Application Note 59

SPIRENT
Communications

Measurement & Alignment of TAS 4500 FLEX Phase & Delay Characteristics

The TAS 4500 FLEX RF Channel Emulator provides multi-path delay, and phase shift as well as fading, and path loss characteristics of RF communication channels. This application note provides guidance on how to measure and align the path delay and phase characteristics of the 4500 FLEX with a RF network analyzer. In this application note the measurement system setup and procedures are described for an eight-branch diversity configuration with a 3.35 GHz carrier and the 4500 FLEX LO source set to "external".

Note: Alignment of absolute path phase and delay characteristics between channels is not a warranted specification of the TAS 4500 FLEX. These characteristics are subject to drift with time and temperature. A phase drift of less than 10 degrees per hour is typical.

Equipment Requirements

The test equipment required to perform this procedure is listed below.

Equipment	Requirements
RF Network Analyzer	Hewlett Packard 8753D or equivalent
	Frequency range of at least 3.4 GHz
	Bandwidth of at least 6.0 MHz
	50 ohm impedance
RF Signal Source	Output frequency range of at least 3.21 GHz
	Output power of at least +13 dBm
	50 ohm impedance

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FLEX Delay Phase & Characteristics

Measurement Equipment Setup

The Hewlett Packard 8753D Network Analyzer is the recommended measurement device for observing the phase and delay characteristics of the 4500 FLEX. The network analyzer is setup to measure the forward transmission (S21) between Port 1 and Port 2. It is extremely important that the 8753D calibration procedures and practices (specified by HP) are followed otherwise all measurements are invalid. The user can reference the Hewlett Packard 8753D Network Analyzer User's Guide for all network analyzer calibration and setup instructions. The network analyzer system calibration must include all cables, splitters and connectors between the network analyzer and TAS 4500 system.

NOTE: It is important to allow sufficient time for all the test and measurement equipment to "warm-up" and stabilize. It is also important to have a temperature stable environment to reduce drift in all of the test and measurement equipment. A 1.5-hour warm-up period has produced the best empirical results when measuring system phase stability at approximately room temperature (21-23 degrees Celsius).

After calibration of the network analyzer the following setup configuration is used:

- A source power of -1.0 dBm.
- Set center frequency and marker to 3.35 GHz.
- Span of 6.0 MHz.
- Data smoothing turned ON with smoothing aperture at 1 % of span.
- Data averaging factor of 16 samples.
- Set display mode to DATA.
- Set the format mode to Delay.

TAS 4500 Flex Test Setup

The test setup and procedures in this application note are described for an eight-branch diversity configuration with a 3.35 GHz carrier and the 4500 FLEX LO source set to "external". Before starting the measurement procedure each TAS 4500 FLEX in the test setup should be set to the following configuration:

- Set the input carrier frequency to 3.35 GHz.
- Set the LO configuration to external.
- Connect the LO reference source to the LO distribution hardware to provide +13 dBm, 3.21 GHz, at the LO IN port of the TAS 4500.
- Set the input reference level to -10.0 dBm
- Set the output attenuation to 0.0 dB.
- For all of the channels and paths within each TAS 4500 unit set:
  - Set the loss of each path to 0.0 dB.
  - Set Log Normal fading for each path to OFF.
  - Set the modulation type to PHASE for each path.

Figure 1 illustrates an example of a test and measurement setup. Port 1 of the network analyzer is input to a 1:8 power splitter, where each splitter output is connected to one of the TAS 4500 channel inputs. Port 2 of the network analyzer is used to measure the phase and delay characteristics for each path relative to path 1 channel 1 of the diversity system.

NOTE: SMA connections that are in the test setup should be tightened with a SMA torque wrench to prevent damage to the connectors and cable. Using a torque wrench will allow a reliable and repeatable measurement system and procedure. Phase stable cables are recommended for connecting the TAS 4500 to the network analyzer.

FLEX Delay Phase & Characteristics

Measurement and Alignment Procedure

Once the measurement setup and 4500 FLEX test setup is complete as described above, the following procedure can be used to measure and align the delay and phase characteristics.

For any specific path, delay should be measured and aligned before phase. Each channel of the 4500 FLEX has a delay variation associated with its RF front end. This is in addition to a small delay variation that may exist between paths within a specific channel. The reference path (Channel 1 Path 1) must have an initial delay setting that is larger than the magnitude of the total delay variation that exists between any pair of paths in the test system. This initial delay setting for the reference path is defined as its delay offset. Delay can not be set to a negative value. As a result, a delay offset on the reference path is required to avoid the need for a negative path delay setting to align path delay. A delay offset of 100 nsec is typical for the reference path.

This procedure measures and aligns path delay relative to the delay offset for Channel 1 Path 1. To accomplish this, the delay of Channel 1 Path 1 is measured and stored as the reference for measurements on all the other paths. The delay of each path relative to Channel 1 Path 1 is monitored by the network analyzer while the delay setting is adjusted on the 4500 FLEX. Delay is adjusted on each path until the measured relative delay is less than 1 nsec. The path delay setting that corresponds to a relative delay measurement of less than 1 nsec is the delay offset value that is required for that path to be aligned with the absolute delay of Channel 1 Path 1.

The procedure also measures and aligns the phase for each path relative to the measured phase of the reference path (Channel 1 Path 1). The phase of each path relative to Channel 1 Path 1 is monitored by the network analyzer while the phase setting is adjusted on the 4500 FLEX. Phase is adjusted on each path until the measured relative phase is less than 0.1 degrees. The phase setting that corresponds to a relative phase measurement of less than 0.1 degrees is the phase offset value that is required for that path to be aligned with the phase of Channel 1 Path 1. The phase offset of Channel 1 Path 1 is 0.0 degrees.

Delay and phase offsets are added to the desired values of relative path delay and relative path phase to better align the absolute delay and phase.

NOTE: It is important to set all paths to "OFF" except for the path being measured.

Measure delay of Channel 1 Path 1

1. Set the 8753D format to Delay scale. Use the "autoscale" function to adjust measurement range and resolution.
2. Turn on Channel 1 Path 1 and set the path delay to 100 nsec. Record this as the delay offset for Channel 1 Path 1. Make sure that all the other paths are off.

Measure phase of Channel 1 Path 1

3. Set the 8753D format to Phase scale, use the "autoscale" function to adjust measurement range and resolution.

Use results of Channel 1 Path 1 delay and phase measurements to set the reference for relative delay measurements and relative phase measurements.

4. Store the 8753D data-to-memory and set the display to DATA/MEM (Figure 2).

NOTE: During each parameter measurement the 8753D channel averaging (AVE) must be reset.

Set current path to "OFF" and set the next path to be measured to "ON"

5. Turn-off Channel 1 Path 1 (current path) and turn-on Channel 1 Path 2 (next path) on the 4500 FLEX.

Align delay of Channel 1 Path 2 (next path)

6. Set the 8753D format to Delay, use the "autoscale" function to adjust measurement range and resolution. Adjust the path delay setting of Channel 1 Path 2 (next path) on the 4500 FLEX until the 8753D reads less than 1 nsec (Figure 3). Record this delay setting is the delay offset for Channel 1 Path 2 (next path).

Align phase of Channel 1 Path 2 (next path)

7. Set the 8753D format to Phase, use the "autoscale" function to adjust measurement range and resolution. Adjust the Channel 1 Path 2 (next path) phase setting on the 4500 FLEX until the 8753D reads less than 0.1 degrees (Figure 4). Record this phase setting as the phase offset for Channel 1 Path 2 (next path).

Align delay and phase on remaining paths of the Channel 1 (current channel)

8. Repeat steps 5 through 7 for all the remaining paths of Channel 1 (current channel).

Setup cables to measure Channel 2 (next channel)

9. After adjusting the phase and delay offset for all paths of Channel 1 (current channel), Port 2 of the 8753D must be disconnected from the Channel 1 (current channel) output of the 4500 FLEX and connected to the Channel 2 (next channel) output. During this step it is important not to disturb the calibration of the cables and connectors. This is accomplished by holding the jacket of the cable stationary and only moving the wrench area of the SMA-connector(s) during disconnection. Also, be sure to use a SMA torque wrench during the connection procedure.

Align delay and phase of paths on Channel 2 (next channel)

10. After connecting the Channel 2 (next channel) output port of the 4500 FLEX to the 8753D Port 2, steps 5 through 7 are repeated for all the paths of Channel 2 (next channel).
11. Repeat steps 5 through 10 for TAS 4500 FLEX Channel 3 through Channel 8.

At this point all of the offset values for phase and delay in the test setup have been measured.

Conclusions

The setup and test procedures for measuring the channel offset parameters of the TAS 4500 in an eight-branch diversity configuration are described and demonstrated. Great care must be taken in setting up the test and measurement system. Calibration of the test and measurement equipment (in this case a HP8753D network analyzer) must be performed, all cables must be phase stable, and all connections must be tightened to the manufacturer's torque specification.

Before measuring the phase and delay offset a 1.5 hour system "warm-up" time is recommended. Testing of the system shows that both path delay and phase offset drift are greatly reduced after a 1.5 hour warm-up period. Along with sufficient system warm-up, a fairly temperature stable (+/- 0.5o C) test environment should be maintained. This will reduce parameter drift and allow for more repeatable (smaller variance) testing.

Figures

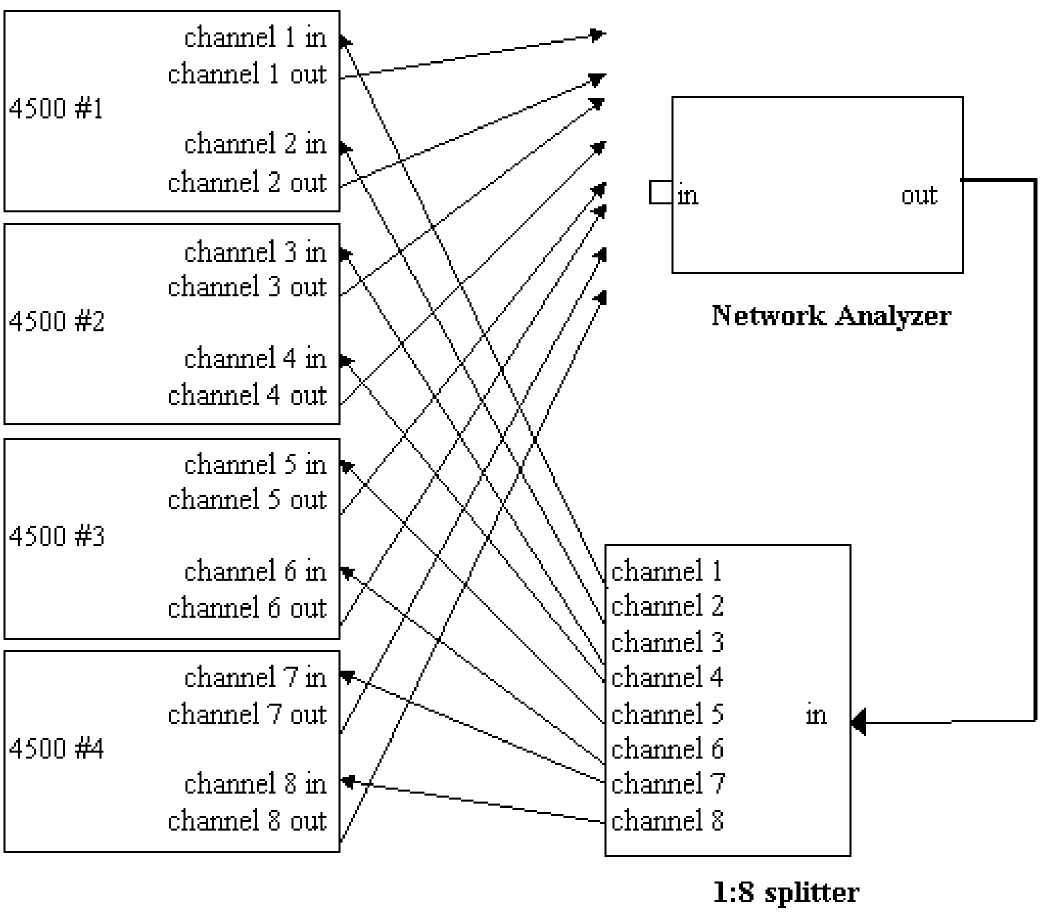

Figure 1. Eight Branch Offset Measurement Test System

Figures - *Continued*

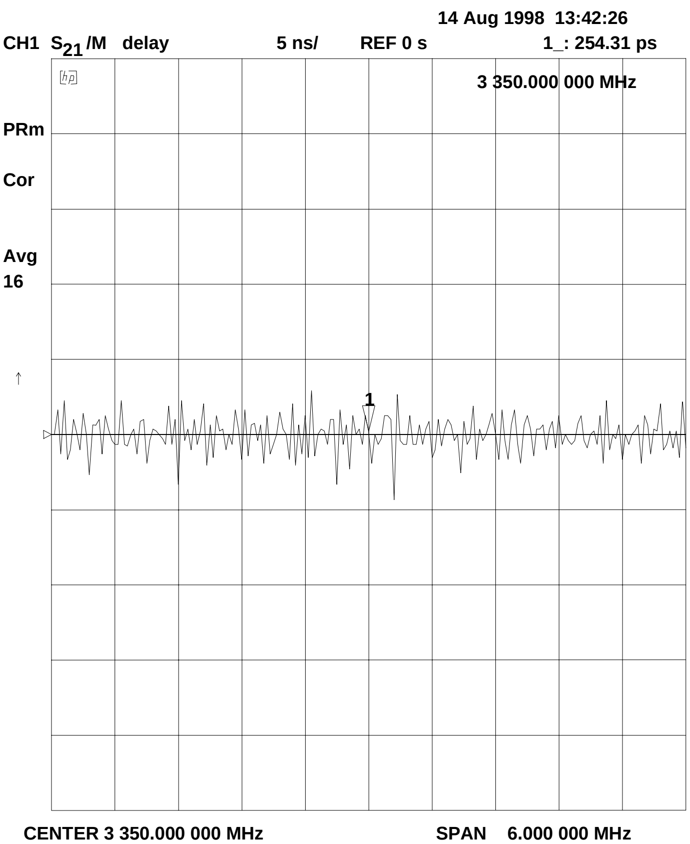

Figure 2. Channel 1 Path 1 Delay Measurement

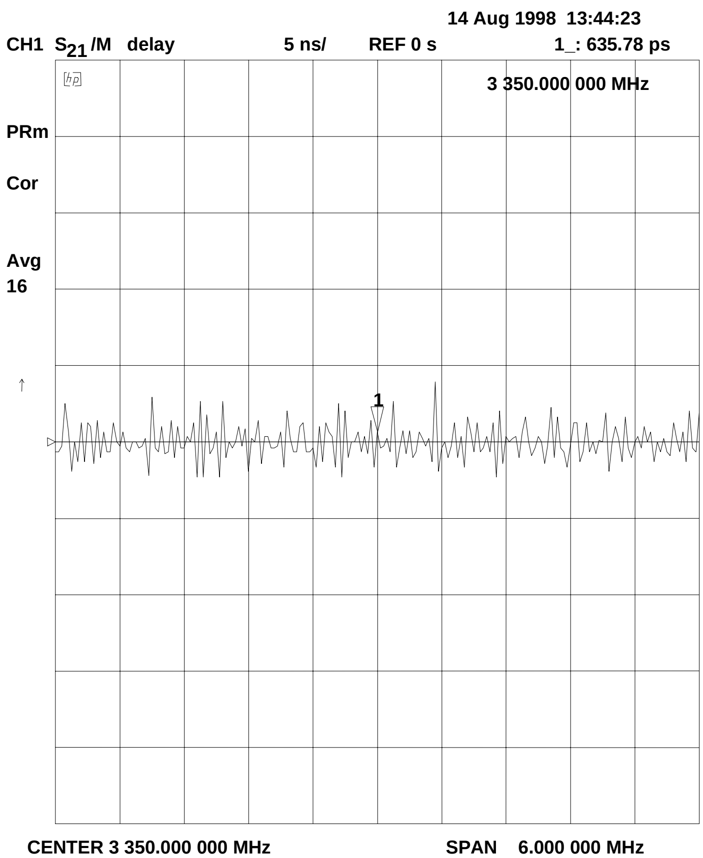

Figure 3. Channel 1 Path 2 Delay Alignment

Figures - *Continued*

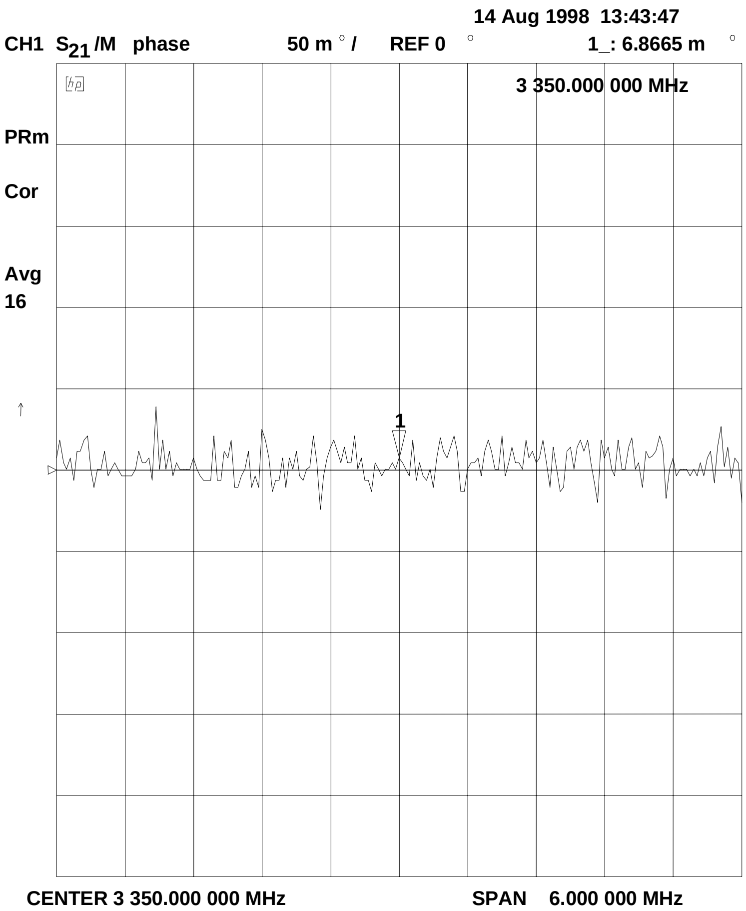

Figure 4. Channel 1 Path 2 Phase Alignment

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