## Overview

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

The Agilent Service Software will generates slope (gain) and offset calibration data, which will be saved to EEPROM . The adjustment is performed on next frequencies: 0.1, 0.25, 0.75, 1.498, 1.5, 3, 6, 10, 15, 19.998, 20, 30, 50, 100, 150, 200, 250…950, 1000, 1001, 1040, 1080, 2020…up to 2000MHz for B version, 3200MHz for C version or 4000MHz for D version.

Calibration array has 108 points. Not used fields are filled by gain/offset values corresponding with last frequency. For example version C, gain/offset fields above 3200MHz are not used but will be filled by same value as 3200MHz.

## Reference Instructions

### Output level: Frequency Extension Calibration (8648B/C/D Only)

**Description**

This adjustment creates the slope and offset calibration data for the output calibration.

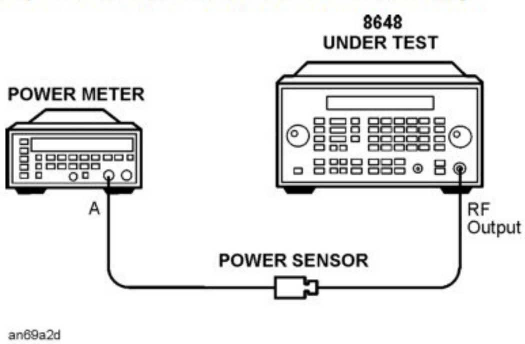
The adjustment will not let you store away any calibration data unless all of the calibration data points are run.

**Required Test Equipment**

- Power Meter
- Power Sensor

**Procedure**

**Figure 7-19. Frequency Extension Calibration 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 sequence)

```
LG
*RST
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
FREQ 100.0000000000 MHZ
POWER:ATT:AUTO 1
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
POWER:AMPL -136.0000000000
AM:STATE 0
FM:STATE 0
PM:STATE 0
OUTPUT 1
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
POWER:AMPL 13.0000000000
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
FREQ 0.1000000000 MHZ
KB4.000000EN
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H666
TR2
CS@18
+14.650E+00
TR2
+14.640E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H3c0
TR2
CS@18
+10.270E+00
TR2
+10.250E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H3a5
TR2
CS@18
+10.030E+00
TR2
+10.020E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H146
TR2
CS@18
+1.5300E+00
TR2
+1.5200E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
```

```
DIAG:LATCH:VAL #Had
TR2
CS@18
-3.3500E+00
TR2
-3.3500E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #Ha0
TR2
CS@18
-3.9400E+00
TR2
-3.9400E+00
...
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
FREQ 1000.0000000000 MHZ
KB99.000000EN
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H666
TR2
CS@18
+13.260E+00
TR2
+13.260E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H465
TR2
CS@18
+9.9900E+00
TR2
+9.9800E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H146
TR2
CS@18
-0.8200E+00
TR2
-0.8300E+00
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #He2
TR2
CS@18
-4.0900E+00
TR2
-4.1000E+00
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
FREQ 1001.0000000000 MHZ
KB99.000000EN
DIAG:LATCH:SELECT "freq_ext_level_DAC"
```

```
DIAG:LATCH:VAL #H666
TR2
CS@18
+13.400E+00
TR2
+13.400E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H453
TR2
CS@18
+9.9800E+00
TR2
+9.9800E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H146
TR2
CS@18
-0.7100E+00
TR2
-0.7200E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #He0
TR2
CS@18
-4.0700E+00
TR2
-4.0800E+00
...
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
FREQ 3200.0000000000 MHZ
KB99.000000EN
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H666
TR2
CS@18
+12.320E+00
TR2
+12.320E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H4e6
TR2
CS@18
+9.9500E+00
TR2
+9.9500E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H146
TR2
CS@18
-2.1700E+00
```

```
TR2
-2.1800E+00
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H109
TR2
CS@18
-4.0700E+00
TR2
-4.0700E+00
*OPT?
0,0,0,0,0,0,
*IDN?
Hewlett-Packard, 8648C, 3847U03029, B.04.09
SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL fextlvl_gain,0,964.6000000000 //0.1MHz
SERV:PRODUCTION:CAL fextlvl_gain,1,492.2000000000
SERV:PRODUCTION:CAL fextlvl_gain,2,300.9000000000
SERV:PRODUCTION:CAL fextlvl_gain,3,306.5000000000
...
SERV:PRODUCTION:CAL fextlvl_gain,106,1241.9000000000
SERV:PRODUCTION:CAL fextlvl_gain,107,1241.9000000000 //4000MHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE fextlvl_data
SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL fextlvl_ofs,0,-33.7960000000 //0.1MHz
SERV:PRODUCTION:CAL fextlvl_ofs,1,-10.2290000000
SERV:PRODUCTION:CAL fextlvl_ofs,2,-4.5550000000
SERV:PRODUCTION:CAL fextlvl_ofs,3,-4.4360000000
...
SERV:PRODUCTION:CAL fextlvl_ofs,106,19.1970000000
SERV:PRODUCTION:CAL fextlvl_ofs,107,19.1970000000 //4000MHz
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE fextlvl_data
SERV:PRODUCTION:PUP
```

## Procedure Overview

### 1. Initial Hookup Summary

Calibrate the HP438A power meter. Connect the power sensor to HP8648 output. Set power meter via GPIB to logarithmic mode, calibration factor and read actual output power by triggering:

```
LG           //Log (dBm)
KB95.000000EN     //Cal Factor
TR2          //Trigger with Delay
CS@18        //Clear status byte
```

Output setup for +13dBm, CW mode:

```
POWER:ATT:AUTO 1
AM:STATE 0
FM:STATE 0
PM:STATE 0
OUTPUT 1
POWER:AMPL 13.0000000000
```

Set frequency 0.1MHz, the 1st calibration point: `FREQ 0.1000000000 MHZ`

Set A6 Output module DAC to #H666 (1638 dec) and read output power:

```
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #H666
```

Set DAC to obtain -4.00dBm (+/-0.1), adjust DAC value up/down:

```
DIAG:LATCH:SELECT "out_carrier_level_DAC"
DIAG:LATCH:VAL #Ha0
```

For example, next set of values will be obtained: #H666 / 14.65dBm, #Ha0 (160) / -3.94dBm.
Based on these values, the calibration gain & offset will be calculated.

Set frequency to 0.25MHz, the 2nd calibration point and repeat above procedure. Continue to repeat for every next points:
0.75, 1.498, 1.5, 3, 6, 10, 15, 19.998, 20, 30, 50, 100, 150, 200, 250…900, 950, 1000 MHz.

## 2. Output Level FE above 1GHz

Keep same output level +13dBm, CW.

Set frequency 1001MHz, `FREQ 1001.0000000000 MHZ`

Set A10 Frequency Extension module DAC to #H666 (1638 dec) and read output power:

```
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #H666
```

Set DAC to obtain -4.00dBm (+/-0.1), adjust DAC value up/down:

```
DIAG:LATCH:SELECT "freq_ext_level_DAC"
DIAG:LATCH:VAL #He0
```

For example, next set of values will be obtained: #H666 / 13.4dBm, #He0 (224) / -4.07dBm.
Based on these values, the calibration gain & offset will be calculated.

Repeat for every 40MHz step up to maximum HP8648's frequency range (1040, 1080…etc).

## 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.

Up to 1000MHz:
A6 Output DAC #H666 (1638 dec) and RF output power obtained.
A6 Output DAC value required for -4.00dBm output.

Above to 1001MHz:
A10 FE DAC #H666 (1638 dec) and RF output power obtained.
A10 FE DAC value required for -4.00dBm output.

## 5. Calibration saving to EEPROM

```
SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL fextlvl_gain,0,964.6000000000
SERV:PRODUCTION:CAL fextlvl_gain,1,492.2000000000
...
SERV:PRODUCTION:CAL fextlvl_gain,106,1241.9000000000
SERV:PRODUCTION:CAL fextlvl_gain,107,1241.9000000000
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE fextlvl_data

SERV:PRODUCTION:CAL:BEGIN
SERV:PRODUCTION:CAL fextlvl_ofs,0,-33.7960000000
SERV:PRODUCTION:CAL fextlvl_ofs,1,-10.2290000000
...
SERV:PRODUCTION:CAL fextlvl_ofs,106,19.1970000000
SERV:PRODUCTION:CAL fextlvl_ofs,107,19.1970000000
SERV:PRODUCTION:CAL:END
SERV:PRODUCTION:CAL:STORE fextlvl_data
```

## 6. Instrument reboot

```
SERV:PRODUCTION:PUP
```

## Remarks

The Output Level FE adjustment routine is used calibrate the gain and offset of the A6 Output DAC and A10 FE DAC. The algorithm initially sets the DAC to a predefined value 1638. The resulting RF output power 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 -4dBm (+/-0.1).

The calibration is performed at various intervals up to 1000MHz using A6 Output module DAC and above 1001MHz by A10 FE module DAC.

The resulting calibration constants, “fextlvl_gain” and “fextlvl_ofs”, are stored in the A10 EEPROM using the “fextlvl_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.

Below are several data samples obtained that may help understanding of the gain and offset calculation. The A6 Output DAC has a 12-bit resolution (4095).

| Index | DAC Hex value (Dec) | Output Level (dBm) | Gain | Offset |
|---|---|---|---|---|
| 1 | H666 (1638) | 14.65 | 964.6 | -33.796 |
| | Ha0 (160) | -3.94 | | |
| 2 | H666 (1638) | 20.37 | 492.2 | -10.229 |
| | H59 (89) | -3.92 | | |
| 3 | H666 (1638) | 24.68 | 300.9 | -4.555 |
| | H37 (55) | -4.06 | | |
| 4 | H666 (1638) | 24.57 | 306.5 | -4.436 |
| | H39 (57) | -3.95 | | |
| 5 | H666 (1638) | 24.62 | 302.2 | -5.881 |
| | H36 (54) | -4.05 | | |
| 6 | H666 (1638) | 23.3 | 352.9 | -6.088 |
| | H40 (64) | -4.04 | | |
| **7** | H666 (1638) | 13.63 | 1076.6 | 0.177 |
| | Hd6 (214) | -4.03 | | |

Target DAC can be calculated using:
$DACtarget = DACref * 10^{[Ptarget - Pref]/20}$

Example (index 7):
DACref = 1638, Pref =13.63, Ptarget = -4
$DACtarget = 1638 * 10^{[-4 - 13.63]/20}$ = 1638 * 0.131 = 214 (Hd6)

This matches the value found by the Agilent Software. However, in practice the result may differ if the output response is not linear, and upward or downward DAC adjustment may be required to reach target output (-4dBm).

73’s de Robert YO4HFU