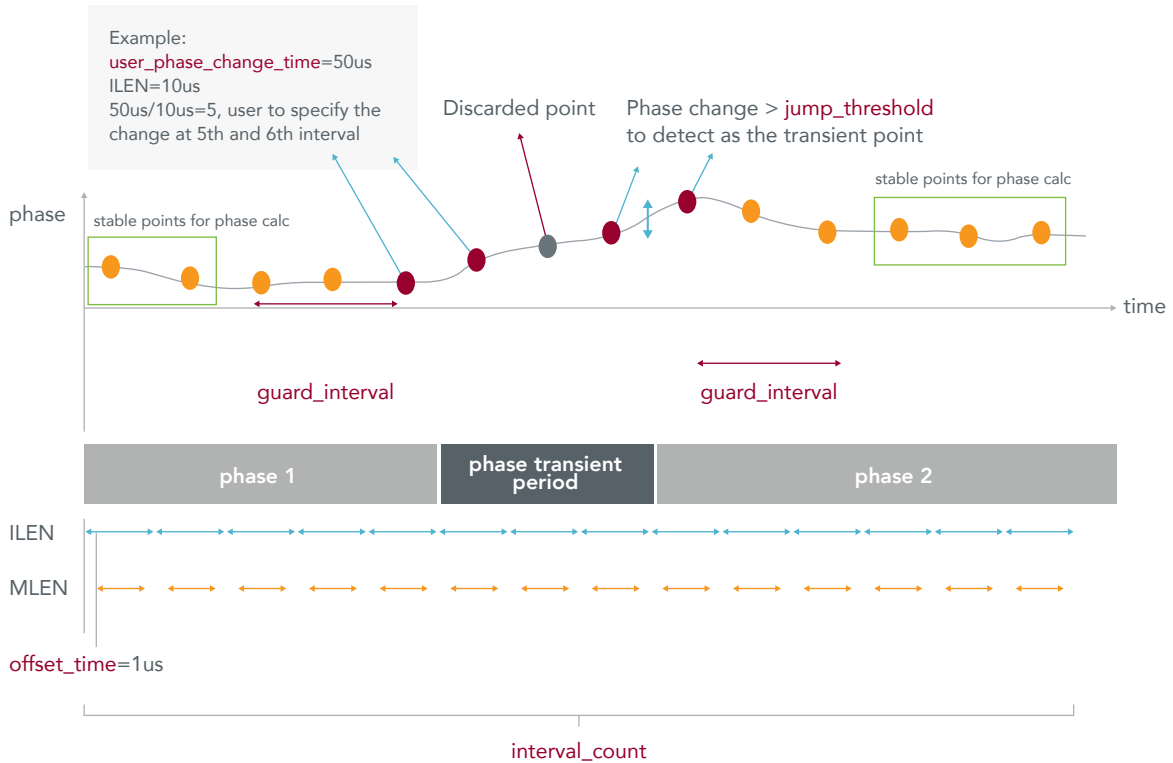
```



### Case #3: User to specify the expected phase change time location and expected phase jump

In this case  $\text{jump\_threshold} \neq 0$ ,  $\text{user\_phase\_change\_time} = !0$  us.

In this case, the phase points detected exceed  $\text{jump\_threshold}$  and the phase points nearby the  $\text{user\_phase\_change\_time}$  location are all considered as the phase transient period phase point.



```
CONF:PHAS:CHAN:CALC 1e-6,20,0,2,50e-6
```

```
offset_time = 1 us
```

```
interval_count = 20
```

```
jump_threshold = 50
```

```
guard_interval = 2
```

```
user_phase_change_time = 50 us
```

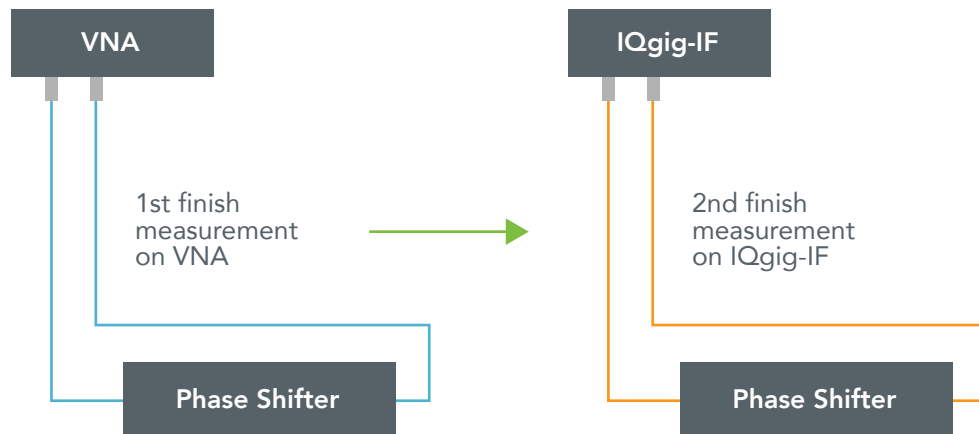
```

:TX=GPRF>> capt:load "/capture/AIP2-e01-to-e02-test12-20190410.iqvs"
form:read:data asc
:prf
:mrst
:prf
:prf
conf:ilen 5 us
conf:mlen 4 us
CONF:PHAS:CHAN:CALC 1e-6,20,0,2,50e-6
EVAL:PHAS:CHAN?
:RX=0 error>>0,-349.432,1.436,2.419,1.872,4.194
    
```

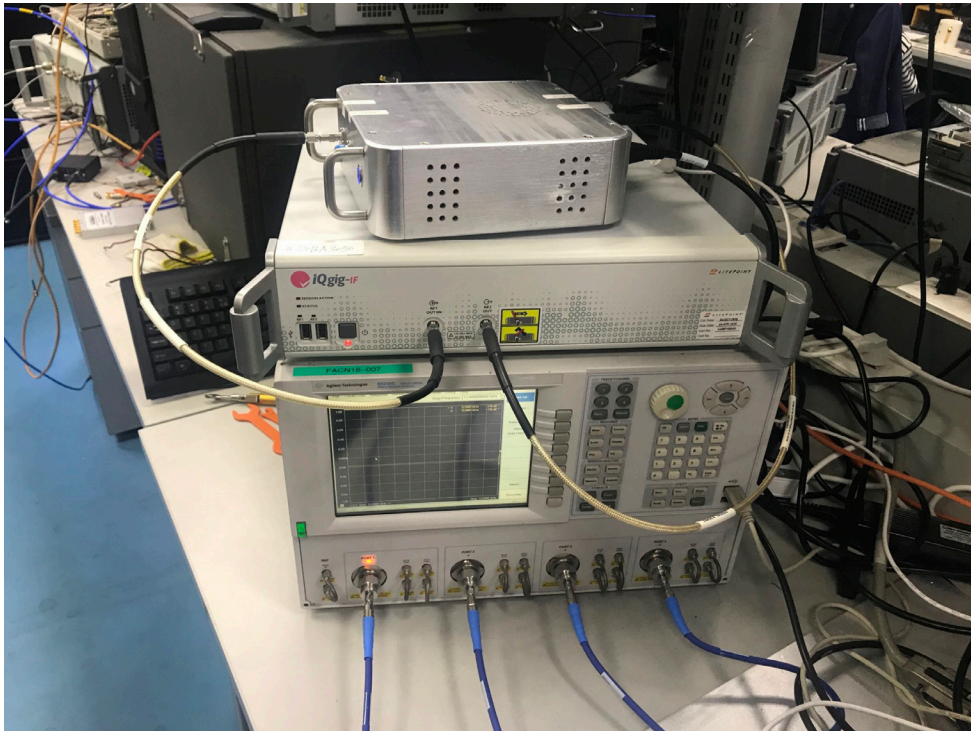
## Application Example

### Phase Measurement Accuracy Experiment

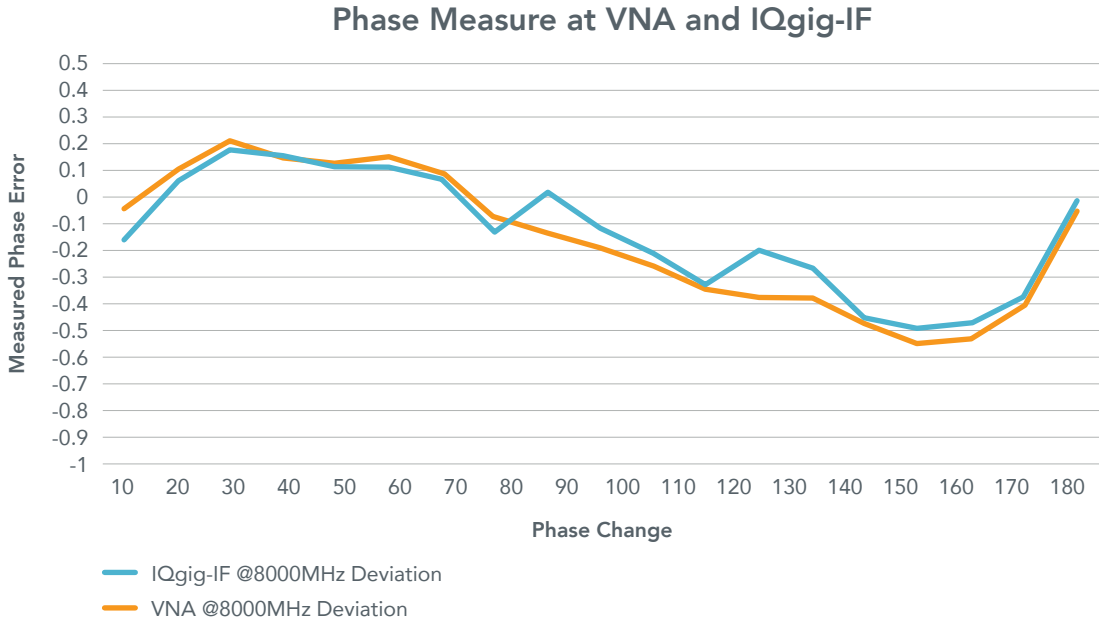
IQgig-IF to do the same measurement. Followed is setup diagram:



Test Setup Photo:



Test results benchmark between VNA and IQgig-IF

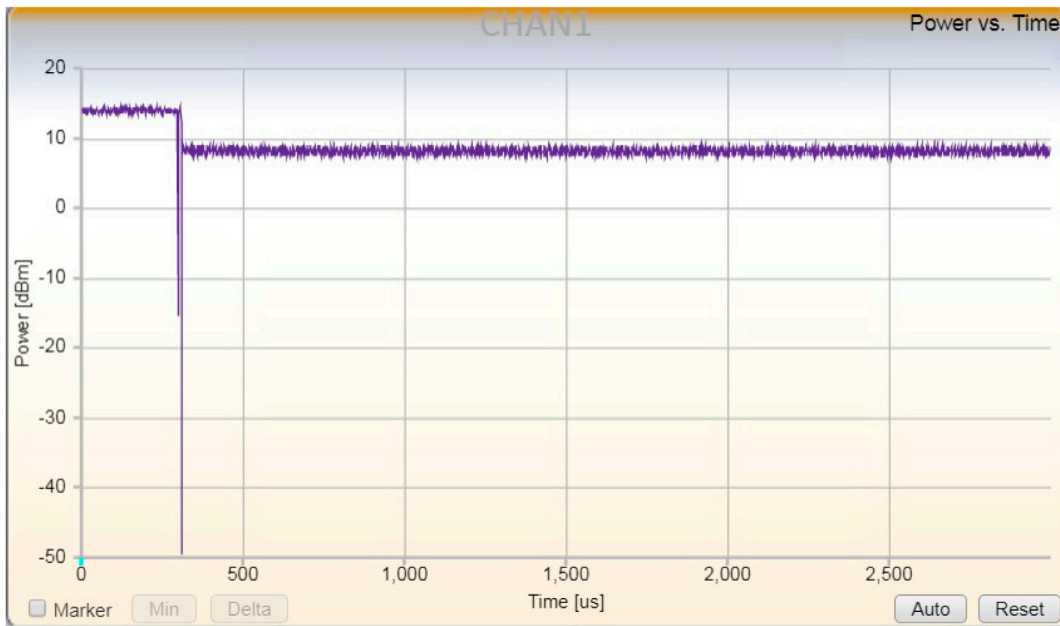


## Phase Measurement Example SCPI commands

In this example it gives a sample SCPI command set that show users the calc on a capture.

This is a capture with with VSA phase shift trigger and trigger offset -300us, therefore we can obviously see a PowerVsTime discontinuous at around 300us of this capture:

```
VSA;  
TRIGger:SOURce PSHift;  
TRIGger:OFFSet:TIME -300e-06;
```



```
CAPT:LOAD '/Capture/ant_element_change_e10-e20.iqvsa'  
form:read:data asc  
gprf  
conf:ilen 10 us  
conf:mflen 8 us  
CONF:PHAS:FEC ON;  
CONF:PHAS:FEM STAN;  
CONFigure:PHASe:CHANge:CALC 1e-6,60,0,1,300e-6  
EVAL:PHASe:CHANge?  
0,-271.600,1.683,3.412,14.419,25.505
```

The SCPI command below shows how to use a different GPRF interval length for the calculation. As an example, if the user wants to capture a total 600 us signal for the phase calculation (the phase change located at 300 us of this capture), then the interval count of the SCPI "CONFigure:PHASe:CHANge:CALC" will be 600 us / ilen. This results in the combinations below:

```

conf:ilen 10 us
conf:milen 8 us
CONFigure:PHASe:CHANge:CALC 1e-6,60,0,1,300e-6
conf:ilen 20 us
conf:milen 18 us
CONFigure:PHASe:CHANge:CALC 1e-6,30,0,1,300e-6
conf:ilen 30 us
conf:milen 28 us
CONFigure:PHASe:CHANge:CALC 1e-6,20,0,1,300e-6
conf:ilen 40 us
conf:milen 38 us
CONFigure:PHASe:CHANge:CALC 1e-6,15,0,1,300e-6
conf:ilen 50 us
conf:milen 48 us
CONFigure:PHASe:CHANge:CALC 1e-6,12,0,1,300e-6
conf:ilen 100 us
conf:milen 98 us
CONFigure:PHASe:CHANge:CALC 1e-6,6,0,1,300e-6

```

The table below shows the different results when using the above settings.

In the SCPI "EVAL:PHASe:CHANge?", the returned numbers include the RMS phase error and peak phase error of phase1 and phase2. These can be used to judge if the GPRF interval setting is proper for the capture.

In this table, it is clear that the GPRF interval length of 10 us results in the largest error in phase1 and phase2. Therefore, using an interval length >= 20us is a more appropriate setting for this test setup.

ILEN	MLEN	Result	phase 1 rms error	phase 1 peak error	phase 2 rms error	phase 2 peak error
<b>10</b>	<b>8</b>	<b>-271.6</b>	<b>1.683</b>	<b>3.412</b>	<b>14.419</b>	<b>25.505</b>
20	18	-301.635	1.466	2.836	1.026	2.197
30	28	-300.569	1.475	2.634	0.925	2.157
40	38	-302.859	1.2	1.805	0.373	0.784
50	48	-301.204	1.211	1.609	0.543	1.012
100	98	-300.738	0	0	0	0

---

## Appendix

### General comments on the phase shift TFC and Applications Note

The term “*phase shift*” to describe a sudden and lasting change of phase. The term “*phase change*” is more general in nature.

Commands are spelled out in full as a reference to the entire command.

Example: PHASe:CHANGe:LIBRary:VERSion?  
CONFigure:PHASe:CHANGe:CALCulation  
FETCh[:SEGMent#]:PHASe:CHANGe?

The abbreviated commands are OK to use in the application and some of the executed output in this Applications Note

The EVALuate command is used in this Applications Note instead of the FETCh command, since this command both calculates and fetches: EVALuate[:SEGMent#]:PHASe:CHANGe?

This phase\_shift\_tfc.js TFC was developed and is distributed by LitePoint Taiwan

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