Overview

This document describes the LF Output Level adjustment (9…100KHz) via GPIB commands, following the procedure specified in the HP8648 Operating and Service Guide Manual.

The Agilent Service Software will generate slope (gain) and offset calibration data, which will be saved to EEPROM. The adjustment is performed on next frequencies: 9, 12, 15, 20, 50, 99.999 KHz.

Reference Instructions

LF Output Level (Most 8648B/C/D)

8648B/C Frequency Range

Early versions of the 8648B and 8648C have a frequency range that begins at 100 kHz rather than 9 kHz. If the DUT has a frequency range that begins at 100 kHz, do not run this adjustment.

Description

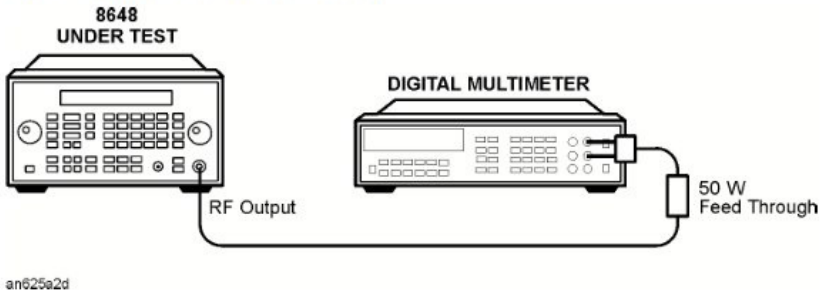
This adjustment creates and stores the slope and offset calibration data for the output module from 9 kHz to 100 kHz. This adjustment will not allow any calibration data to be stored unless all of the calibration data points are measured.

Required Test Equipment

- DVM
- 50Ω Feedthrough

Procedure

Figure 7-30. LF Output Level Test Setup



1. Connect the equipment as shown above.
2. Preset all of the equipment.
3. Follow the instructions as they are displayed on the PC.

GPIB sequence according to Agilent Service Support Software (partial simplified)

```
*IDN?
Hewlett-Packard, 8648B, 3847A02762, B.04.09
*RST
FREQ 100.0000000000 MHZ
POWER:ATT:AUTO 1
POWER:AMPL -136.0000000000
AM:STATE 0
FM:STATE 0
PM:STATE 0
OUTPUT 1
RESET
FUNC ACV
SETACV SYNC
ARANGE ON
RES 0.500000
*IDN?
Hewlett-Packard, 8648B, 3847A02762, B.04.09

FREQ 0.0090000000 MHZ
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
```

```
0.19360E+00

FREQ 0.0120000000 MHZ
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00

FREQ 0.0150000000 MHZ
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
```

```
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00

FREQ 0.0200000000 MHZ
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00

FREQ 0.0500000000 MHZ
```

```
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00

FREQ 0.0999990000 MHZ
POWER:AMPL 0.0000000000
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
TRIG AUTO
0.47184E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H246
TRIG AUTO
0.34735E+00
TRIG AUTO
0.34735E+00
TRIG AUTO
```

```
0.34735E+00
TRIG AUTO
0.34735E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00
TRIG AUTO
0.19360E+00

SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL outllvl_gain,0,1191.0000000000  //9KHz
SERV:PRODUCTION:CAL outllvl_gain,1,1191.0000000000  //12KHz
SERV:PRODUCTION:CAL outllvl_gain,2,1191.0000000000  //15KHz
SERV:PRODUCTION:CAL outllvl_gain,3,1191.0000000000  //20KHz
SERV:PRODUCTION:CAL outllvl_gain,4,1191.0000000000  //50KHz
SERV:PRODUCTION:CAL outllvl_gain,5,1191.0000000000  //99.999KHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE Out_lf_data
SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL outllvl_ofs,0,-3.0000000000  //9KHz
SERV:PRODUCTION:CAL outllvl_ofs,1,-3.0000000000  //12KHz
SERV:PRODUCTION:CAL outllvl_ofs,2,-3.0000000000  //15KHz
SERV:PRODUCTION:CAL outllvl_ofs,3,-3.0000000000  //20KHz
SERV:PRODUCTION:CAL outllvl_ofs,4,-3.0000000000  //50KHz
SERV:PRODUCTION:CAL outllvl_ofs,5,-3.0000000000  //99.999KHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE Out_lf_data
```

Procedure Overview

1. Initial Hookup Summary

Connect AC digital voltmeter to HP8648 output, across a 50Ω resistor. Set DVM

```
RESET
FUNC ACV
SETACV SYNC
ARANGE ON
RES 0.500000
```

Output setup to 0dBm, CW mode:

```
POWER:ATT:AUTO 1
AM:STATE 0
```

```
FM:STATE 0
PM:STATE 0
OUTPUT 1
POWER:AMPL 0.0000000000
```

Set frequency 9KHz, the 1st calibration point: `FREQ 0.0090000000 MHZ`

Set A6 Output module DAC to #H31d (797 dec) and read output level:

```
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H31d
```

Set DAC to obtain 193.6mV (192...195mV) / -1…-1.25dBm, adjust DAC value up/down:

```
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H143
```

For example, next set of values will be obtained: #H31d / 0.47184V, #H143 (323) / 0.19360V. Based on these values, the calibration gain & offset will be calculated.

Set frequency to 12KHz, the 2nd calibration point and repeat above procedure. Continue to repeat for every next points: 15, 20, 50, 99.999 KHz.

4. Gain and Offset calculation

DAC Gain / Offset values for every frequency point are calculated by Agilent Service Software. Unfortunately, the formula used to generate these 2 constants is still unknown. The algorithm is based on:
A6 Output DAC #H31d (797 dec) and output level obtained.
A6 Output DAC value required for 193.6mV output across 50Ω load.

5. Calibration saving to EEPROM

```
SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL outllvl_gain,0,1191.0000000000  //9KHz
SERV:PRODUCTION:CAL outllvl_gain,1,1191.0000000000  //12KHz
SERV:PRODUCTION:CAL outllvl_gain,2,1191.0000000000  //15KHz
SERV:PRODUCTION:CAL outllvl_gain,3,1191.0000000000  //20KHz
SERV:PRODUCTION:CAL outllvl_gain,4,1191.0000000000  //50KHz
SERV:PRODUCTION:CAL outllvl_gain,5,1191.0000000000  //99.999KHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE Out_lf_data

SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL outllvl_ofs,0,-3.0000000000  //9KHz
SERV:PRODUCTION:CAL outllvl_ofs,1,-3.0000000000  //12KHz
SERV:PRODUCTION:CAL outllvl_ofs,2,-3.0000000000  //15KHz
SERV:PRODUCTION:CAL outllvl_ofs,3,-3.0000000000  //20KHz
```

```
SERV:PRODUCTION:CAL outllvl_ofs,4,-3.0000000000  //50KHz
SERV:PRODUCTION:CAL outllvl_ofs,5,-3.0000000000  //99.999KHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE Out_lf_data
```

6. Instrument reboot

```
SERV:PRODUCTION:PUP
```

Remarks

The LF Output Level adjustment routine is used calibrate the gain and offset of the A6 Output DAC. The algorithm initially sets the DAC to a predefined value 797. The resulting output voltage is then measured and used as a reference point.
Based on this reference measurement, the target DAC value is estimated and fine-adjusted to achieve the specific output level 193.6mV across 50Ω resistor. The calibration is performed at various intervals up to 99.999KHz.

The resulting calibration constants, “outllvl_gain” and “outllvl_ofs”, are stored in the A6 Output module EEPROM using the “Out_lf_data” command syntax.

Unfortunately, the formula used to calculate the gain / offset parameters is deep embedded within the Agilent Service Support Software and remains undocumented.
The following values were simulated, Agilent Software results for gain / offset constants may help for better understanding of algorithm. The A6 Output DAC has a 12-bit resolution (4095).

Index	DAC Hex value (Dec)	Output Level (V)	Gain	Offset
1	H31d (797)	0.47184	1191	-3
	H143 (323)	0.1936		
2	H31d (797)	0.4	1669	-134
	H143 (323)	0.1936		

Target DAC can be calculated using:

$$\mathrm{DACtarget} = \mathrm{DACref}\ \mathrm{x}\ \frac{Vtarget}{Vref}$$

Example:
DAC ref = 0.5V,DACref = 797, Vtarget = 0.1936V.
DACtarget = 707 x 0.3872 = 309 (H135).

Gain – shifts the overall output level up or down relative to 0dBm. A gain value of zero is not supported.
Offset – a negative offset increase the output level per 1dB step. A positive offset decrease the output level per 1dB step.
Gain and offset interact, therefore the Offset must adjusted first to obtain the correct 1dB step size. Then, adjust Gain to achieve the required 0dBm output level.

73’s de Robert YO4HFU