DC100 USER GUIDE

VER 2.0

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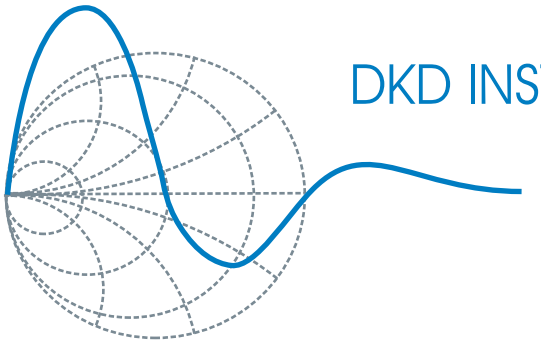


DKD INSTRUMENTS

Some FAQ's

What does the DC100 option do for my HP8568B?

The DC100 adapter enables the HP8568B spectrum analyzer to extend its frequency coverage range, see figure 1. It does this by intercepting the RF input and redirecting it to a separate down converter to produce the 21.4MHz IF used by the display section. The operation of the input RF relay has been modified to accomplish this. The result is an instrument with a single RF input that now covers past 4.5GHz that is electronically switched via front panel buttons using three distinct bands, BAND1, BAND 2 and BAND3. Throughout this user guide we will assume the wake up state of the HP8568B is the factory provided one, 0 to 1500Mhz.

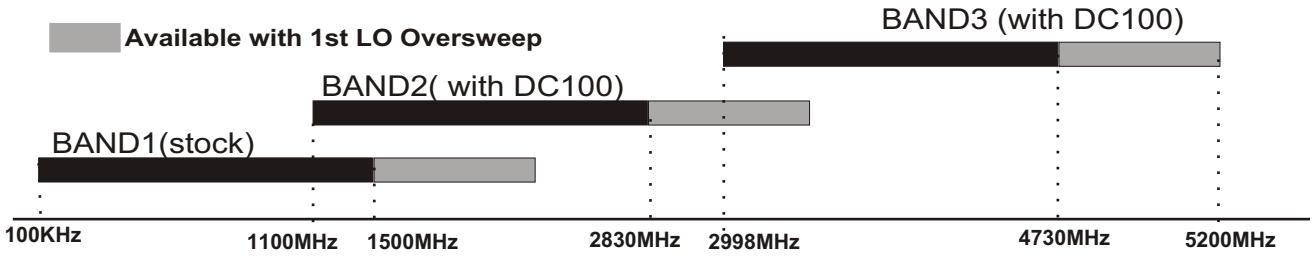


FIG. 1: The HP8568B bands with added DC100 Band Coverage. Figure shows band over lap and portions of bands available using HP8568B 1st LO oversweep ability.

Does the DC100 degrade or in any way interact with the original performance of the HP8568B?

The DC100 was carefully engineered to minimize any interaction or impact on the stock frequency coverage and the exceptional signal fidelity of the HP8568B. Our measurements indicate no measurable impacts to the stock instrument abilities.

How does the instrument properly display frequencies that are outside its stock band coverage?

The stock software of the HP8568B allows frequency offsets to applied to all user entered frequency data. In this way two frequency offsets, one for Band 2 and another for BAND3 are used to rescale the HP8568B's displayed frequencies.

How does the RF input signal get routed to the three different bands?

The existing HP8568B front panel RF select relay is reconfigured to re-route the incoming RF to either BAND1 processing or BAND2/3 processing

Can I still use the second RF input present on stock HP8568B?

No, that input (typically a DC coupled BNC but also can be 75 ohm input) is removed. With DC100 installed the Therefor input for all bands goes thru the AC coupled N type connector..

Is it required for the user to manually reconfigure the HP8568B every time the added bands are to be used?

No, the changes to instrument setup to accommodate BAND 2/3 operation are saved in the instrument state memory. Once the instrument memories are setup properly the user simply recalls one of three different state memories to configure the instrument for the band needed. The setup needed is covered in detail later in this document.

Can the instrument be swept thru all bands in one sweep?

No. Only one band can be used at a time.

What is 1st LO oversweep?

The stock HP8568B allows sweeping the first LO well past the spec bandwidth of 1500Mhz, the instruments stated maximum frequency. this feature is not to useful in the stock instrument as internal lowpass filtering band limit the RF input. But the DC100 does is not preselected in anyway. Because of this the instrument does have image responses present but it also allows Bands 2 and 3 to cover well over 2 GHz of bandwidth.

Are there image responses present in the display of Band 2 and 3 of the DC100?

Yes. There will be images as the 1st mixer of the DC100 is not image protected or preselected .The offset of these images(from the input signal) is related to the input frequency and the LO frequency, that is they are not at a "fixed" offset from the desired, see below for more discussion.

What are the frequency and power accuracies of the DC100 added Bands 2 and 3 as compared to the stock Band 1 performance?

They are not as accurate.This is due to uncorrected gain variations and the fact LO2 is not ***independently*** phase locked in the stock HP8568B. The power error is typically less than +/-2db and the frequency is usually less than +/-100Khz with careful measurement and subsequent entry into FREQ OFFSET , see below.

Can I use the 10HZ RBW with the DC100 added bands?

Yes you can, but below 300Hz RBW internal unlocked LO2 phase variations will render such use as marginal. Additionally the lack of phase lock on LO2 will limit the use of very narrow RBW's, see below.

Is there a way to phase lock lock LO2 when using the DC100?

Yes, option 001 for the DC100 can lock LO2 to internal 10Mhz. With LO2 locked 10MHZ the frequency accuracies and RBW issues outlined above are greatly reduced or are eliminated.

Band Selection by Control of RF Input Relay

The RF relay in the stock instrument selected between one of two inputs. Input 1 is a BNC type connector while input 2 is a type N connector. The two buttons between the the RF input connectors control which connector was fed to the internal signal processing.

With the DC100 adapter installed this input RF relay is now used to select between the original band of the instrument and two new additional bands. In other words the function of the input RF relay has changed, but its control circuitry has not. It is still controlled by the same two buttons as before. This preserves not only front panel control of the RF relay but also GPIB control of it as well. In fact all settings needed by the DC100/HP8568B system can be set via GPIB if needed.

Band 1 , from 100KHz to 1.5Ghz is selected by the right hand button. This is the original band of the 8568B and is the default wake up sate of the machine.

Bands 2 and 3 are selected by the left hand button. These bands correspond to the two mixer products(High side and Low side mixer products) produced in the DC100 system. No pre-selction is done so both bands share the same band select button.

The N connector is now the only input to the machine and the BNC connector is removed and a cover installed over it's mounting hole. Figure 1 below shows the new operation of the relay control buttons.

All bands pass through the N connector to the RF attenuator and then to the RF relay. The relay then splits the signal processing to existing HP8568B processing or to the DC100 processing. It is important to understand that all bands pass through the attenuator section before any other processing. This ensures all attenuator signal scaling works as expected in all bands.

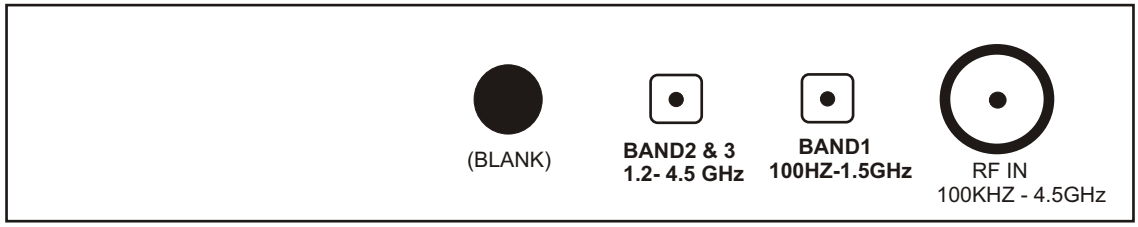


FIG. 2: BAND SELECT BUTTONS WITH DC100 INSTALLED

Band Select Buttons In Operation

When the HP8568B is turned on the 100Hz to 1500MHz band is automatically selected. This is the defualt "wake up state" of the HP8568B. With the DC100 installed all features and performance of the HP8568B are unchanged in BAND1 with exception of the RF input select , which has been modified as just described above. The SPAN should be set to 1.5GHz with the start frequency of 0Hz. The DC return response will be seen as before at 0Hz.

If the BAND2&3 button is selected the user will not see the DC return line and the displayed noise will also change. This is normal and indicates the DC100 has been activated properly by the BAND2&3 button. Pressing BAND1 button will return the instrument to the 100Hz to 1.5GHz band and turn off the DC100 system. Its important to realize that the DC100 is powered off during BAND1 operation to assure no interference that might occur if it were left ON.

When BAND 2 & 3 button is selected, as above, the displayed frequency information will not be correct, the frequency information will still be that of BAND1.. In order for the frequency information to be correct an OFFSET frequency must be entered into the HP8568B. This standard feature of the HP8568B will allow automatic correction of the displayed frequency information for BANDS 2 & 3.

Entering a Frequency Offset & frequency Stability Issues

We can force the HP8568B to rescale its displayed frequency information by using the FREQUENCY OFFSET function. This will allow the user to rescale the frequency axis for the two new bands, BAND2 and BAND3. Once this is properly done the frequency information displayed will be accurate to within the limits of the DC100 system for both new bands.

The frequency offset for BAND1 operation is approximately 1106MHz. The frequency offset for BAND2 operation is approximately 3001MHz. The precise offsets must be determined by injection of a known frequency for each band and for each instrument. This small problem is caused by the fact that in the new BANDS 2 & 3 true phase lock is lost in the HP8568B signal processing. This is caused by the unique nature of the HP8568B phase lock system and not by the any modifications done to the HP8568B when installing the DC100. In short unless the entire signal processing scheme of the HP8568B is used the resulting signal at 21.4MHz IF is not phase locked.

Due to loss of true phase lock the exact frequency offset will be slightly different for each instrument and must be determined by known signal injection method as just discussed. The high quality of the HP8568B local oscillators assures that even though they are not precisely phase locked for DC100 operation, excellent frequency stability is still achieved.

To determine the Frequency OFFSET for BAND2 first enter the approximate OFFSET of 1106MHz. Then inject a known frequency between 1.2 and 2.7Ghz and measure the error using a narrow span and the 300Hz RBW. With the error for BAND2 in hand , go back and reenter the new offset adjusted for the measured error. This same process is repeated for BAND3 using a known frequency between 3 to 4.5GHz

To enter a frequency offset use the following key sequence (BAND2 shown):

Commanding HP8568B Second LO to Single Frequency Operation

The 2nd LO (LO2) of the HP8568B is used in DC100 signal processing, see block diagram of figure 7. The HP8568B uses a two different frequencies for this LO depending on where in sweep of the 1st LO the instrument is. The approximate values of the two frequencies of LO2 used are 1748 and 1753 MHz. LO2 is not locked in the HP856B , but is a free running cavity oscillator. By switching between the two frequencies the HP8568B reduces some of the spurious response in BAND1.

For BAND 2 & 3 operation using the DC100 we need to turn this automatic switching off. Fortunately a means to do just this is provided via front panel buttons.

The following key sequence selects the upper frequency value of LO2:

Once the above key sequence is entered a "LO2Î" symbol will appear on the left side HP8568B CRT display. This indicates that the LO2 will now be held in the upper frequency state and not be switched as LO1 is swept.

Shortly we will show how to combine all the above key strokes(and a few more) into one instrument state memory. Once this is done all the setup for any of the three bands can be done by just two key strokes, RECALL X, where X is the instrument state memory number.

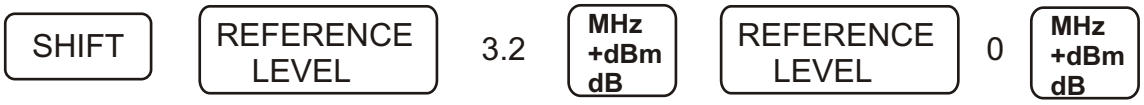
Entering Amplitude Offsets

The two new bands added by the DC100 have small gain variation with frequency and different gain offsets with respect to each other and BAND1. Unlike BAND1 these changes are not corrected out automatically as the instrument is swept. The HP8568B has an amplitude offset function that can be used to minimize amplitude readout errors.

Unlike the frequency OFFSET and error, Amplitude errors will vary depending on where in the frequency range of BAND2 or BAND3 operation is occurring. For best overall correction a mid-band point is chosen for setting amplitude error to zero using the amplitude offset function. These offsets are in the 2 to 3 dB range typically. If the DKD model LPF2.8-68B Low Pass filter is used (IL ~4 dB) on the input for BAND2 operation(see below) amplitude offsets will increase to 5 to 6 dB for that band.

If the user wishes the amplitude offset can be adjusted up or down for a particular narrow band to increase power accuracy in that band. It should be noted the delta amplitude measurement accuracy is largely unaffected for small frequency offsets in BAND2 and BAND3. This is because the gain variation is small over small frequency offsets and absolute power accuracy is not a factor.

A +3.2dB Amplitude Offset (power readings are to low) can be entered by the following key strokes:



In the above keystrokes the resetting of reference level needs some explanation. The HP8568B software seems to have a small bug in it. Unless the reference level is reset after a amplitude offset instruction the offset is applied to the reference level and not the displayed power level. By resetting the reference level the desired effect is achieved.

Instrument State Memories Save BAND1, 2 and 3 Setup Information

The HP8568B has six instrument sate memories(1 to 6) that can be used to store all the keystrokes needed to setup the instrument for BAND1, 2 or 3 operation. These memories , once setup, can be accessed by a RECALL # keystroke operation. This makes it possible to setup the instrument using just 2 keystrokes per band. The instrument state memories are retained by battery supplied memory enabling retention during power off and power removal conditions. This memory retention allows entering the band configuration information once and simply recalling later as needed.

One instrument memory is used for each band of the instrument. Which ones are used is arbitrary , but using 4,5, 6 allow's the bottom three memories to be used for other purposes. It is up to the user to decide. Using an instrument sate memory for BAND1 is recommended rather than just using the INSTRUMENT PRESET button. The reason is the HP8568B not only resets the start, stop frequency , etc, it actually sends a hardware reset to the main processor. The overall effect is that a INSTRUMENT PRESET takes longer than a RECALL state operation to return instrument to BAND1 operation. Below are all keystrokes needed to program HP856B memories for each band.

To program BAND1(100Hz to 1.5GHz) information into State Memory 4:

1) POWER UP INSTRUMENT and WAIT for all presets to occur

2) SAVE **4**

3) Instrument State 4 is now programmed for BAND1 operation

STEP BY STEP KEY STROKES FOR CONFIGURING HP8568B FOR BAND2

To program BAND2 (1.2 to 2.7GHz) information into State Memory 5 with frequency offset 1106.10Mhz and power offset of 3.3db:

1) POWER UP INSTRUMENT and WAIT for all presets to occur

2) Select BAND2&3 operation by pressing: [•]

BAND2 & 3
1.2- 4.5 GHz

3) Select LO2 frequency: [SHIFT] [U ⇑]

4) Set Span to 1MHz: [SPAN] 1 [MHz +dBm dB]

Note: HP8568B Software may ignore lower significant digits of freq offset unless span is narrow.

5) Enter Frequency Offset: [SHIFT] [CENTER FREQUENCY] 1106.10 [MHz +dBm dB]

6) Enter Start Frequency: [START FREQ] 1200 [MHz +dBm dB]

7) Enter Stop Frequency: [STOP FREQ] 2700 [MHz +dBm dB]

8) Enter Amplitude Offset: [SHIFT] [REFERENCE LEVEL] 3.3 [MHz +dBm dB] [REFERENCE LEVEL] 0 [MHz +dBm dB]

9) Save this setup in Instrument State 5: [SAVE] 5

STEP BY STEP KEY STROKES FOR CONFIGURING HP8568B FOR BAND3

To program BAND3 (3.0 to 4.5GHz) information into State Memory 6 with a frequency offset of 3300MHz and power offset of 2.4db:

1) POWER UP INSTRUMENT and WAIT for all presets to occur

2) Select BAND2&3 operation by pressing: [•]

BAND2 & 3
1.2- 4.5 GHz

3) Select LO2 frequency: [SHIFT] [U ⇑]

4) Set Span to 1MHz: [SPAN] 1 [MHz +dBm dB]

Note: HP8568B Software may ignore lower significant digits of freq offset unless span is narrow.

5) Enter Frequency Offset: [SHIFT] [CENTER FREQUENCY] 3003 [MHz +dBm dB]

6) Enter Start Frequency: [START FREQ] 3000 [MHz +dBm dB]

7) Enter Stop Frequency: [STOP FREQ] 4500 [MHz +dBm dB]

8) Enter Amplitude Offset: [SHIFT] [REFERENCE LEVEL] 2.4 [MHz +dBm dB] [REFERENCE LEVEL] 0 [MHz +dBm dB]

9) Save this setup in Instrument State 6: [SAVE] 6

Now that we have programed the HP8568B state memories we can simply setup the instrument to any of the three bands by just using RECALL X where X is 4, 5 or 6. If for some reason this information is erased from memory it must be reentered as above. The user should record their particular frequency and amplitude offsets here for future reference , if needed:

BAND2 Frequency Offset_____
BAND2 Amplitude Offset_____

BAND3 Frequency Offset_____
BAND3 Amplitude Offset_____

LO1 Over-Sweep , Center Span Limitations and DC100 Band Gap

The DC100/HP8568B system appears to have a "gap" in its frequency coverage between 2700 and 3000MHz. Also the DC100 can produce valid response well past 4.5 GHz. The ability to cover the gap between 2700 and 3000 MHz as well getting to approximately 5.2GHz can be explained by understanding just how the HP8568B sweeps its first LO (LO1).

The HP8568B has a first LO with a range of 2 to over 4GHz. This can be discovered by setting the START & STOP frequencies carefully in the fundamental band (BAND1). The specifications state that the maximum span is 1500MHz. But LO1 range suggest the instrument is capable of >2Ghz of span.

In reality the maximum span the instrument will allow is ~1700MHz. But this does not mean that the highest frequency it can achieve in the fundamental band is 1700MHz. It is possible to exceed 2Ghz as a stop frequency in BAND1 operation using the START/STOP frequency inputs. This is not a modification, it is part of the stock instrument. Of course the RF signal processing is rolling off in amplitude past about 1.6Ghz due to a low pass filter(LPF) in the signal path for BAND1 operation. Even though you can sweep through this region amplitude is low due to this LPF.

Achieving these extended frequency areas past ~1730Mhz comes with a price: No Phase lock. When the HP8568B is in a wide band sweep LO1 is not phase locked , except at the start frequency (and a mid point check frequency?). What occurs is lock is achieved on LO1 oscillator at the start frequency (a YIG type) and then the oscillator is swept from there "open loop". This is referred to by HP as "Lock and Roll".

The HP8568B can do a "Lock and Roll" over a much wider area of frequency than it can do a complete lock at every measurement point. The result is that you can sweep wide areas of frequency past 1.6Ghz (again BAND1 operation) but you will not be able to "zoom in" on them. For example you can sweep the HP8568B from 1000 to 1900 MHz in BAND1. But you cannot set the center frequency to 1850Mhz with a span of 1Mhz. The reason is that for narrow spans the HP8568B wants to "lock up" LO1 at all measurement points. Unfortunately the synthesis method used in the HP8568B cannot do this past ~1730MHz. If you do try this you should see "YTO UNLOCK" error message appear in upper right-hand graticule area of display .

The net result of the above statements is that the band gap present between ~2800MHz (at the top of BAND2) and 2990Mhz(at bottom of BAND3) cannot be inspected with fine resolution in terms of span. The gap can be swept through in a wide band sense but you cannot "zoom in" on this area of the frequency axis. The ability of the HP8568B to open loop sweep its LO1 past the 1.7GHz limit is referred to in DKD instruments documents as "LO1 over-sweep". It is this over sweep that allows the gap between bands to be covered as well as the top end of BAND3 to exceed 5GHz. Figure 2 shows the frequency coverage of DC100 system for BAND2 and BAND3.

Arithmetic Overflow In HP8568B Frequency Calculations

The HP8568B has limited arithmetic abilities. It appears to be based on integer based arithmetic. This has some repercussions in how it handles the FREQUENCY OFFSET function. We have discovered that in BAND3 operation it is possible to get erroneous displays, in terms of frequency information, if attention is not paid to START and STOP frequencies.

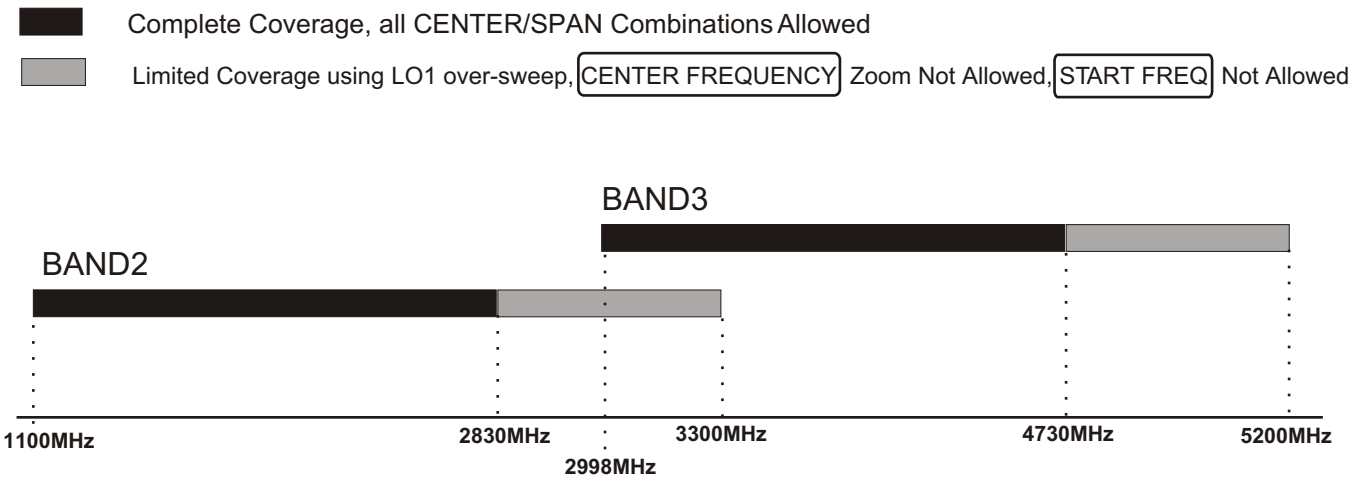


FIG. 2: DC100 Band Coverage. Figure shows band over lap and areas where Center Frequency Zoom is prohibited, see text.

These types of problems can occur when the entered frequencies result in to large of a span or significant negative start frequencies occur after the frequency offset is applied. For example entering a start frequency of 2500 MHz in BAND3 operation would result in a start frequency of approximately *minus* 500MHz when translated down to BAND1 frequencies. Remember, inside the HP8568B it is always doing calculating as if it was in BAND 1. The Frequency Offset value is applied to the displayed frequency numbers, not internal commands used to control the synthesis, etc.

To avoid this problem do NOT enter frequency data carelessly while in BAND2 or BAND3 operation. Do not enter frequency data that results in significant negative frequencies (after applying OFFSET Frequency) and be careful when sweeping into the LO1 over-sweep areas, which are above ~2.8GHz in BAND2 , and above ~4.5GHz in BAND3. If the "YTO UNLOCK" message appears user entered data may be the cause.

If the user experiences a erroneous state a simple RECALL 4 to set machine back to BAND1 and then RECALL 5 or 6 to get back into the band where problem occurred will set things right.

Images and Harmonic Mixing Products in BAND2&3

The DC100 makes use of both sum and difference frequencies at its first IF of approximately 950MHz. No filtering is provided internally by the DC100 to select sum or difference products from the first mixer. In addition this lack of filtering allows the input signal to be present at all times even when the 1st LO has swept by a given input signal. In short the DC100 is not preselected or image protected at the first mixer. This results in Images and other spurious responses from the first mixer appearing in the display.

The Images are two times the IF so that puts them quite a distance from desired signal response for a given BAND. For example if a signal is being inspected at 2.4GHz the image response is at ~4.3GHz. thus the image is usually not visible except in the widest spans. More problematic is the response from 2xRF by 2xLO and 2RF by LO. These spurious responses can be closer in depending on exact area of the band being used.

Reducing Spurious and Images with Input Filtering

A simple way to reduce these unwanted responses is with a filter on the input of the HP8568B when in BAND2 or BAND3 operation. A simple lowpass is quite effective in BAND2 operation. It should have a cutoff frequency of approximately 2.8GHz. This allows good coverage of the 2.4GHz band while not affecting the amplitude response there. Filtering for BAND3 is more problematic in that a wide bandpass is needed starting at 3GHZ and rolling off around 5GHz.

Minimum usable RBW

As explained above the signal processing as implemented in the DC100/HP8568B system is not tightly phase locked (as it is in BAND1 operation) during BAND2 and BAND3 operation. This results in more drift and phase noise than seen in BAND1 operation. Unlike BAND1 where analyzer induced frequency drift is very small the drift in BAND2 and BAND3 is significant. As the instrument warms up the drift rate in BANDS 2&3 decreases substantially. Once warmed up drift is usually less than a few kilohertz over many minutes of operation. The drift is not fast but slow in nature. After warm up the purity of the open loop LO's is quite good. Its is possible to use the 300Hz RBW with quite acceptable results. Below this RBW the drift and phase noise start to become quite distinct. If a minimum span of 30 times the RBW is assumed this sets a limit on the usable minimum span for close in signal work of ~10KHz.

3MHz RBW reduction in BW

In BAND2 and BAND3 operation (NOT BAND1) there is a small degradation of the 3MHz RBW response. This is due to the IF filter response in the DC100 system and not to any changes to the HP8568B hardware or software. The reduction is small, typically 0.5 MHz in the 3dB bandwidth. The overall shape of the 3MHZ RBW filter is also changed slightly. These changes do not significantly effect the accuracy of the instrument when using the DC100 added bands. When the DC100 is OFF this effect is not present.

HP8568B with Option H96

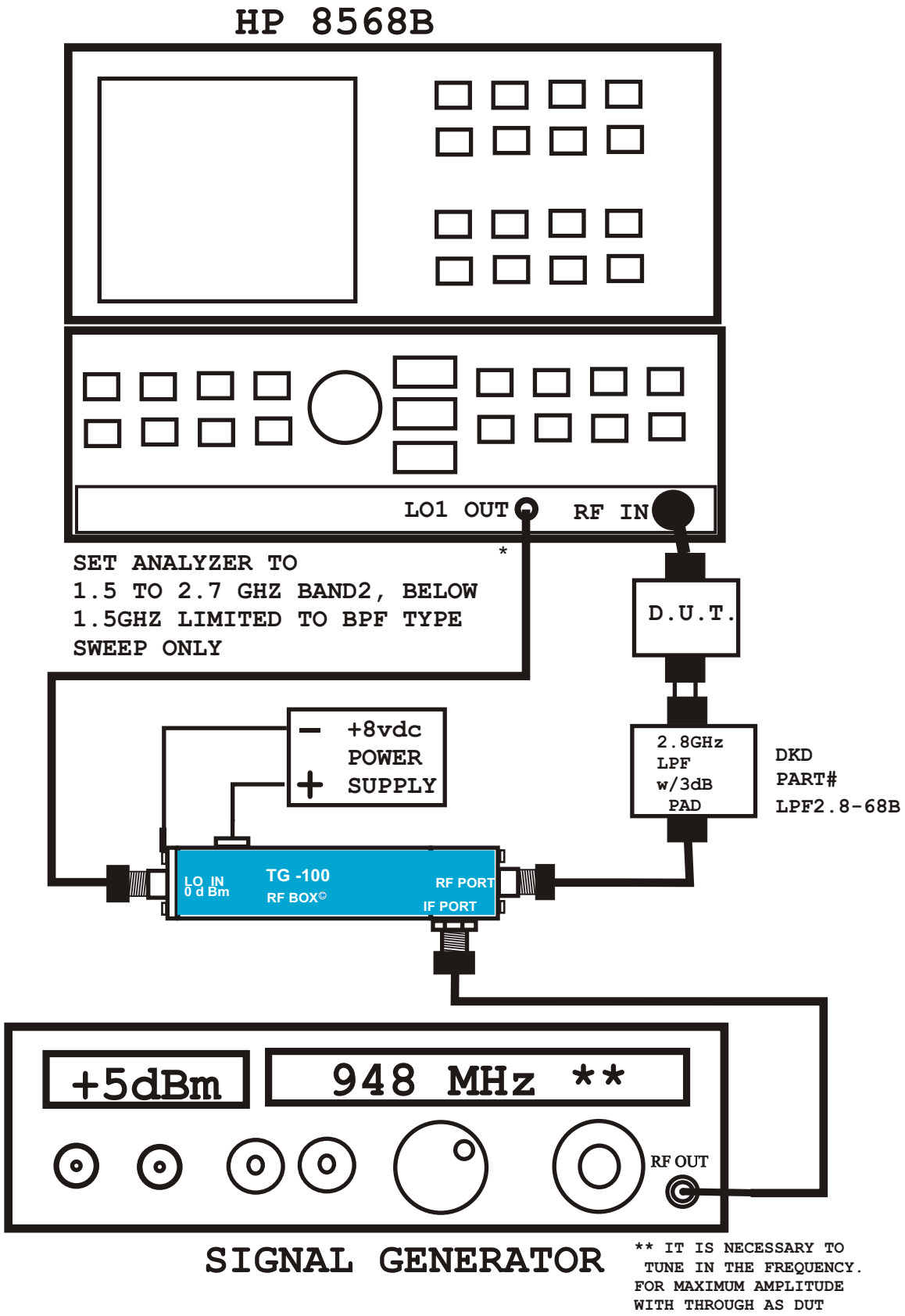
Option H96 removes the RF input relay and RF input 1(BNC type) and other components from standard HP8568B systems.. The DC100 system can be installed in these systems but it is more complex and costly as the RF relay and its supporting buttons must installed. For more information on the H96 option see www.dkdinst.com web site.

Using the TG100/200 Tracking Generators with the DC100/HP8568B

The DC100 can be used with DKD instruments TG100/200 tracking generator systems. This enables swept measurements across most of the bandwidth of the DC100. Both the TG100 and TG200 systems support BAND1 operation of the HP8568B. They can also support BAND2 and BAND3 if input filtering is used at the HP8568B analyzer input. If a Image Reject Mixer(IRM) is used with theTG200 system the input filters can be omitted as there is a dedicated output from the mixer for BAND2 and one for BAND3. Without input filtering (or an IRM in combination with TG200) an erroneous display will result. This is due to both mixer products being present in the TG100/200 output.

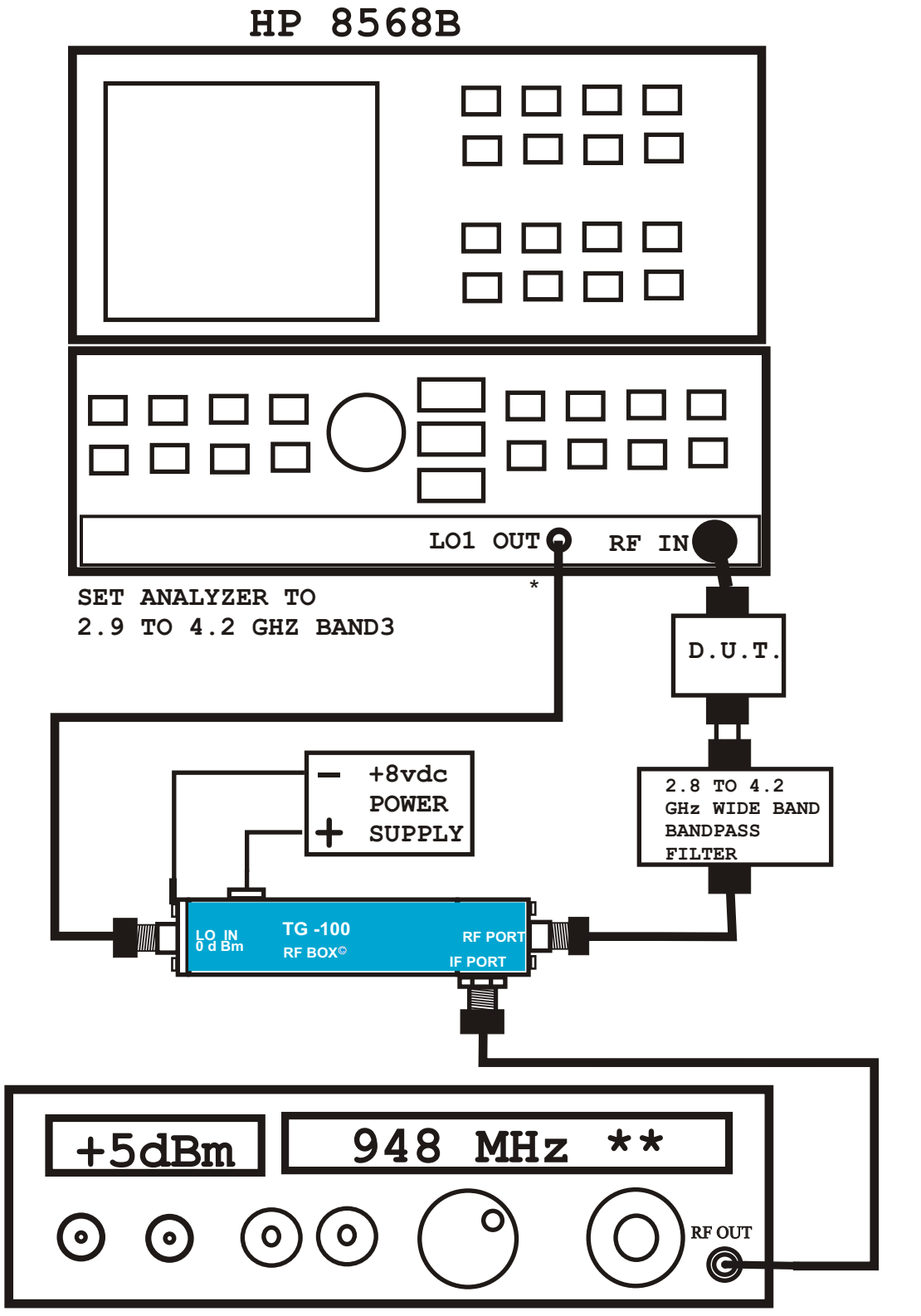
Figure 3 shows suggested connections for BAND2 TG100 operation. Figure 4 shows TG100 suggested configuration for BAND3 operation. Figure 5 shows connections using the TG200 in conjunction with a IRM for BAND2 operation. Lastly Figure 6 shows how the TG200 and IRM can be used for BAND3 operation. For more information on the TG100 and TG200 tracking generator systems please see www.dkdinst.com

FIG.4:TG100 RECOMMENDED SETUP FOR OPERATION W/ HP8568B and DC100 BAND2



* LO1 test point is RR panel, shown on Front Panel for clarity

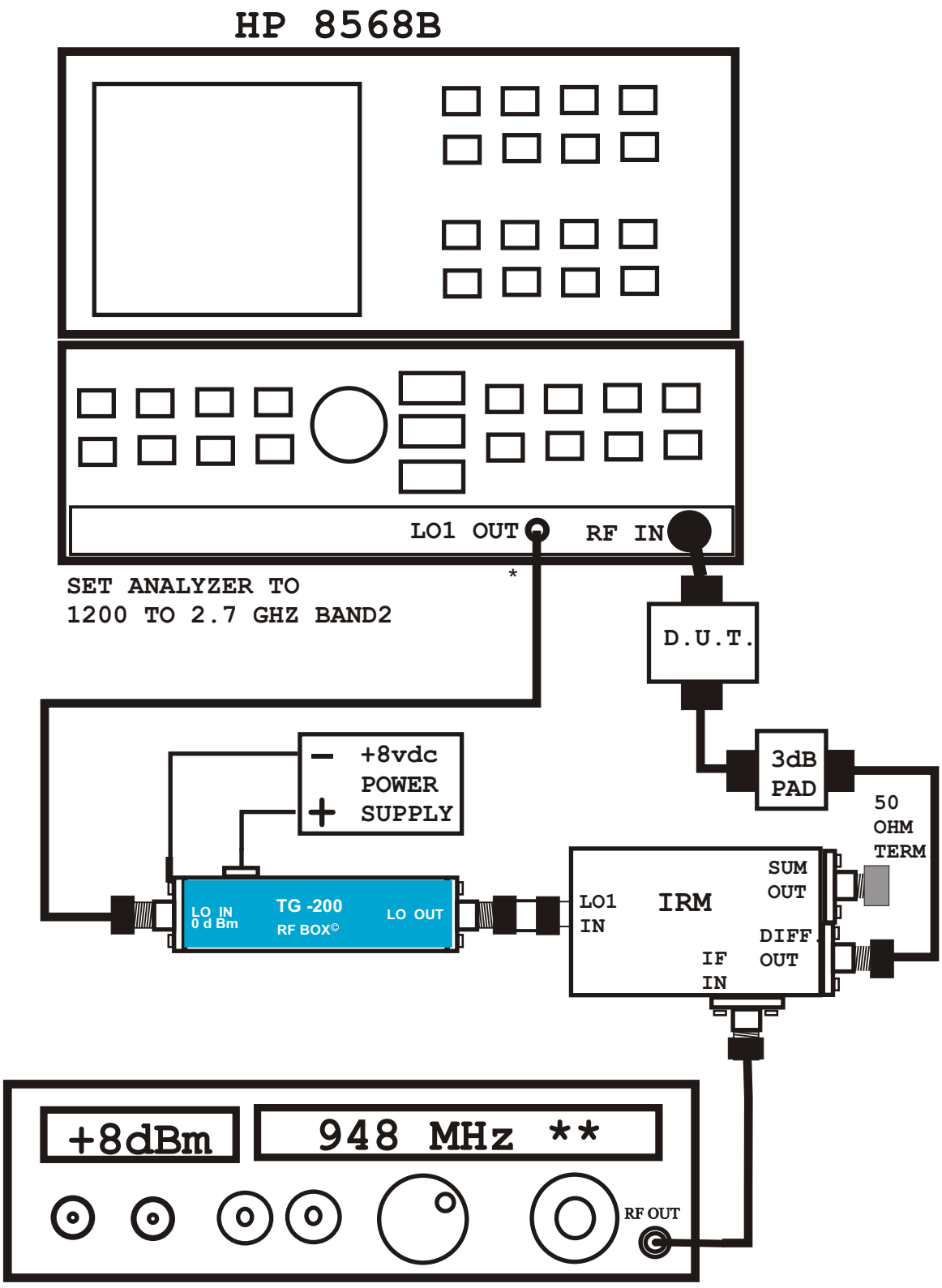
FIG.5:TG100 RECOMMENDED SETUP FOR OPERATION W/ HP8568B and DC100 BAND3



** IT IS NECESSARY TO TUNE IN THE FREQUENCY. FOR MAXIMUM AMPLITUDE WITH THROUGH AS DUT

* LO1 test point is RR panel, shown on Front Panel for clarity

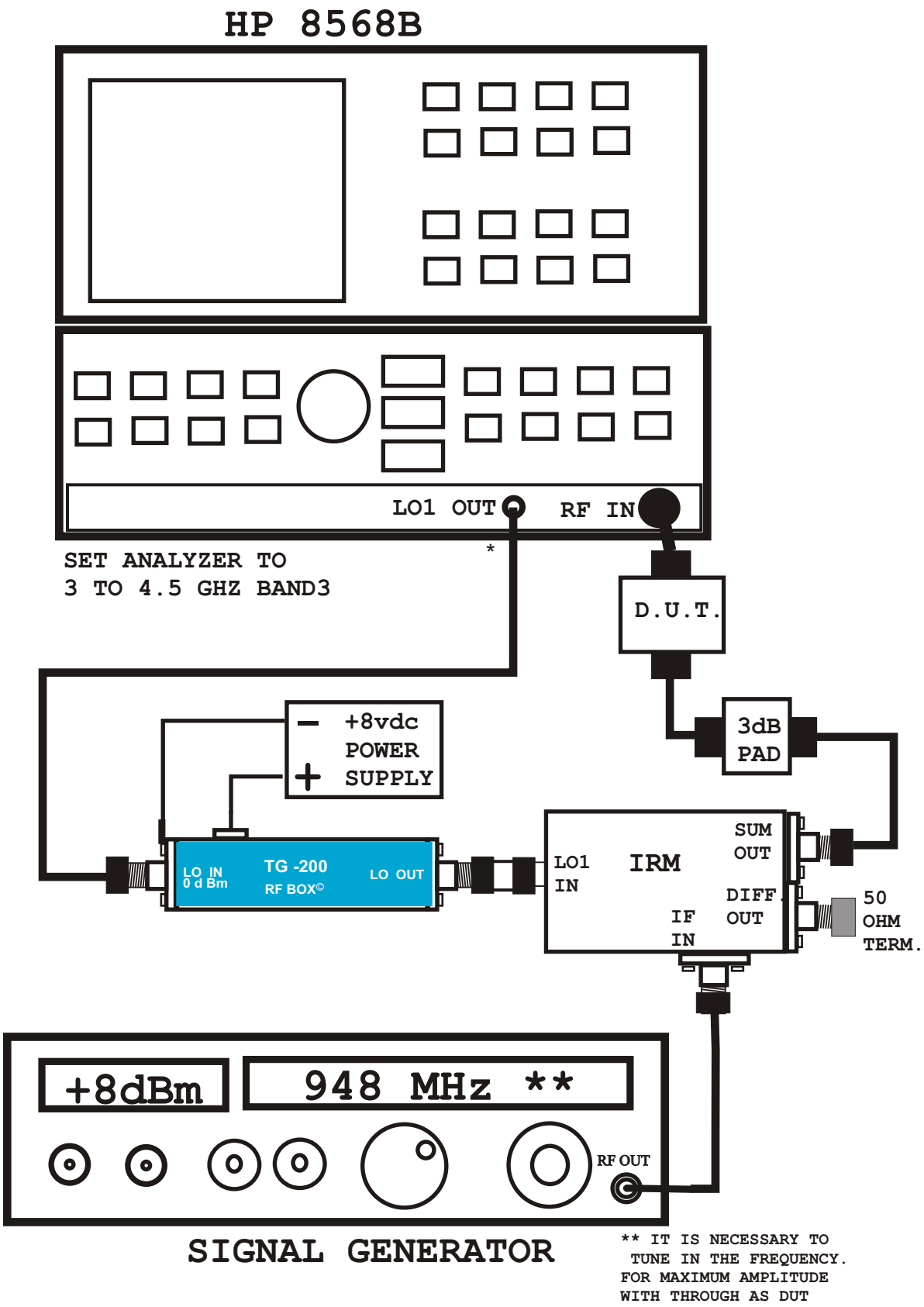
FIG.6:TG200& IRM RECOMMENDED SETUP FOR OPERATION W/ HP8568B and DC100 BAND2



** IT IS NECESSARY TO TUNE IN THE FREQUENCY. FOR MAXIMUM AMPLITUDE WITH THROUGH AS DUT

* LO1 test point is RR panel, shown on Front Panel for clarity

FIG.7:TG200& IRM RECOMMENDED SETUP FOR OPERATION W/ HP8568B and DC100 BAND3



** IT IS NECESSARY TO TUNE IN THE FREQUENCY. FOR MAXIMUM AMPLITUDE WITH THROUGH AS DUT

* LO1 test point is RR panel, shown on Front Panel for clarity

FIG. 8: HP 8568B RF PROCESSING WITH DC-100/CONVERTER INSTALLED