
Using multiple test sets with the HP 8510B

Product Note 8510-14



Introduction

A single HP 8510B 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 shown on page 14.

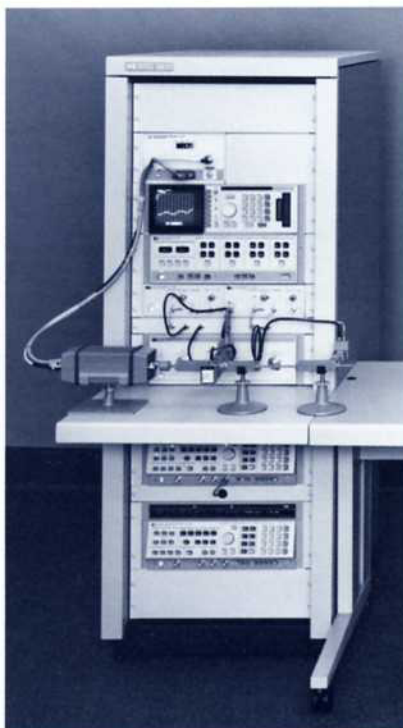
Applications

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

▲ *Combined millimeter-wave/microwave setups.* The HP 8510B can be configured for millimeter-wave measurements with waveguide test sets in the waveguide bands from 26.5 to 100 GHz. If lower frequency coverage is also required, the millimeter-wave system can be combined with a coaxial test set, such as the HP 8516A (0.045 to 40 GHz). Using the multiple test set capability of the HP 8510B, the operator can easily switch from the coaxial test set to the millimeter-wave test set without reconnections. Product Note 8510-12 describes the millimeter-wave configuration in more detail (HP literature number 5956-4331).

▲ *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 HP 8510B multiple test set operation. The cover photo shows a simple example using two test sets. While a measurement is proceeding on device #1 on test set #1, the operator can accomplish the connection of device #2 on test set #2. Device measurement time (test system) and connection time (operator) may be overlapped, thus decreasing total time.



Combined millimeter-wave/
microwave system.

▲ *When testing in various connector types.* Most HP 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 therefore 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. Now, switching connector types is 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.

▲ *Multi-user R&D test stations.* In an R&D environment, test stations with specialized fixtures can be very complex. Setup and calibration can be time-consuming for the user. Suppose user #1 has configured the HP 8510 for measurements using a wafer probe station and has completed a system calibration. Suppose that another user (user #2) must make some measurements using the same system but with a different setup. If there is only one test set, then user #2 is forced to disconnect the setup of user #1. User #1 would be forced to set up and recalibrate the system again later.

With two test sets in the system, user #2 could use the HP 8510B by switching to the second test set, without disturbing user #1's setup or calibration. When user #2 is finished, user #1 simply returns to the first test set and recalls the calibration. The setup remains intact.

▲ *Antenna measurements.* Multiple test set capability is also useful in many antenna measurements. For example, many HP 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.

▲ *Taking advantage of test set capabilities.* Each test set in the HP 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 HP 8510 system. The HP 85110A S-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 HP 8516A (0.045 to 40 GHz). Multiple test set operation provides an economical and convenient way for the user to take advantage of both test sets with a single HP 8510 system.

System description

In the HP 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 HP 8510. With multiple test sets, the HP 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 1).

RF switching

The HP 8510B must first route the RF output of the network analyzer source to the RF input of the ACTIVE test set. The HP 8510B accomplishes this by issuing a command to the HP 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 HP 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 HP 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 HP 8510B 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.

In the configuration of 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 HP 8510B. Note that test set #1 must be configured with option 001 (IF switching), but test set #2 does not require option 001.

The HP 8510B determines which test set is active using the test set address. Each time the test set address is changed, the HP 8510 issues an Off (Inactive) command to the previously addressed test set and an On (Active) command to the newly addressed test set.

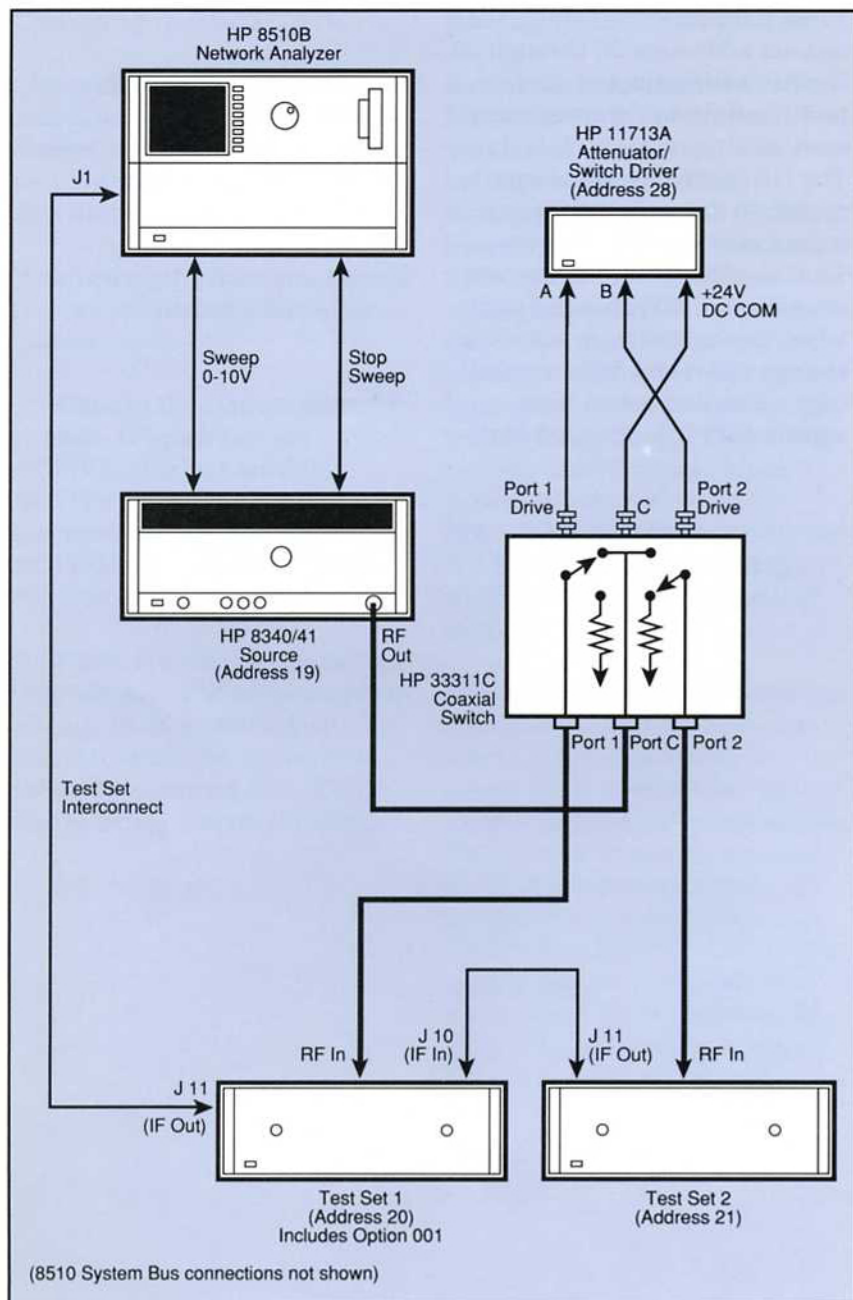


Figure 1. HP 8510 dual coaxial test set configuration.

New Address of Test Set	Test Set Selected	HP 33311C Coaxial Switch Port Selected
20 21 (or 31)	1 2	Port 1 Port 2

Table 1. Coaxial switch positions with two test sets.

With more than two test sets

The dual test set configuration can be easily extended to include up to four test sets. Figure 2 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.

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 HP 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).

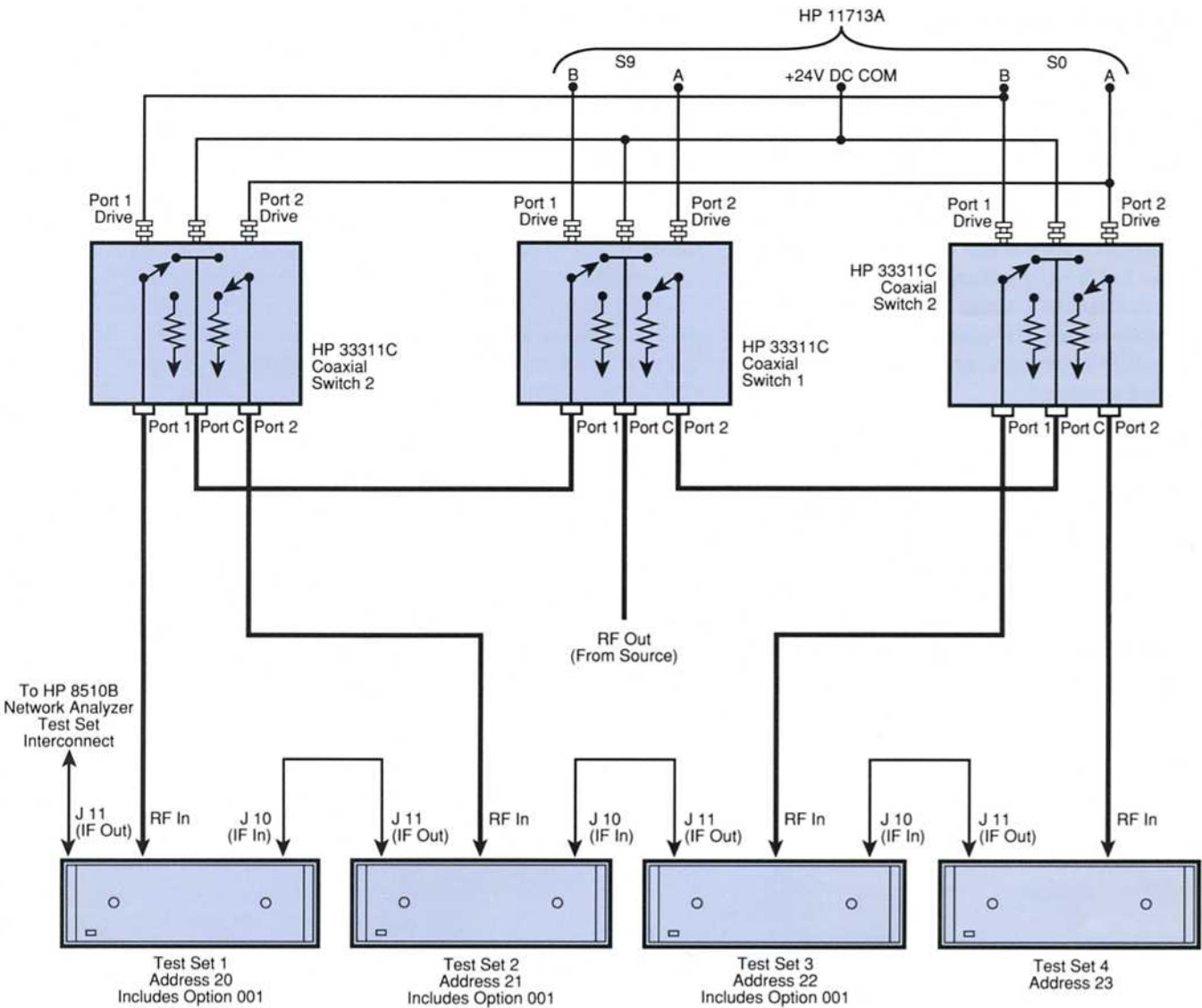


Figure 2. RF and IF switching with four test sets.

Table 2. Coaxial switch position with four test sets.

Address of Test Set	Test Set Selected	HP 33311C 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

Millimeter-wave or external mixer configurations

In the HP 8510B millimeter system or in external mixer configurations, the "test set" consists of external signal separation devices and downconverting mixers to create the IF signals. The LO for the external mixers is a separate source, either a phase-locked HP 8350B Sweep Oscillator or another synthesized sweeper.

When using millimeter or external mixer test sets in multiple test set systems, there are additional considerations.

1. Only one millimeter or external mixer test set can be used in each system, and it must be the last test set in the chain. No IF switching option is available with these systems. Figure 3 shows a two test set system with a millimeter test set. The external mixer setup is similar.

2. The millimeter or external mixer test set address should be 31, and this must be set on the HP 8510B. The HP 8510B will not attempt to control address 31 over the 8510 system interface.

3. The RF signal is routed to the RF input of the millimeter or external mixer test set. For the millimeter-wave setup, the RF is switched into an HP 8349B amplifier and then into the millimeter-wave multiplier, as shown in Figure 3.

4. The STOP SWEEP line must be disconnected for proper operation of a millimeter or external mixer test set. When using the coaxial test set (test set #1), the STOP SWEEP line must be connected from the source to the HP 8510. This line must be disconnected when a millimeter or external mixer test set is active. The STOP SWEEP relay shown in Figure 3 allows this to be controlled automatically by the HP 8510B, without reconnections.

5. Hardware states should be saved onto tape or disc. Millimeter and external mixer test sets use two sources and the multiple source control of the HP 8510B. Once configured, the multiple source settings should be saved so that they can be easily recalled. Note that these settings are saved in the hardware state, not the instrument state. This is described in detail under *System Operation*.

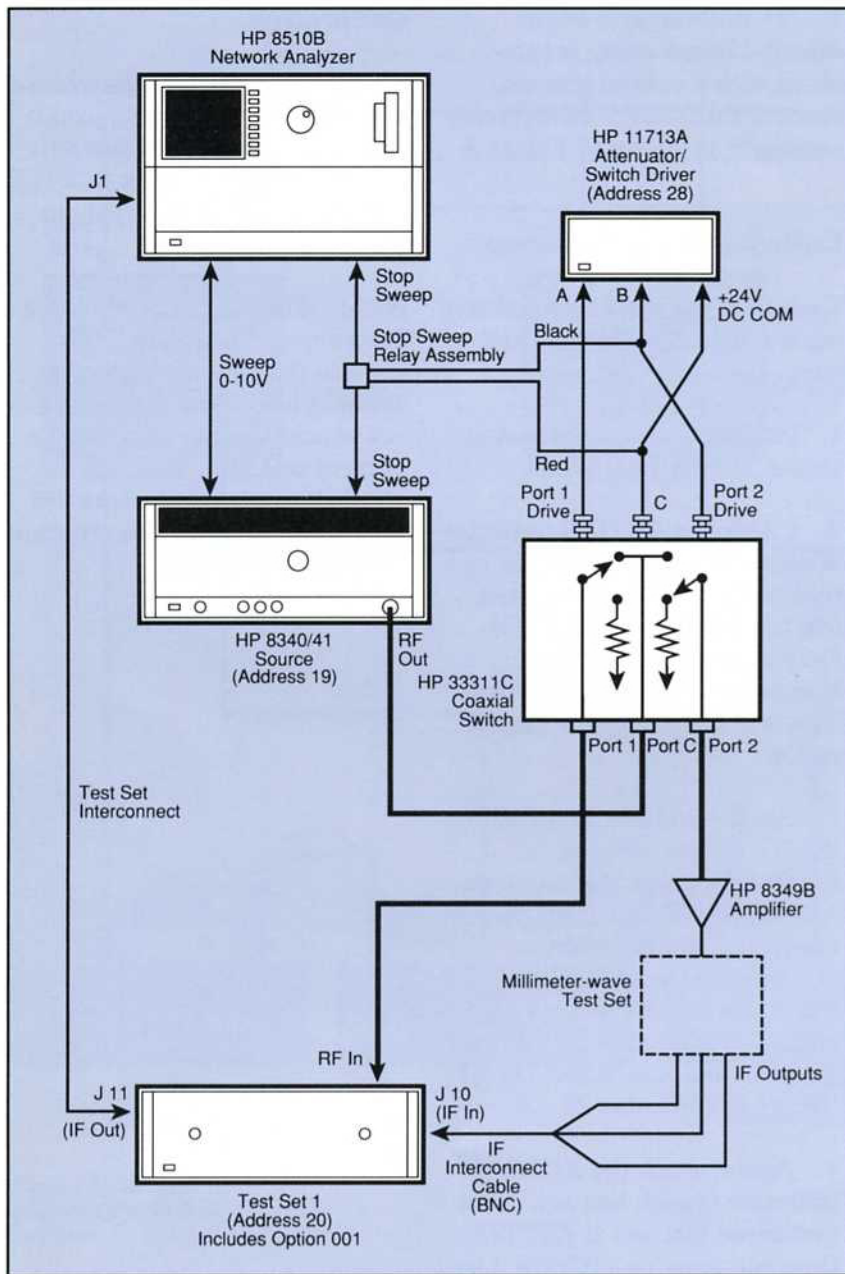


Figure 3. Dual test set configuration with millimeter-wave test set (simplified).

System operation

This section describes how to operate the HP 8510B 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 HP-IB. A list of required equipment is shown on page 14.

Installation

1. Connect the equipment as shown in Figure 1. If more than two test sets are used, see Figure 2. Be sure all instruments, including the test sets and the HP 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. Note that the address of a millimeter-wave test set or an external mixer setup is 31. Only one such setup can be connected at a time.

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

4. If a millimeter-wave or external mixer setup is combined with a coaxial test set, connect the STOP SWEEP relay assembly as shown in Figure 3.

Initialization at power-up

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

1. Power on all system instruments, the HP 8510B 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 HP 8510B. On the HP 8510B, press LOCAL, then ADDRESS OF TEST SET. Check the test set address expected by the HP 8510B. 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 HP 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 millimeter or external mixer test sets are used, then see Saving and Recalling States.

When changing from one coaxial 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 and external mixer configurations. For the millimeter-wave system, hardware states and instrument states are already contained on the system tape (see Product Note 8510-12 for more detail). If a disc drive is used, then it is possible to take advantage of the MACHINE DUMP feature of the HP 8510B to further simplify the procedure of changing test sets.

The hardware state includes the addresses of all system instruments, as well as multiple source configurations for millimeter or external mixer 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 TAPE (or DISC). Press TAPE/DISC, and select STORAGE IS TAPE (or DISC). Press 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 TAPE/DISC, STORAGE IS TAPE (or 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. If switching to a millimeter-wave test set or external mixer setup, be sure that the STOP SWEEP line is disconnected. This is done automatically if the STOP SWEEP relay assembly is used.
3. Recall the INSTRUMENT STATE by pressing RECALL and select the appropriate internal INSTRUMENT STATE register. The active cal set (if any) is automatically recalled.

Disc drive can simplify setup procedure

When using multiple test sets, the addition of an external disc drive, such as the HP 9122D can simplify the process of switching test sets. This procedure takes advantage of the HP 8510 MACHINE DUMP feature, where the entire HP 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 for millimeter-wave test sets or an external mixer 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. Connect the disc drive to the 8510 system interface and enter its address into the HP 8510B. Press LOCAL, ADDRESS OF DISC. Enter the disc address, usually 0, then press X1.

Insert a blank disc into drive 0 and initialize the disc by pressing TAPE/DISC, STORAGE IS DISC, SETUP DISC. Press INITIALIZE DISC, Yes.

3. Store the MACHINE DUMP to disc. Press TAPE/DISC, STORAGE IS DISC, STORE, MORE, MACHINE DUMP. Enter the desired disc file label, for example RBAND or 8516, 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 TAPE/DISC, STORAGE IS 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.

HP-IB considerations

All multiple test set features may be programmed over HP-IB using a computer, such as the HP 9000 Series 300. All of the above procedures may be automated. Figure 4 shows an example listing of a BASIC program which shows the setup procedure, as well as changing the active test set.

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

Performance verification considerations

Standard system performance verification procedures are used to verify the test sets in the multiple source 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;"ADDRTESS",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;"ADDRTESS",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 4. Example program for multiple test set operation.

Required equipment

The HP 8510B system requires the following equipment to take full advantage of the multiple test set capability.

HP 8510B Network Analyzer¹

Up to four of the following test sets²:

HP 8511A Frequency Converter Option 001. IF switching.

HP 8514B S-Parameter Test Set (0.045 to 20 GHz)

Option 001. IF switching.

HP 8515A S-Parameter Test Set (0.045 to 26.5 GHz)

Option 001. IF switching.

HP 8516A³ S-Parameter Test Set (0.045 to 40 GHz)

Option 001. IF switching.

HP 85110A S-Parameter Test Set (2 to 20 GHz).

HP 11643A Series Millimeter-wave test set (26.5 to 100 GHz).

External mixer test set, e.g. for antenna measurements.

HP 11713A Attenuator/Switch driver

HP 33311C Coaxial RF Switch (1 switch for 2 test sets, 2 switches for 3 test sets, 3 switches for 4 test sets).

RF cables as required (e.g. HP 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 HP 851X test set ordered without option 001).

08510-60106, 5 foot IF cable

(included with HP 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

(included with HP 85100A LO/IF kit for the millimeter system, also recommended for external mixer configurations).

STOP SWEEP Relay Assembly (HP part number 85106-60008)

This assembly is required if using an HP 851X test set combined with a millimeter-wave or external mixer setup. If the relay is not used, then the STOP SWEEP line must be disconnected.

1. To upgrade an HP 8510A to an 8510B, order the HP 85103A 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 HP 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.

3. An RF doubler internal to the HP 8516A Test Set allows system operation to 40 GHz with a 20 GHz source (HP 8341B). Since a special cable must be connected from the test set to the source for proper control of the HP 8516's internal doubler, only one HP 8516A Test Set can be used in an HP 8510B system.

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