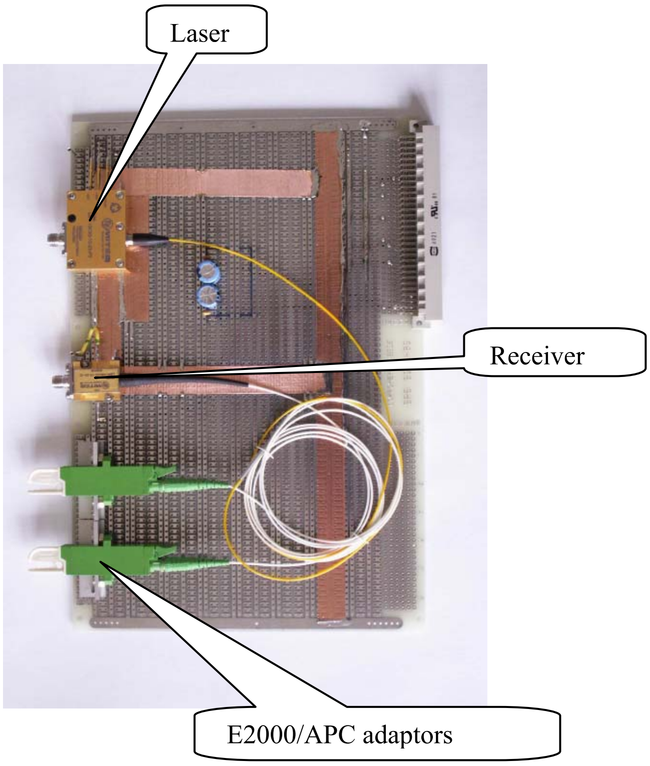
MITEQ optical links Evaluation Report

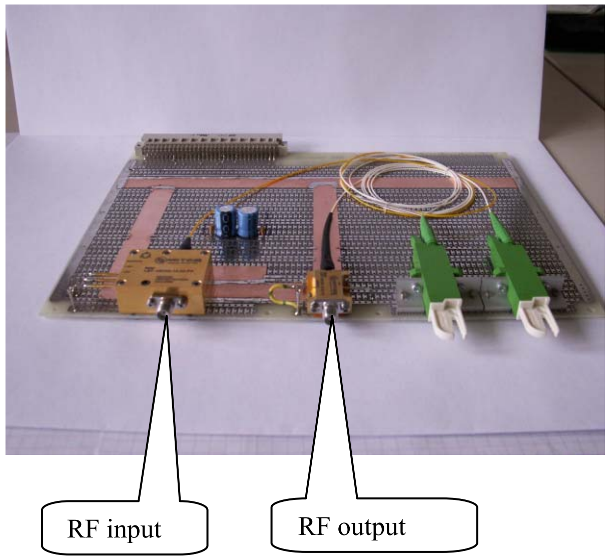
Table of Contents

I. EVALUATION BOARD

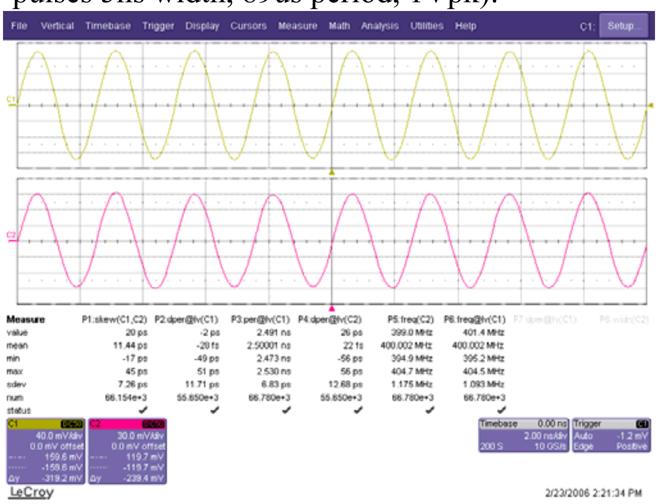
Two prototype boards have been made to allow the following tests to be made. These are 6U VME boards, each equipped with one laser and one receiver, some filtering and some front panel adaptors for the E2000/APC optical connectors.

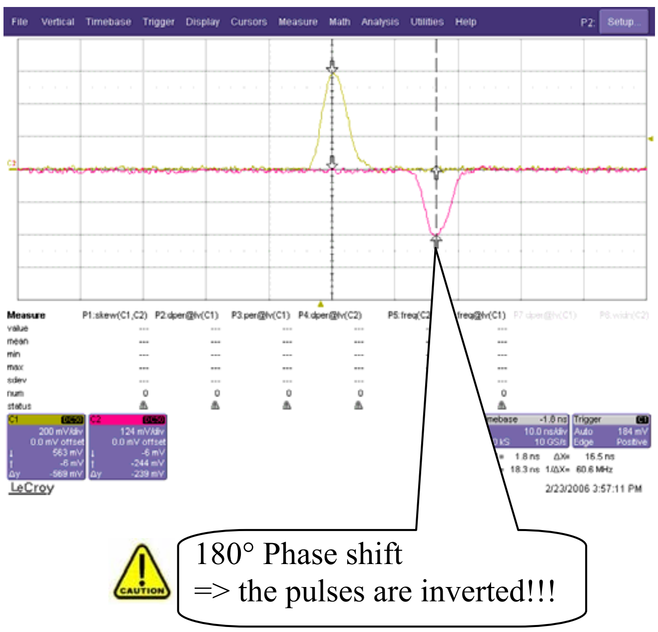
The optical transmitters and receivers are the MITEQ LBT-10K3G-13-23-P3.





This analog optical link will typically transmit RF signals (10MHz, 40MHz, 400MHz at 0dBm and pulses 5ns width, 89us period, 1Vpk):

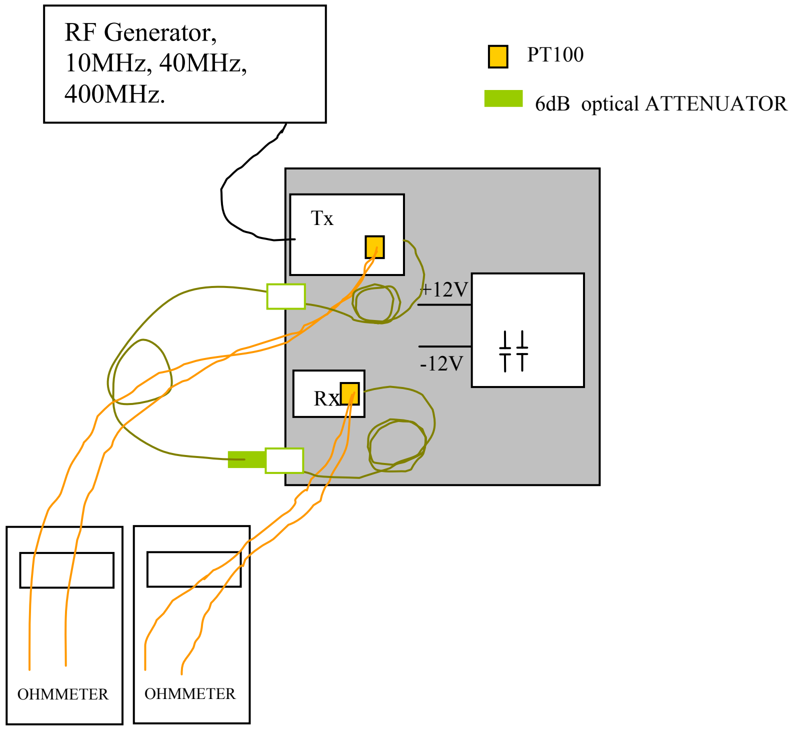


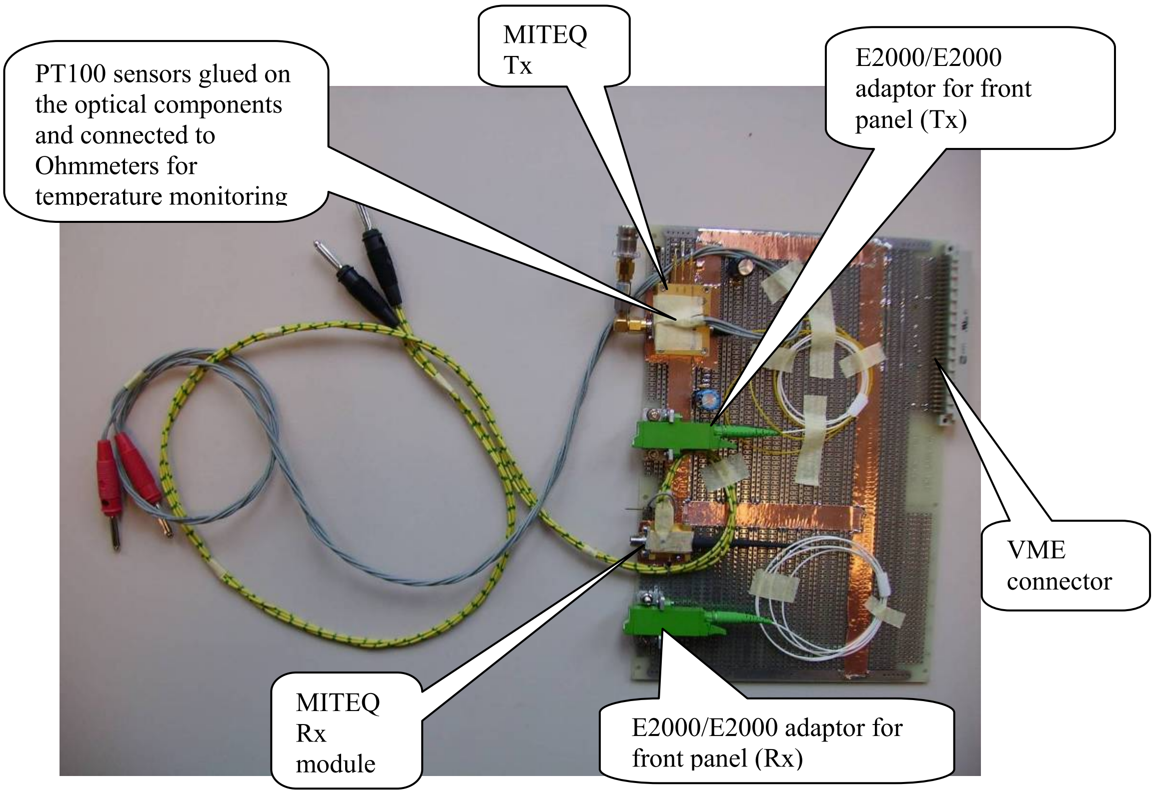


II. TEMPERATURE MEASUREMENTS

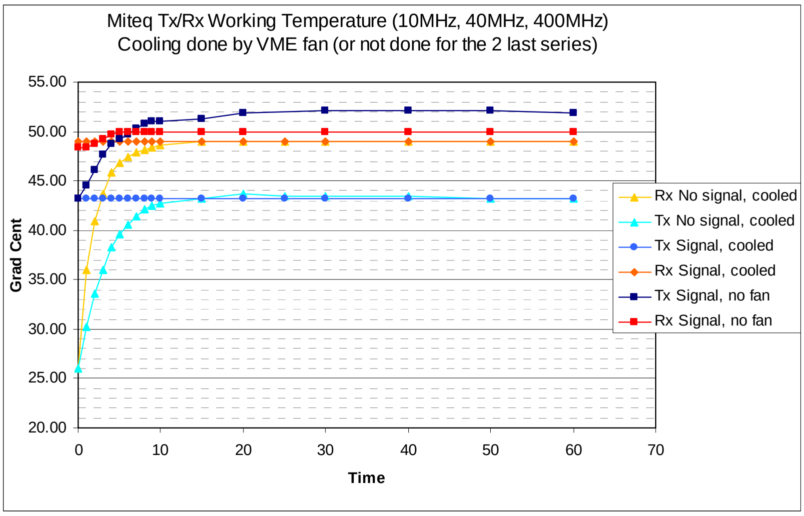
A. Setup

- One RF generator – 100kHz-2000MHz - HP 8648B for the 3 RF signals 10MHz, 40MHz, 400MHz.
- VME 6U board with:
  - 1 Tx – MITEQ 3GHz LBL link transmitter (equipped with one pt100 glued on its cover)
  - 1 Rx – MITEQ 3GHz LBL link receiver (equipped with one pt100 glued on its cover)
  - Filtering on the power supplies done by 47uF & 100nF
- 2 Ohmmeters (to measure the pt100 resistance)





B. Results



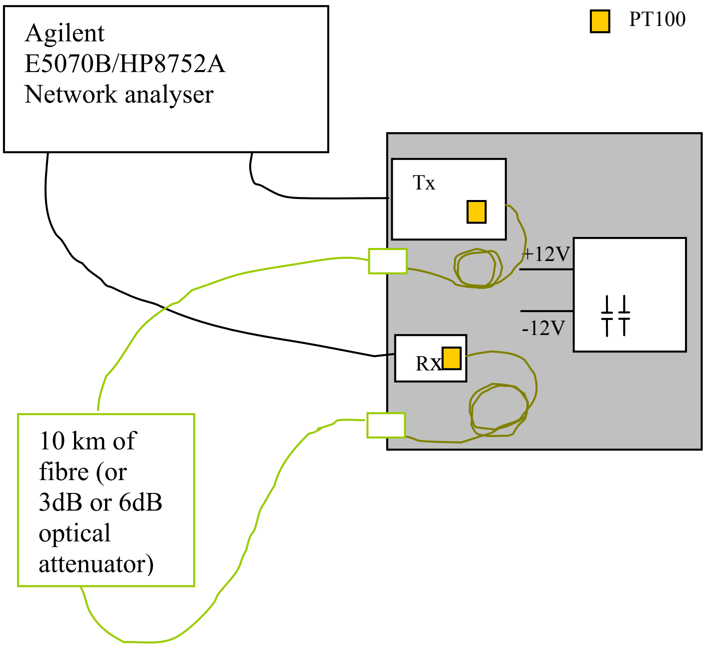
- First measurements without any input signal
- Then with input signal (the temperatures are the same for 10MHz, 40MHz and 400MHz)
- And finally with the air flow from the fan blocked, and the crate closed

The Tx and Rx have not been stopped and cooled down between the 3 measurement sequences.

III. FREQUENCY SWEEP

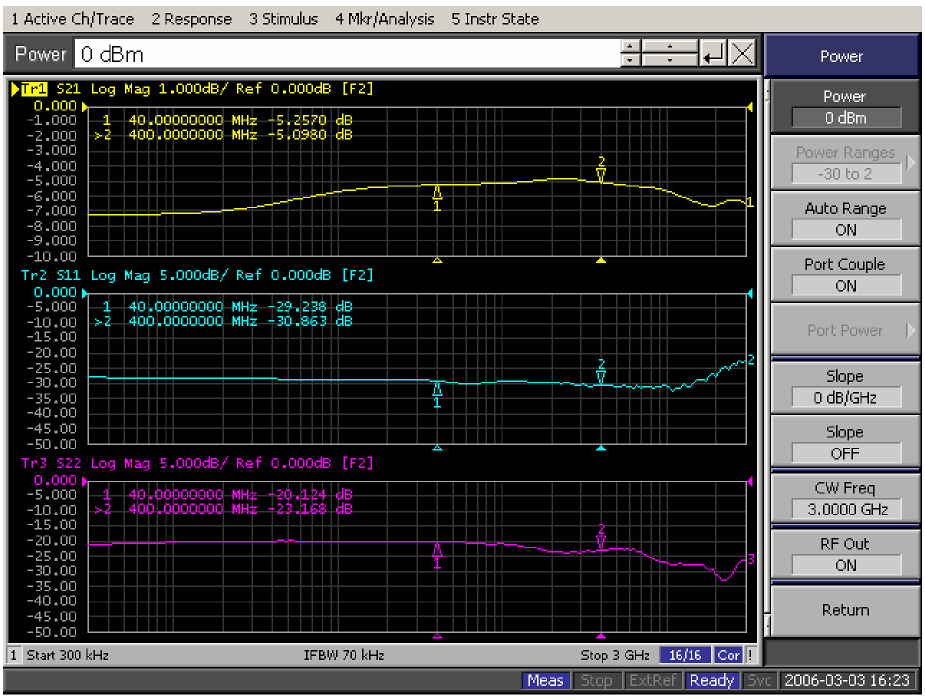
A. Setup

- Network analyzers: Agilent E5070B or HP8752A
- 10 km optical link



B. Results

1. Without cooling: (components temperature ~ 50 C)

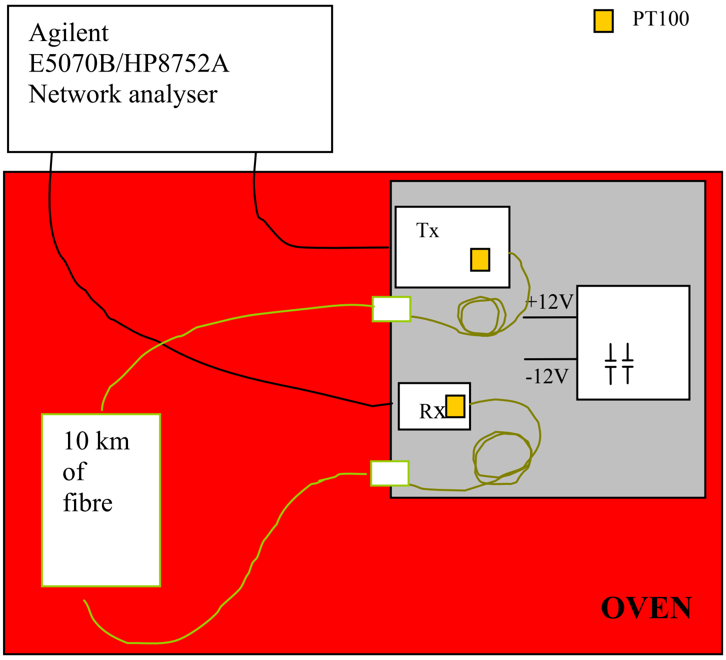


- Network analyzer type E5070B
- Measurement done with 6dB optical attenuator and 1m of fibre only.
- -10 dBm input.
- 5dB loss at nominal frequencies.

2. **With cooling:**

The previous setup (fibres + DUT) is installed in a climatic chamber, and the oven temperature is set to 15°C, 8°C and 32°C.

- The Network analyzer is in this case the HP8752A.
- The RF input level is -10dBm.
- 10km of fibre and no optical attenuator



The Tx and Rx case temperature is monitored, as well as the frequency sweep:

Oven 15°C	Case Temperature
Tx	35°C
Rx	39°C

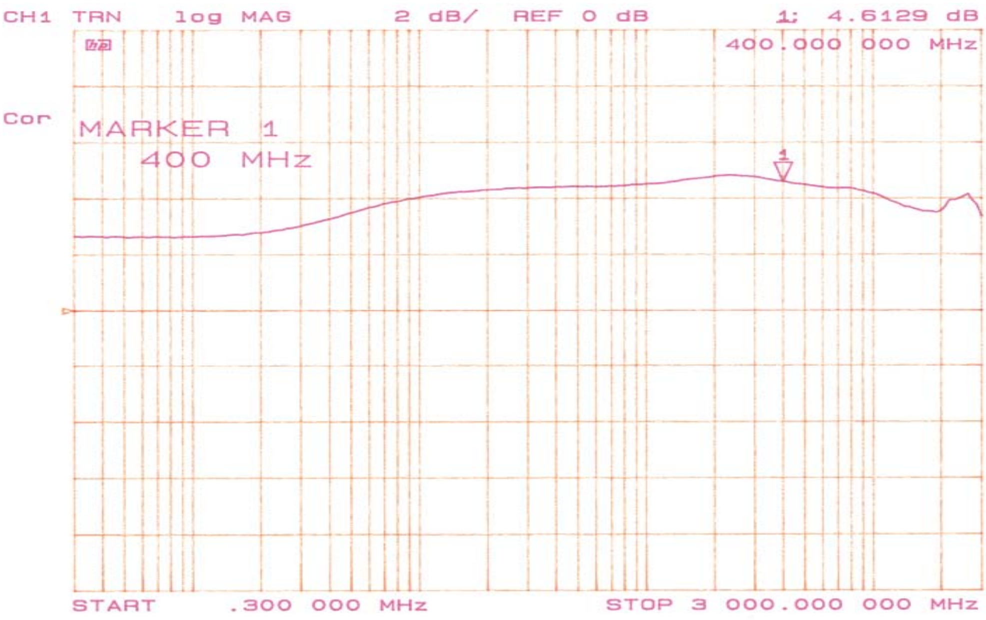
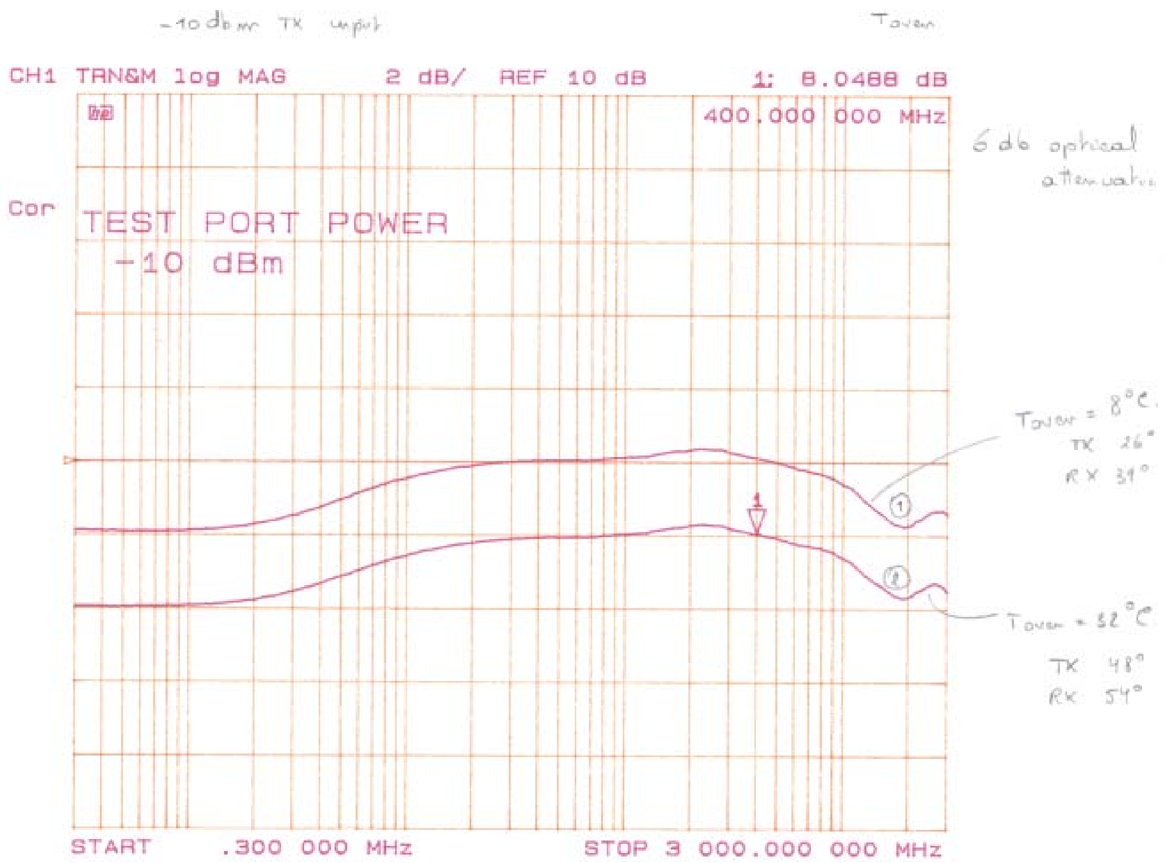


Figure 1: Frequency sweep at 15°C

3. Gain drop with temperature

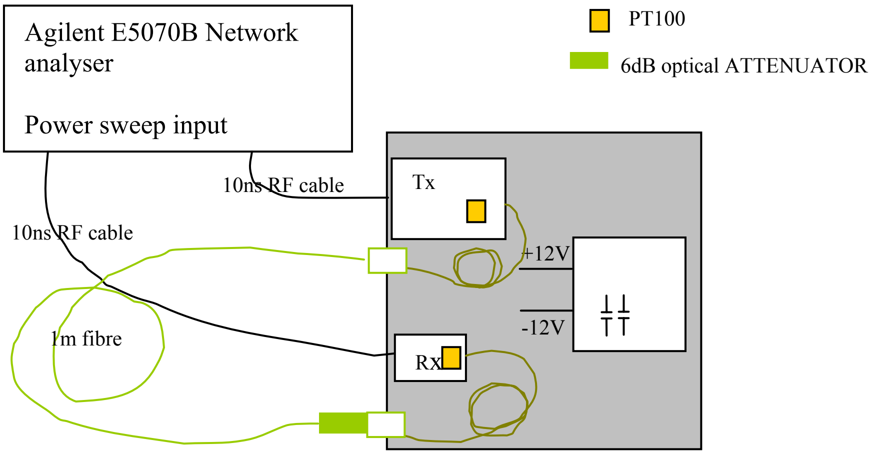
The frequency response is analysed at 2 different oven temperatures (8°C and 32°C). 6dB optical attenuator and 1m of fibres are used instead of the 10km of fibres. The rest of the setup remains identical to the previous one.



Conclusion: to avoid too much gain drop, the Rx and Tx should be equipped with appropriate heatsinks. The objective would be to keep their case temperature below 35°C-40°C.

IV. POWER SWEEP

A. Setup

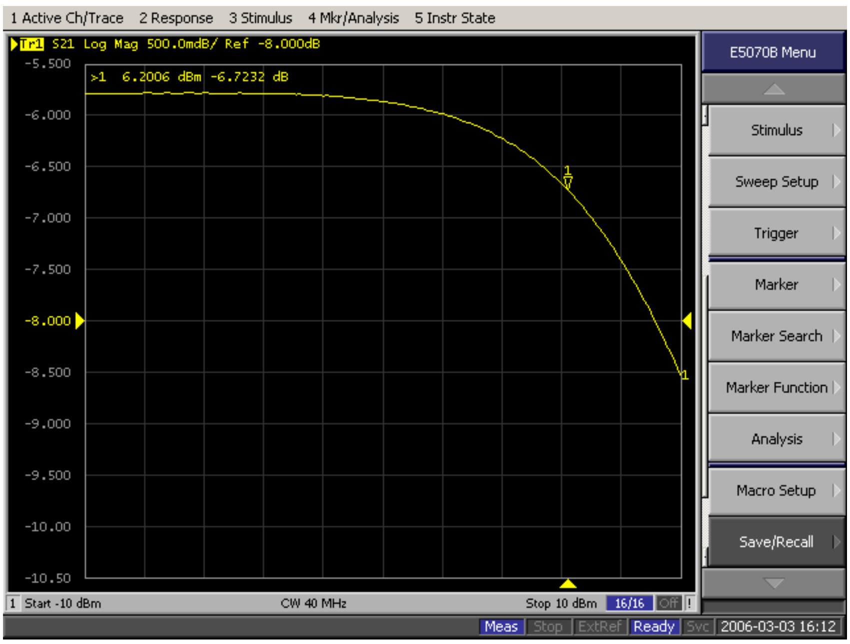


- No cooling => case temperature of Tx and Rx ~ 50°C

B. Results

1. 40MHz

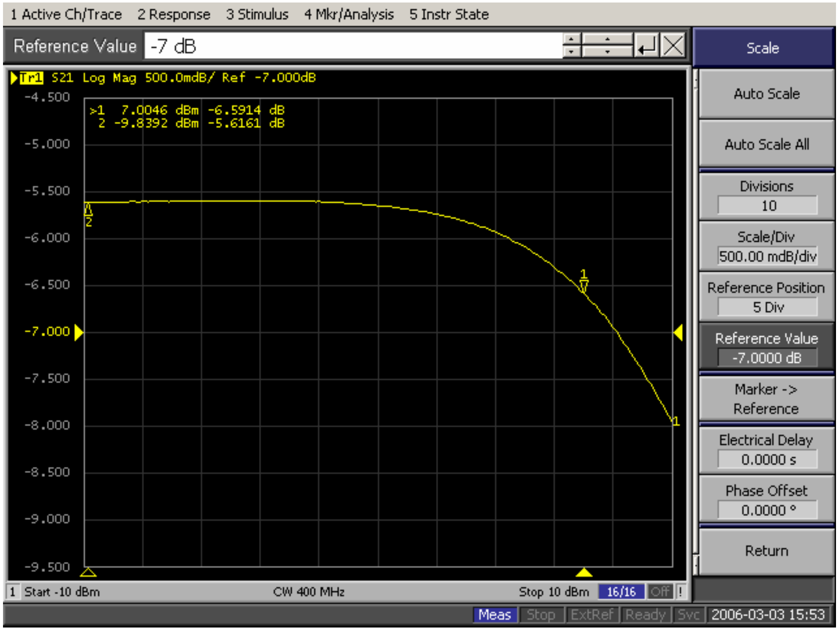
Measured input power 1 dB compression at 6.2dBm.
(cable loss negligible at 40MHz)



2. 400MHz

- Measured input power 1 dB compression at 7 dBm.
- Cable loss 0.5 dB

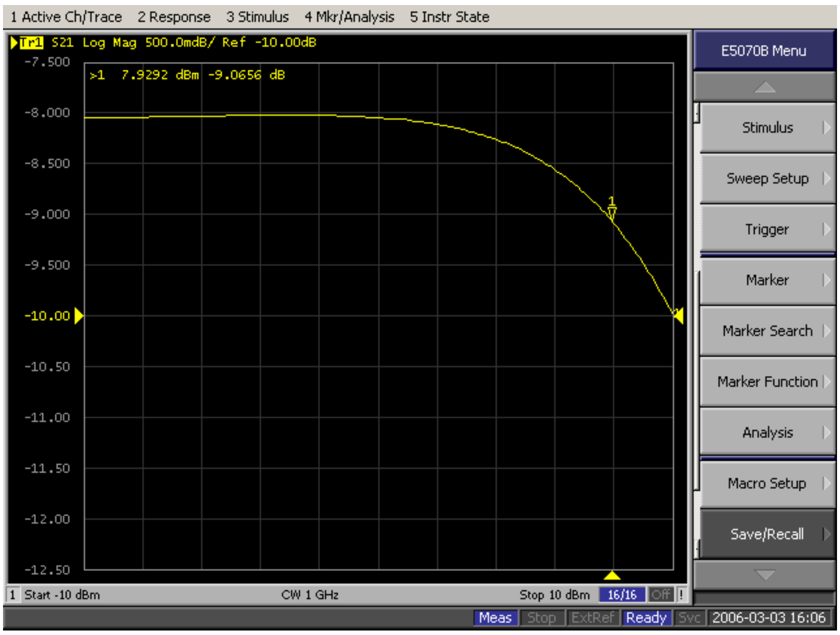
Input power 1dB compression at 6.5 dBm



3. 1GHz

- Measured input power 1 dB compression at 7.9 dBm.
- Cable loss 1 dB

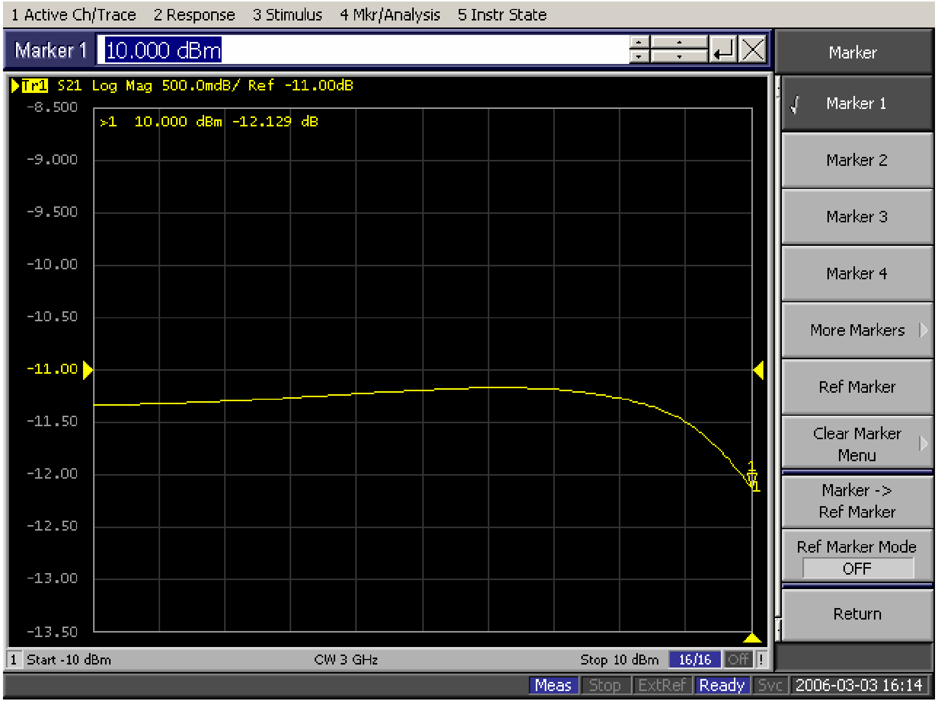
Input power 1dB compression at 6.9 dBm



4. 3GHz

- Measured input power 1 dB compression at 10 dBm.
- Cable loss 1.5 dB

Input power 1dB compression at 8.5 dBm

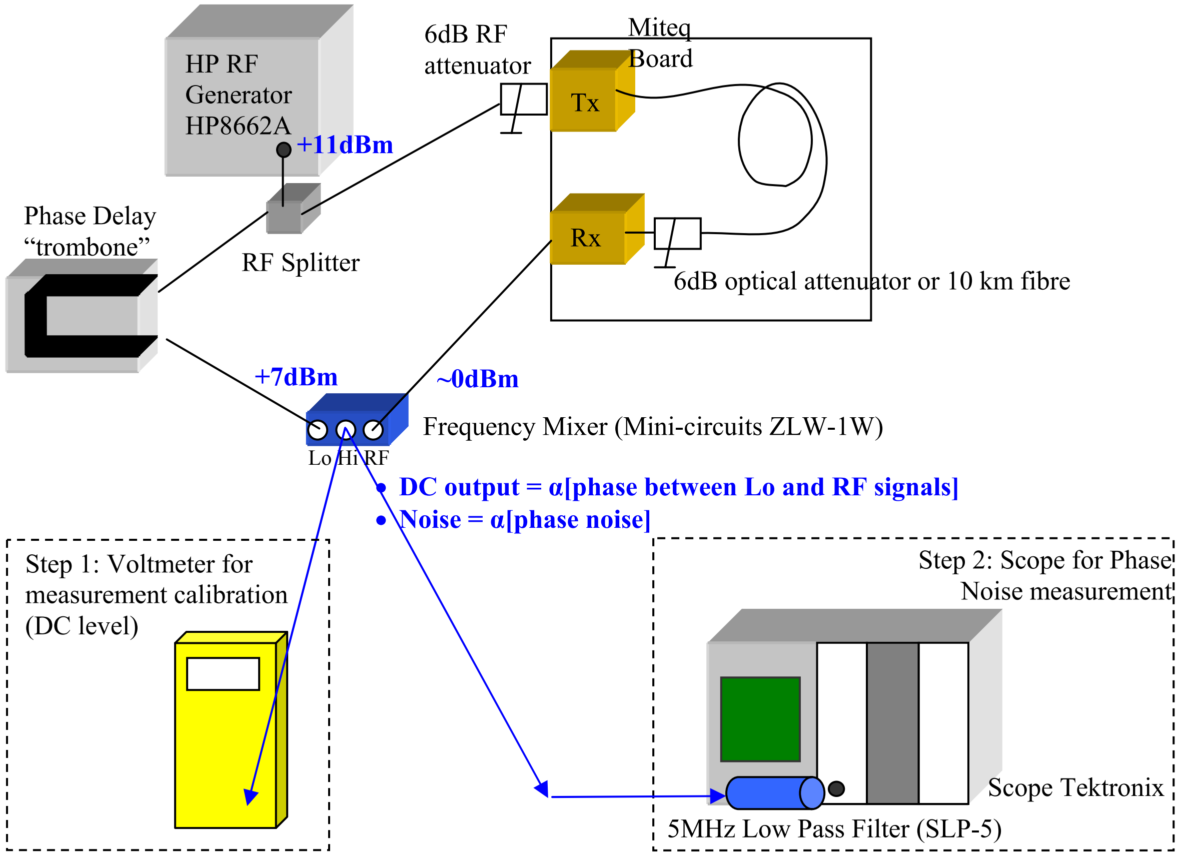


5. Summary

Frequency	Input power 1dB compression point
40MHz	6.2 dBm
400MHz	6.5 dBm
1GHz	6.9 dBm
3GHz	8.5 dBm

V. PHASE NOISE

A. *Setup*



- RF generator type HP8662A
- Oscilloscope Tektronix type 7613 with modules 7B92A for triggering and 7A22 for very high vertical resolution (10uV/division). Max bandwidth 1MHz.
- RF splitter, attenuators and LPF (type SLP-5) from mini-circuits
- Frequency mixer type ZLW-1W

B. Results

First remarks:

- During our measurements, we faced a 50Hz noise which was independent from the link itself and that we did not really manage to remove, except by adding an extra 100Hz filter at the input of the scope. This implies that the real phase noise of the link is far smaller than the actual measured values.
- As the oscilloscope input has only 1MHz bandwidth, the phase noise measurement is limited to the DC-1MHz band.

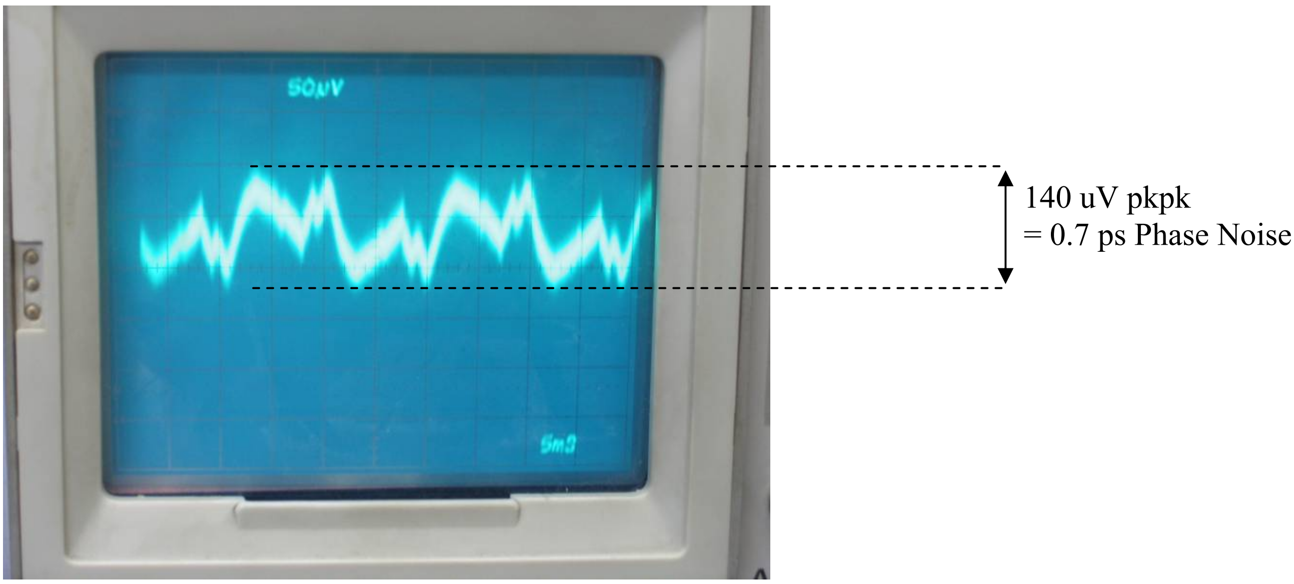
1. 400MHz with 6dB optical attenuator

Calibration of the measurement, using the Voltmeter:

5 cm	40mV swing

Which gives us, using the relation 1cm = 33ps in vacuum,

4ps	1mV



Results:

Total Phase Noise = 0.7 ps pkpk
Phase Noise without the 50Hz = 0.2 ps pkpk

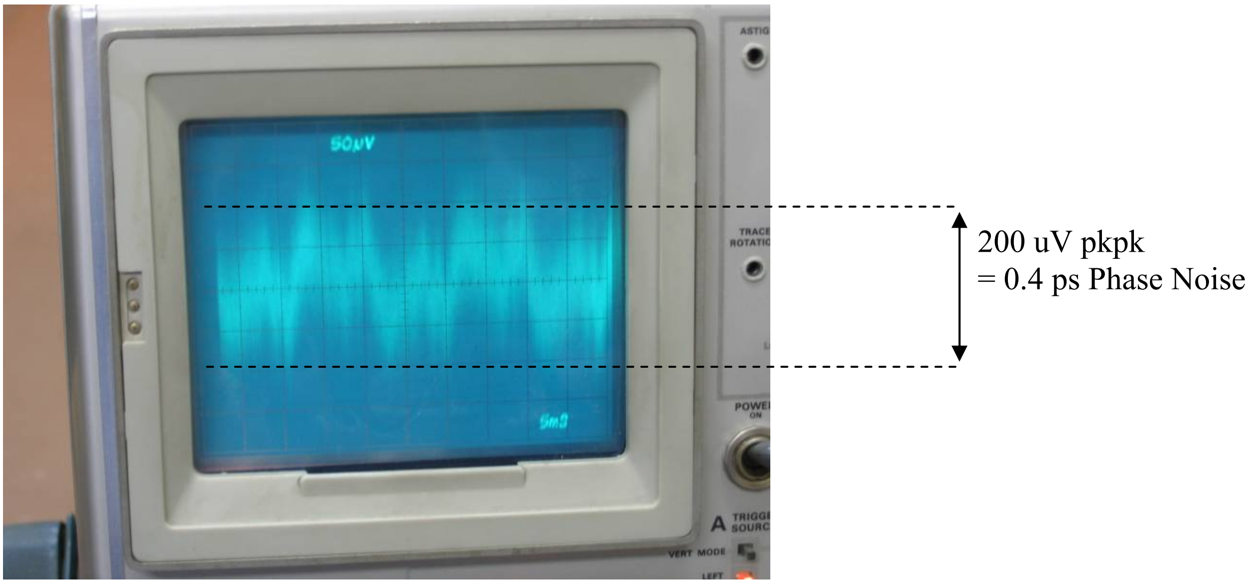
2. <u>400MHz with 10km long fibre</u>

Calibration of the measurement, using the Voltmeter:

5 cm	84mV swing

Which gives us, using the relation 1cm = 33ps in vacuum,

2ps	1mV



Results:

Total Phase Noise = 0.4 ps pkpk Phase Noise without the 50Hz = 0.2 ps pkpk

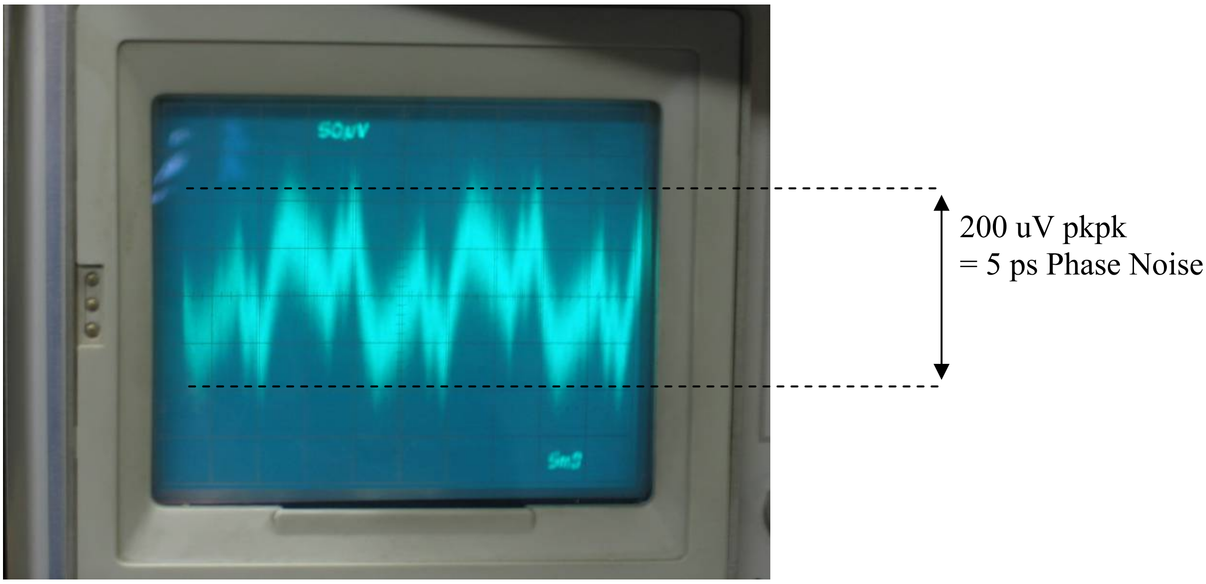
3. 40MHz with 10km long fibre

Calibration of the measurement, using the Voltmeter:

5 cm	6.75mV swing

Which gives us, using the relation 1cm = 33ps in vacuum,

25ps	1mV



Results:

Total Phase Noise = 5 ps pkpk Phase Noise without the 50Hz = 2.5 ps pkpk

4. 10MHz with 10km long fibre

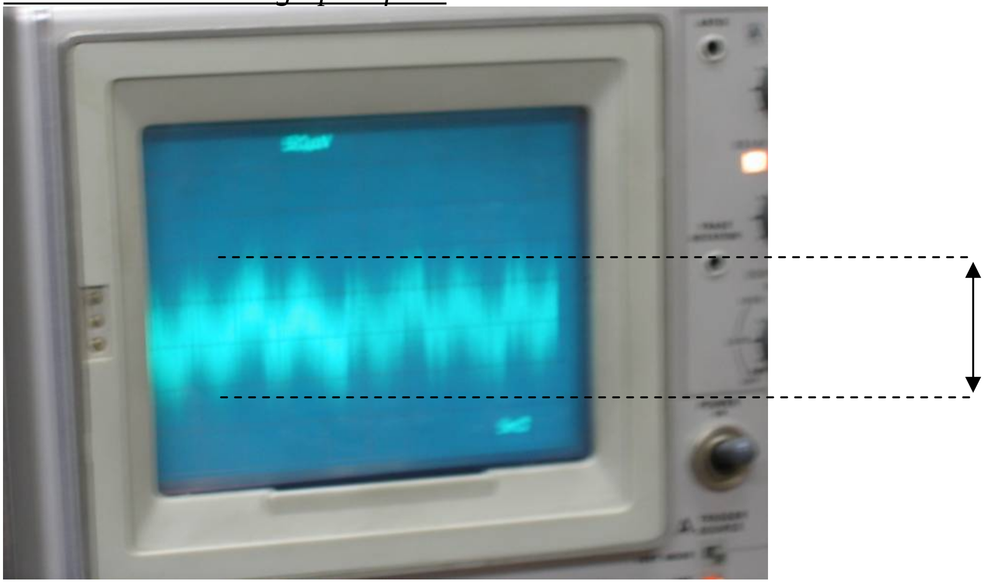
Calibration of the measurement, using the Voltmeter:

20 cm	5 mV swing

Which gives us, using the relation 1cm = 33ps in vacuum,

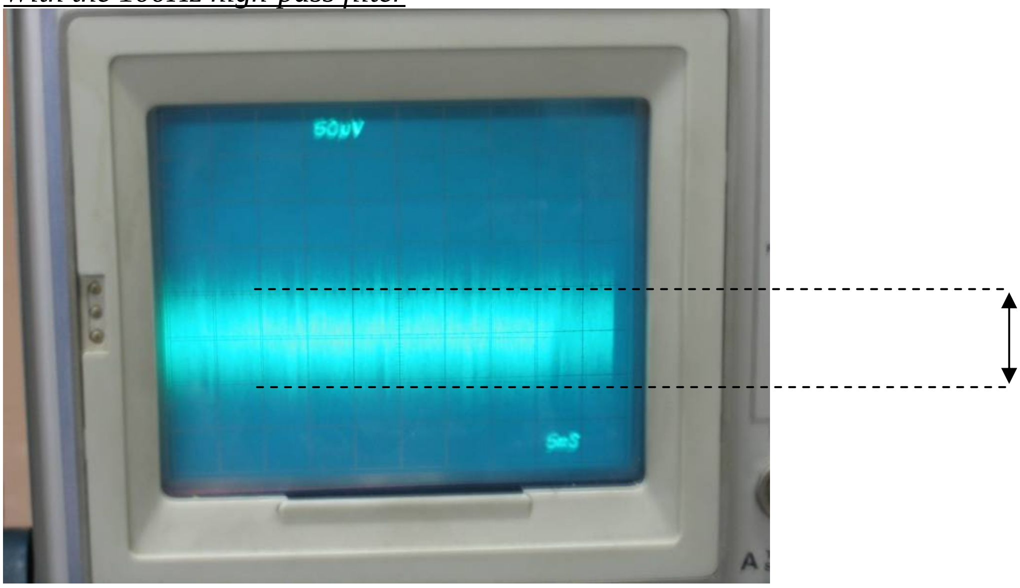
132ps	1mV

Without the 100Hz high-pass filter



150 uV pkpk
= 20 ps Phase Noise

With the 100Hz high-pass filter



100 uV
= 13 ps Phase Noise

Results:

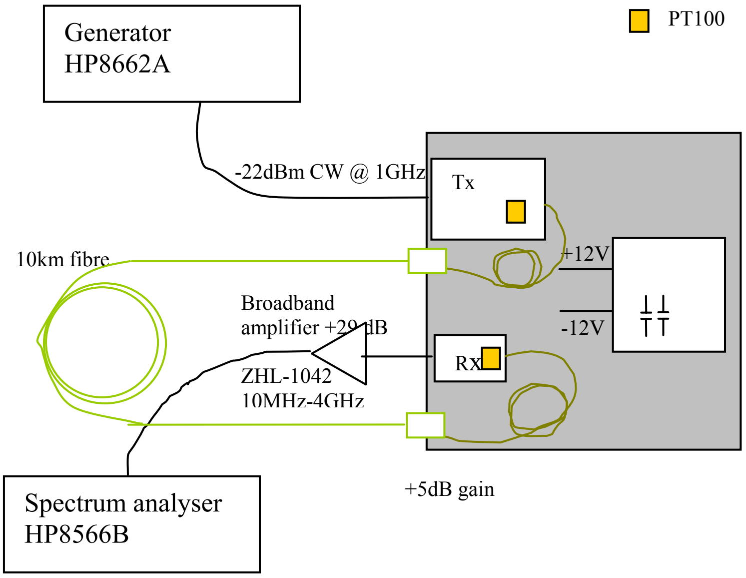
Total Phase Noise = 20 ps pkpk
Phase Noise without the 50Hz = 13 ps pkpk

5. Summary

Setup	Total Phase Noise (pkpk) in DC-1 MHz band	Phase Noise without the 50Hz (pkpk) in 1 MHz band
400MHz – 6dB optical att	0.7 ps	0.2 ps
400 MHz – 10km fibre	0.4 ps	0.2 ps
40 MHz – 10km fibre	5 ps	2.5 ps
10 MHz – 10km fibre	20 ps	13 ps

VI. NOISE FLOOR MEASUREMENT

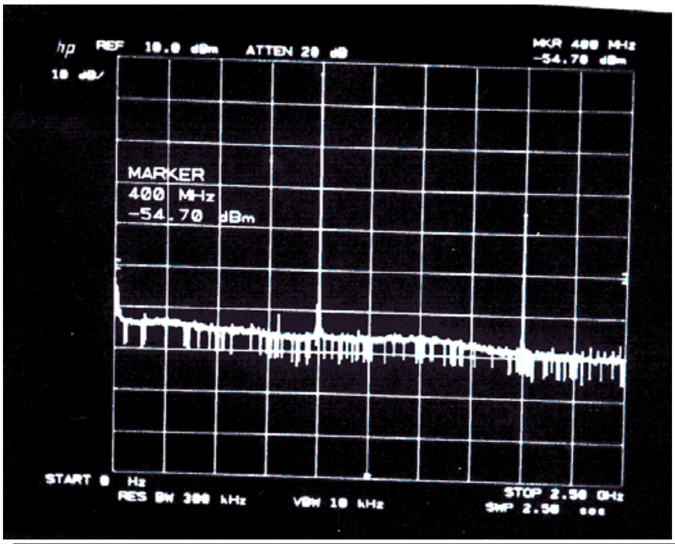
A. Setup



B. Results

- Measured Noise Power ≈ -55 dBm in 300 kHz band @ 1GHz, (300kHz is the spectrum analyzer resolution).
- Normalised Noise Power = NP_{norm} = -55dBm – 10 log (300kHz) = -110dBm/Hz.
- The Spectrum analyzer measures a PSD of $kT_oF_{DUT}G_{DUT}G_P$.
- $NF = NP_{norm} - 10\log G_{ampl} - 10\log G_{link} + C_{analyser} - 10\log(kT_o)$.
    - $10\log G_{ampl}$ = Gain of the ZHL-1042 amplifier in dB = 29dB
    - $10\log G_{link}$ = Gain of the link in dB = 5dB
    - $C_{analyser}$ = Correction factor for the logarithmic amplifier of the spectrum analyzer = 2dB
    - $10\log kT_o = 10\log(290 \cdot 1.38 \cdot 10^{-23} \cdot 10^{3}) = -174$ dBm/Hz

Noise Figure = +32 dB/Hz @ 1GHz



[Miteq specification was 22dB/Hz]