Agilent PN 8510-14

Using Multiple Test Sets with the Agilent 8510C

Product Note

Discontinued Product Information
— For Support Reference Only —

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Introduction

A single Agilent Technologies 8510C network analyzer can be configured to alternately control up to four test sets. The operator can switch between test sets, without reconnections, using only front panel controls. In many applications, this results in reduced setup times, reduced test times, and increased productivity. This product note describes the multiple test set capability, including a description of how it works and detailed operating instructions. A list of required equipment is detailed on page 13.

Applications

Multiple test set capability is particularly useful in the following applications.

Combined millimeter-wave/microwave setups.
The 8510C can be configured for millimeter-wave measurements with waveguide test sets in the waveguide bands from 33 to 110 GHz. If lower frequency coverage is also required, the millimeter-wave system can be combined with a coaxial test set, such as the Agilent 8517B (0.045 to 50 GHz). Using the multiple test set capability of the 8510C, the operator can easily switch from the coaxial test set to the millimeter-wave test set without test system reconfiguration (see Figure 1).

*Multiple coaxial test sets for volume production.*
When a test station is used in volume production, throughput is a primary consideration. Throughput can be limited by measurement time, particularly when the device must be cycled over its operating conditions, such as temperature or bias. Throughput is also limited by the amount of time required for the operator to connect and disconnect the device under test.

In many such applications, throughput can be greatly enhanced using 8510C multiple test set operation. (For example, it only takes six keystrokes to switch between test sets.) The cover photo shows a simple example using two test sets. While a measurement is proceeding on device #1 using test set #1, the operator can connect device #2 to test set #2. Device measurement time of device #1 (test system) and connection time of device #2 (operator) may be overlapped, thus decreasing total test time.

When testing in various connector types. Most 8510 test stations are used for measurements in a variety of connector types. When the connector interface is changed frequently, multiple test set operation can save time by reducing the number of calibrations required.

Consider the case of single test set operation. Whenever connector types are changed, test port cables and/or adapters must be reconfigured, and a new calibration is required. This can be very frustrating and time-consuming, particularly if the connector type is changed frequently. With multiple test sets, each test set may be configured and calibrated for a particular connector type. Switching connector types is now as easy as changing the active test set and recalling the appropriate cal set. The operator saves time since it is not necessary to recalibrate or change cables or adapters.

One test set is dedicated for on-wafer measurements, while another is dedicated for coaxial measurements. Having one system dedicated for device characterization in an on-wafer environment avoids set up and re-set up each time wafer probing is required. Since wafer probing stations and accessories are not only expensive, but require a high level of expertise to use, minimizing the
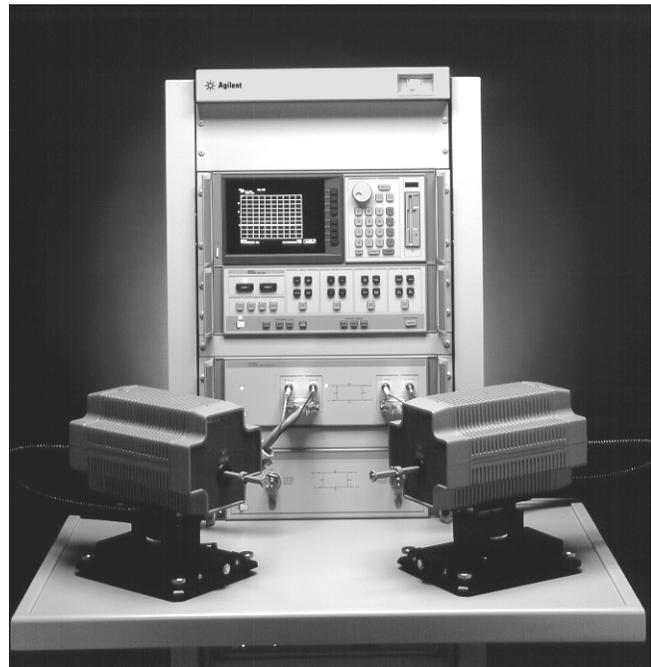
Figure 1. Combined millimeter-wave/microwave system

number of setups will save time and money. With one system dedicated for coaxial measurements, one can easily switch back and forth between wafer and coaxial testing without reconfiguring the system each time. From device characterization in chip form to final testing in packaged components, all measurements can be made using the same Agilent 8510 system.

Multi-user R&D test stations. In an R&D environment, test stations with specialized fixtures can be very complex. In addition, setup and calibration can be very time-consuming for the user. The 8510 allows multiple test set capability within the system with independent setup and calibration. Easy switching ability allows several users to utilize the same test station without disturbing or disconnecting another user's setup.

Antenna measurements. Multiple test set capability is also useful in many antenna measurements. For example, many 8510 antenna measurement systems have both external mixer capability for pattern measurements and an S-parameter test set for impedance measurements. Switching active test sets without reconnections saves the operator time. (Note: using the Agilent 8530A would require a different operating system.)

Taking advantage of test set capabilities. Each test set in the 8510 family excels in a particular type of measurement. Multiple test set operation allows the user to combine the unique capabilities of multiple test sets into a single 8510 system. The 85110AS-parameter test set, for example, allows measurements of pulse profiles using a pulsed RF signal from 2 to 20 GHz. However, the user may also wish to have a general purpose test set with a wider frequency range, such as the 8517B (0.045 to 50 GHz). Multiple test set operation provides an economical and convenient way for the user to take advantage of both test sets with a single 8510 system.

System description
In the Agilent 8510 system, the test set routes the source RF signal to the device under test, then separates the signals to be measured (reference, transmitted, reflected). The test set then downconverts the signals to a 20 MHz IF which is then routed to the 8510. With multiple test sets, the 8510 must:

1. Route the source RF to the active test set.
2. Select the IF signals from the active test set.

In this section we describe how the RF and IF signals are switched with multiple test sets in the system, beginning with two test sets (see Figure 2).

RF switching
The 8510C must first route the RF output of the network analyzer source to the RF input of the ACTIVE test set. The 8510C accomplishes this by issuing a command to the Agilent 11713A attenuator/switch driver (address 28) which in turn controls a coaxial switch. As shown in Table 1, when test set #1 is active, the coax switch is set to port 1, so the RF output is applied to test set #1. When the 8510 test set address is changed from even to odd (e.g., 20 to 21), the coaxial switch is changed to port 2 and the RF source output is applied to test set #2. If the address is changed back from odd to even (e.g., 21 to 20), then the RF output is re-routed to test set #1.

IF switching
Besides routing the RF, the 8510 must select the IF signals from the active test set. In the standard test set, the 20 MHz IF signals generated within the test set are applied to the J11 TEST SET INTERCONNECT, and then routed to the 8510C for processing. Option 001 for the test set adds a set of IF switches to also allow the selection of IF signals from other system test sets.

For the configuration shown in Figure 1, when test set #1 is active, the IF signals from test set #1 are applied to J11. When test set #2 is active, the IF signals from test set #2 are applied to J10 of test set #1, passed through to J11 of test set #1, and on to the 8510C. Note that test set #1 must be configured with Option 001 (IF switching), but test set #2 does not require Option 001.

The 8510C determines which test set is active using the test set address. Each time the test set address is changed, the 8510 issues an Off (Inactive) command to the previously addressed test set and an On (Active) command to the newly addressed test set.
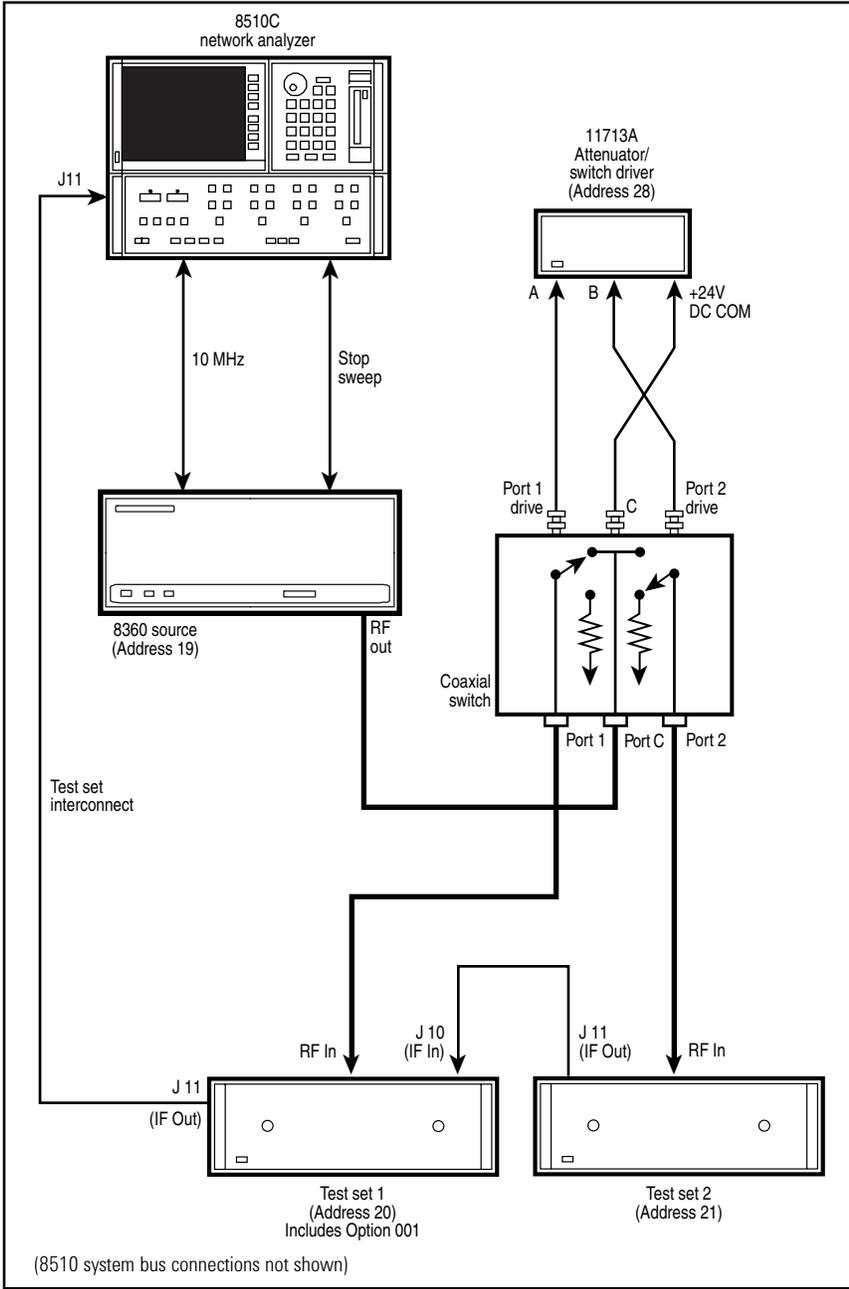
Figure 2. Agilent 8510 dual coaxial test set configuration

New address of test set	Test set selected	Coaxial switch port selected
20 21 (or 31)	1 2	Port 1 Port 2

Table 1. Coaxial switch positions with two test sets
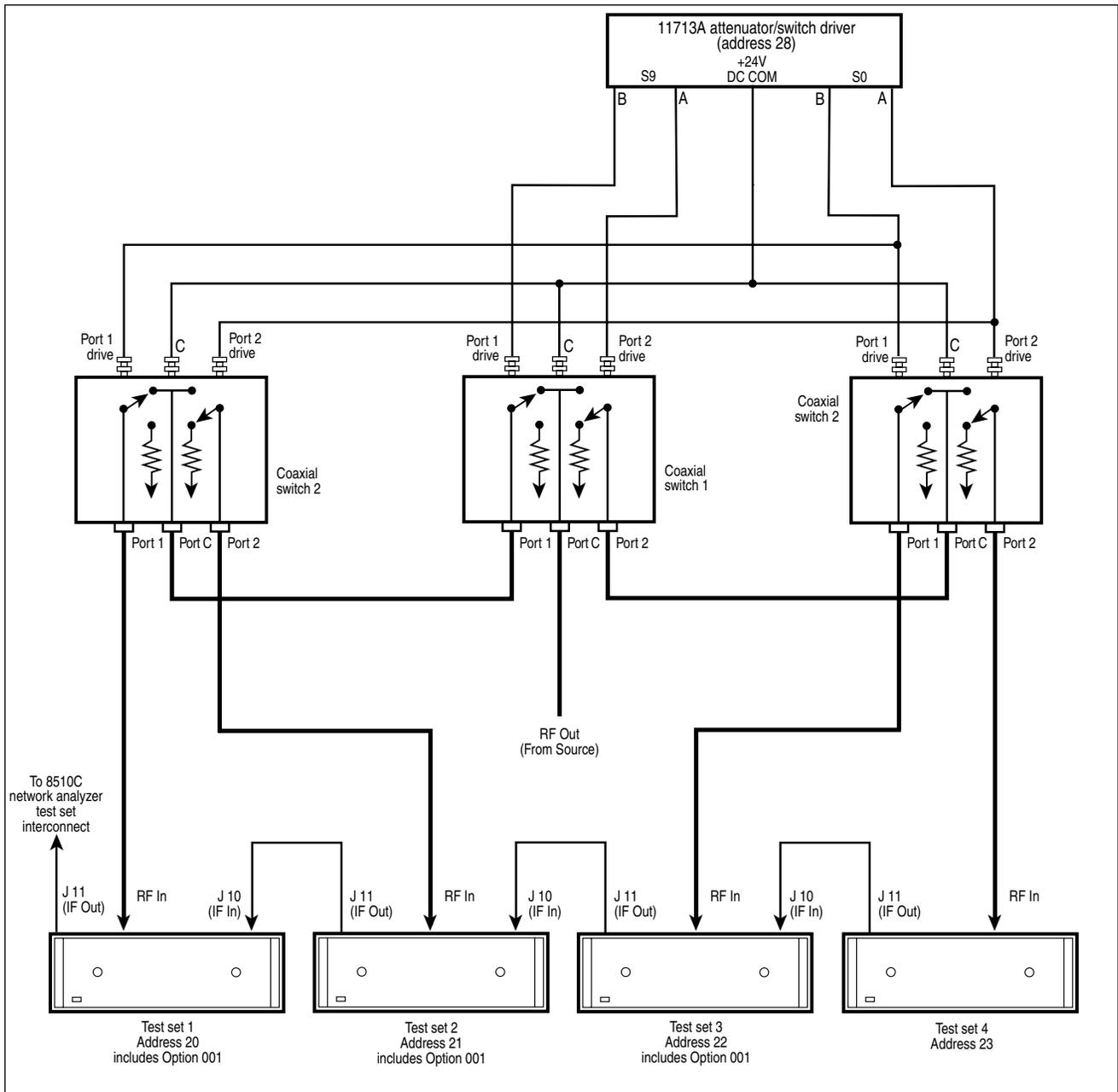
Figure 3. RF and IF switching with four test sets using three SPDT switches

Address of test set	Test set selected	Coaxial switch port selected	
		Switch #1	Switch #2
20	1	Port 1	Port 1
21	2	Port 1	Port 2
22	3	Port 2	Port 1
23 (or 31)	4	Port 2	Port 2

Table 2. Coaxial switch positions with four test sets using three SPDT switches

More than two test sets

The dual test set configuration can be easily extended to include up to four test sets. Figure 3 shows the configuration with four test sets in the system. Note that more coaxial switches are required, and that all test sets must have Option 001 (IF switching), except the last one in the chain.

Multiple single-pole-double-throw (SPDT) coaxial switches can be replaced by one multiport switch such as a single-pole-4-throw switch (SP4T).

Table 2 shows the recommended test set addresses 20 through 23. If other addresses are used, their modulo 4 addresses must each be unique; i.e., 0, 1, 2, 3. The 8510 only sends commands to the switch driver when a change is made in the two least significant bits of the test set address. S0 is toggled only when the least significant bit is changed (1's) and S9 is toggled only when the second least significant bit is changed (2's).

Millimeter-wave and microwave configuration

Microwave test sets can easily be added to the Agilent 85106D millimeter-wave system. The standard millimeter-wave test set controller, the 85105A, comes equipped with IF and RF switching for test set routing up to 26.5 GHz. Adding Option 050 to the 85105A extends RF switching capability up to 50 GHz.

Reconnections are not required when switching between millimeter-wave and microwave operation. External switches or switch drivers are not necessary. The RF and IF signals are automatically switched to the appropriate test set when that test set is turned ACTIVE.

Millimeter-wave test sets use two sources and the multiple source control of the 8510. Once configured, the multiple source settings should be saved so that they can be easily recalled. These settings are saved in the hardware state, not the instrument state. Hardware states should be saved onto disc. This is described in detail under *System operation.*

Figure 4. Agilent 85106D with Option 001, coaxial and waveguide capabilities all in one
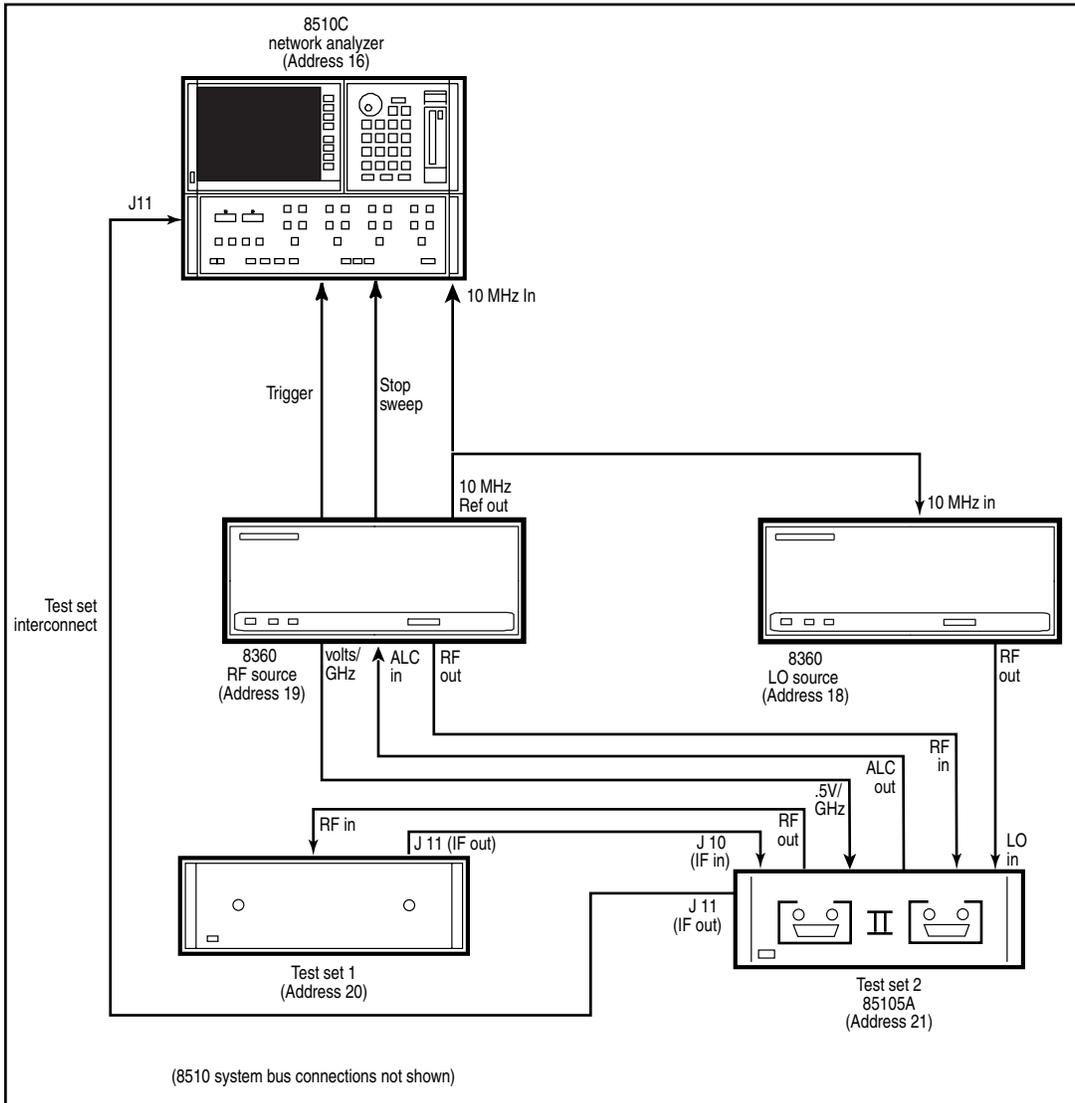
Figure 5. Dual test set configuration with millimeter-wave and microwave test sets (simplified)

8510XF system with additional microwave test set

The Agilent 8510XF system (Figure 6) consists of the 8510C receiver, millimeter-wave subsystem, 83651B RF synthesizer, and 83621B LO synthesizer. (The millimeter-wave subsystem consists of a millimeter-wave controller and two test heads.)
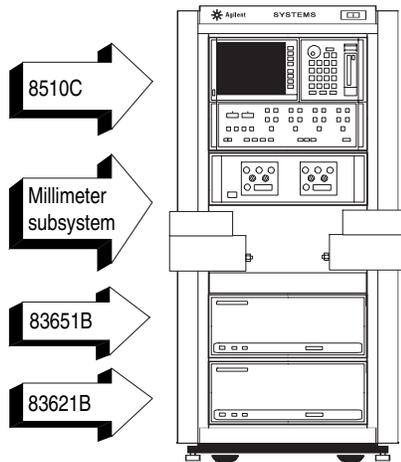

Figure 6. Agilent 8510XF system

This system provides the broadest frequency coverage in one continuous sweep, 45 MHz to 110 GHz. Because of the broadfrequency coverage of the 8510XF system, it is desirable to dedicate this system to perform one type of measurement, such as on-wafer broadband device characterization. However, it is easy to add microwave test sets (such as the 8517B) to perform banded coaxial measurements as well (see Figure 8).

To configure the 8510XF system for multiple test sets, the system is required to have Option 006. Option 006 adds a 50 GHz coupler and amplifier to the RF input path of the millimeter-wave controller to provide a 50 GHz coupled RF output. This option does not provide any RF switching capability; instead, the RF output is available whenever there is an RF input signal.

Reconnections are not required when switching between the 8510XF and microwave operation. External switches or switch drivers are not necessary. The RF signals (both RF-In to the 8510XF and RF-In to the microwave test set) are always available. The IF signal is automatically switched to the appropriate test set when that test set is turned ACTIVE.

Operating system requirements

The 8510XF system requires a different operating system than the standard 8510 test sets. When using the 8510XF system for broadband measurements, the operating system with part number E7340-10001 must be installed. When using the standard 8510 test sets, the operating system with part number 85101-80116 must be installed. After the correct operating system is installed, the system will be fully configured for the desired testing.

Loading the operating system

To load the operating system disk into the 8510C using the floppy drive on the front panel, perform the following sequence:

    hardkey SYSTEM
    softkey MORE
    softkey SERVICE FUNCTIONS
    softkey TEST MENU
    enter 1, 9
    hardkey = MARKER
    select PG_8510C or PG_8510XF
    softkey LOAD FILE

After the desired operating system (PG_8510C or PG_8510XF) has been successfully loaded, the ACTIVE lights on both test sets (8510XF and 851X microwave test set) are lit. To de-activate the test set not being used, perform the following sequence:

    hardkey SYSTEM
    softkey GPIB ADDRESS
    softkey TEST SET
    enter 2, 3 or 2, 0 (enter the GPIB address of the
        test set to be de-activated)
    hardkey X1
    enter 2, 0 or 2, 3 (enter the GPIB address of the
        test set to be activated)
    hardkey X1

The ACTIVE light of the test set to be de-activated is now turned OFF. The ACTIVE light of the desired test set remains turned ON. Repeat the above procedure each time a change of test set is needed.

Synthesizer (Agilent 8360) language setting

If the system is not operating properly, check the language setting of the synthesizer. The dip switches for language setting are located on the rear panel of the unit. The language setting should be 111 for the 8510XF, and 001 for the 851X microwave test sets.
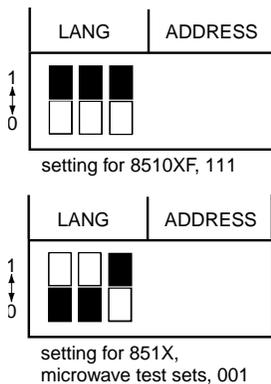
Figure 7. Synthesizer dip switch
language settings
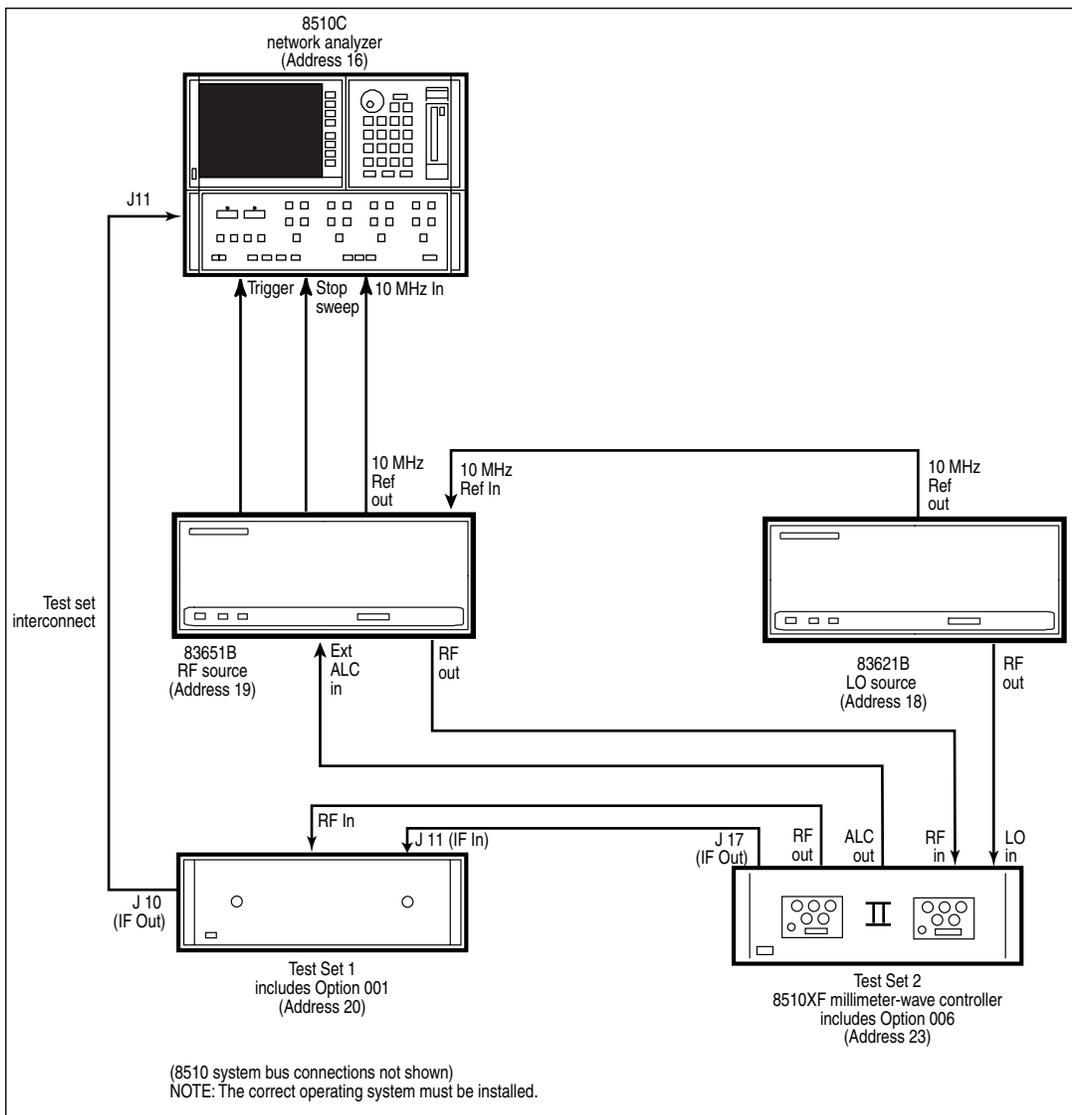
Figure 8. Agilent 8510XF system configured with a microwave test set (simplified)

System operation

This section describes how to operate the Agilent 8510C system with multiple test sets. This includes the hookup, system initialization, and instructions for transitioning from one test set to another. Also included are special considerations when operating under computer control over GPIB. A list of required equipment is shown on page 13.

Installation

1. Connect the equipment as shown in Figure 2. If more than two test sets are used, see Figure 3. Be sure all instruments, including the test sets and the Agilent 11713A, are connected to the 8510 system interface.

2. Set the addresses of the system's coaxial test sets on the test set rear panel. The recommended addresses are 20, 21, 22, and 23. To help you keep track of the addresses, you may wish to put a label on the test set front panel.

3. Set the address of the 11713A switch driver to 28, and connect the coaxial switches to the S9 and S0 banana plug terminals at the rear panel of the 11713A. Any common wire is adequate for this connection. Soldering the wires to the coaxial switch terminals is recommended.

Initialization at power-up

Each time the system is powered on, it must be properly initialized.

1. Power on all system instruments, the 8510C last.

2. Check the ACTIVE indicator of all coaxial test sets in the system. At power-up, more than one test set may be ACTIVE. Only one system test set should be ACTIVE at any time. This will be resolved in steps 3 and 4.

3. Set the address expected by the 8510C. On the 8510C, press LOCAL, then ADDRESS OF TEST SET. Check the test set address expected by the 8510C. Enter the desired test set address, followed by X1. Press MORE, then ADDRESS OF RF SWITCH and enter 28, X1.

4. Again, check the ACTIVE indicator of each test set. If an undesired test set is ACTIVE, then you must de-activate it by temporarily addressing it. Enter the test set's address, followed by X1. Now address the desired test set again. All test sets should be inactive except the desired test set.

Calibration

You can now perform the system calibration procedure as usual. Recall that the calibration only applies to the currently ACTIVE test set, and does not apply to other test sets.
Note: Since a Cal Set Limited Instrument State does NOT include the address of the test set, it is possible to turn on a cal set which does not apply to the current test set. Although no 8510 caution messages are displayed, there will be errors in the displayed data.

Changing test sets

Changing between coaxial test sets is quite simple. When changing from one test set to another, proceed as follows.

1. Change the test set address to make the new test set ACTIVE. Verify that the ACTIVE indicator of the new test set goes ON, and the ACTIVE indicator of the previous test set goes OFF.

2. Perform a calibration for the new test set. If a calibration has already been performed for that test set, recall the appropriate cal set by pressing CAL, ON, and selecting the cal set number.

Saving and recalling states

Saving an instrument state and hardware state for each test set may simplify the transition between test sets. This is strongly recommended for millimeter configurations.

The hardware state includes the addresses of all system instruments, as well as multiple source configurations for millimeter setups. Unlike instrument state parameters, the hardware state parameters are not changed at PRESET or POWER-UP. If only coaxial test sets are used, the hardware state is not required, since it may be easier to simply change the test set address.

Once the system is set up for the desired operation, the following procedure saves that configuration.

1. (Optional) Save the HARDWARE STATE on DISC. Press DISC STORE, MORE, HARDWARE STATE and select the file number (or enter a file name) for that test set.

2. Save the INSTRUMENT STATE in internal memory. Press SAVE and then select the desired INSTRUMENT STATE register. The active cal set (if any) is included as part of this state.

To recall the setup, proceed as follows.

1. (Optional) If a HARDWARE STATE was saved, recall it by pressing DISC, LOAD, MORE, HARDWARE STATE, and select the desired file number (or name). If a HARDWARE STATE was not saved, then change the test set address.

2. Recall the INSTRUMENT STATE by pressing RECALL and select the appropriate internal INSTRUMENT STATE register. The active cal set (if any) is automatically recalled.

Simplified setup procedure

When using multiple test sets, setup procedure can be simplified by taking advantage of the 8510 MACHINE DUMP feature, where the entire 8510 setup, including HARDWARE STATE, INSTRUMENT STATES, TRACE MEMORIES, and CAL KITS, are all saved or recalled in a single step. This is particularly useful in the multiple source setups, such as the millimeter-wave test set configuration.

1. Be sure the configuration is set up as desired. You may wish to modify other instrument settings, such as the averaging factor, display format, etc. These will all be saved with the MACHINE DUMP.

2. Insert a blank disc into the disk drive and initialize the disc by pressing DISC, SETUP DISC. Press INITIALIZE LIF DISC, Yes.

3. Store the MACHINE DUMP to disc. Press DISC, STORE, MORE, MACHINE DUMP. Enter the desired disc file label, for example VBAND or 8517, using the knob and the SELECT LETTER key. The prefix MD_ indicates a MACHINE DUMP file. Press STORE FILE.

4. To recall this configuration at any time, simply press DISC, LOAD, MORE, MACHINE DUMP. Select the desired MACHINE DUMP file, and press LOAD FILE.

Once the MACHINE DUMP is loaded, the hardware state, instrument state, and cal kit are all loaded in a single step.

Operational check

To check that the multiple test set configuration is operating properly, perform the following quick check.

1. With test set #1 ACTIVE, connect a device with known response (for example, a THRU or SHORT) to test set #1.

2. Store the trace in internal memory, by pressing DISPLAY, DATA→MEMORY, DISPLAY: DATA and MEMORY. This will be used for later comparison.

3. Activate another test set in the system by using ADDRESS of TEST SET. Then change back to test set #1. Observe any difference in the response between the stored trace and the result after switching back and forth between the test sets. Any difference believed to be due to the IF or RF switching should be investigated further.

GPIB considerations

All multiple test set features may be programmed over GPIB using a computer. All of the above procedures may be automated. Figure 9 shows an example listing of a BASIC program that includes the setup procedure and a way to change the active test set.

With the 11713A on the 8510 system interface, switch S9 and S0 are automatically changed when the 8510C test set address is changed. In some applications, the user may wish to control more switches or attenuators with the 11713A. In this case, the 11713A must be connected to the GPIB bus (instead of the 8510 system interface) and fully controlled by the computer. The 8510C pass-thru mode cannot be used with the 11713A.

Performance verification considerations

Standard system performance verification procedures are used to verify the test sets in the multiple test set configurations. Simply make sure that the desired test set is ACTIVE, then proceed as usual.

```
10  !  During initialization, all system test sets must
20  !  be activated, then deactivated.
30  !
40  FOR Test_set_addr=20 TO 23
50  OUTPUT 716;"ADDRESS",Test_set_addr,";"
60  NEXT Test_set_addr
70  !
80  !  Now any system test can be activated.
90  !
100 INPUT "ENTER TEST SET ADDRESS,
    THEN PRESS RETURN.",Test_set_addr
110 OUTPUT 716;"ADDRESS",Test_set_addr,";"
120 !
130 !  Whenever the test set is changed, a new calibration
140 !  must be performed or a previously stored calibration
150 !  must be recalled.
160 !
170 INPUT "ENTER CAL SET NUMBER FOR TEST SET",Cal_set_num
180 OUTPUT 716;"CORRON; CALS",Cal_set_num,";"
190 !
200 END
```

Figure 9. Example Basic program for multiple test set operation

Required equipment

The Agilent 8510C system requires the following equipment to take full advantage of the multiple test set capability:

8510C network analyzer[1]
Up to four of the following test sets:[2]
   8511A frequency converter
     Option 001. IF switching.
   8514B S-parameter test set (0.045 to 20 GHz)
     Option 001. IF switching.
   8515A S-parameter test set (0.045 to 26.5 GHz)
     Option 001. IF switching.
   8517B S-parameter test set (0.045 to 50 GHz)
     Option 001. IF switching.
   85110A S-parameter test set (2 to 20 GHz)
   85105A millimeter-wave test set controller

11713A attenuator/switch driver

33311C 26.5 GHz coaxial switch SPDT (1 switch for 2 test sets, 2 switches for 3 test sets, 3 switches for 4 test sets)
8762C 26.5 GHz coaxial switch, SPDT (identical to 33311C)

87104C 26.5 GHz multiport switch, SP4T
08517-80002, 50 GHz coaxial switch, SPDT

RF cables as required (e.g., part number 08513-60009, 18-inch SMA (f) to SMA (m))
IF cable (one cable for each test set). The total IF path length must not exceed 40 feet.
   08510-60102, 32-inch IF cable
   (included with 851X test set ordered with out Option 001)
   08510-60106, 5-foot IF cable
   (included with 851X test set ordered with Option 001)
   08510-60107, 10-foot IF cable
   08510-60103, 20-foot IF cable
   08510-60105, BNC-IF interconnect cable

1. To upgrade an 8510A or an 8510B to an 8510C, order the 85103C or 85103D performance upgrade package.
2. Option 001 (IF switching) is required in all but the last test set in the chain. The last test set in the chain does not require Option 001.

Any test set without Option 001 may be retrofitted to contain Option 001 with a simple retrofit kit (order 8511A Option K01). In this case, no IF cable is included with the kit. If the existing IF cable is not long enough, a new IF cable must be ordered.

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