LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
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aLIGO IO H1 EOM in-situ characterization

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1 Overview

This document summarizes a set of in-situ measurements of the EOM conducted at LHO in December of 2013. The measurement was performed because we had applied in-situ modifications on the EOM to solve an issue with the RF phase [1]. The intention of the measurement was to double-check if the EOM was still functioning after the modifications.

We performed two types of measurements as follows:

- Modulation Depth (efficiency) as a function of frequency
- Input impedance and return loss

2 Modulation depth measurement

2.1 Setup

The measurement setup is shown in figure 1. We used a BS, which had been already in the path for the Faraday loss measurement, to pick off the main light off to an optical spectrum analyzer. The EOM was connected to an RF source, IFR 2025A in order for us to explore a wide range of the RF frequencies with the modulation depth being measured.

2.2 Results

The three inputs were tested one at a time.The results of the measurement are shown in figures 2, 3 and 4. In oder to convert the measured peak heights at the carrier and sideband of interest, V_c and V_sb, to modulation depths Γ in rad, we used the following approximated form:

$$\Gamma = 2\sqrt{\frac{V_\mathrm{sb}}{V_\mathrm{c}}} \tag{1}$$

When the 9 MHz input was studied, the RF input at the input was set to be 25 dBm. As for the 24 MHz input, it was at 29 dBm. Lastly it was at 19 dBm for the 45 MHz input.

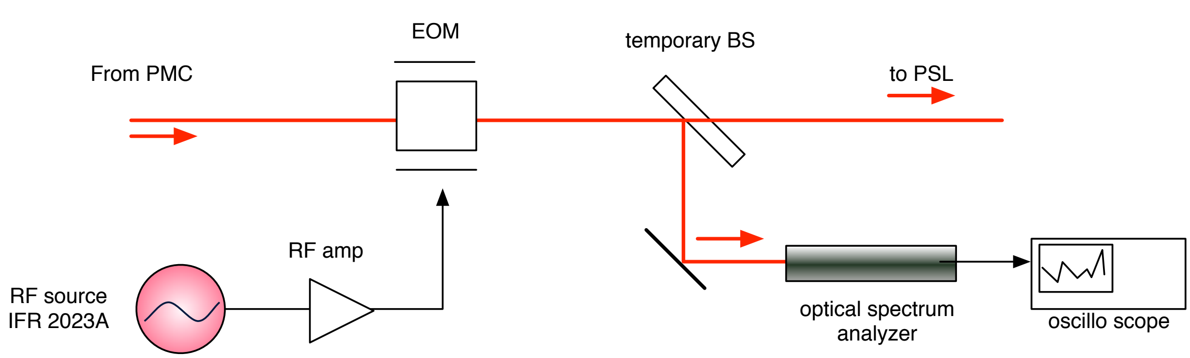

Figure 1: A simplified view of the measurement setup for measuring the modulation depths.

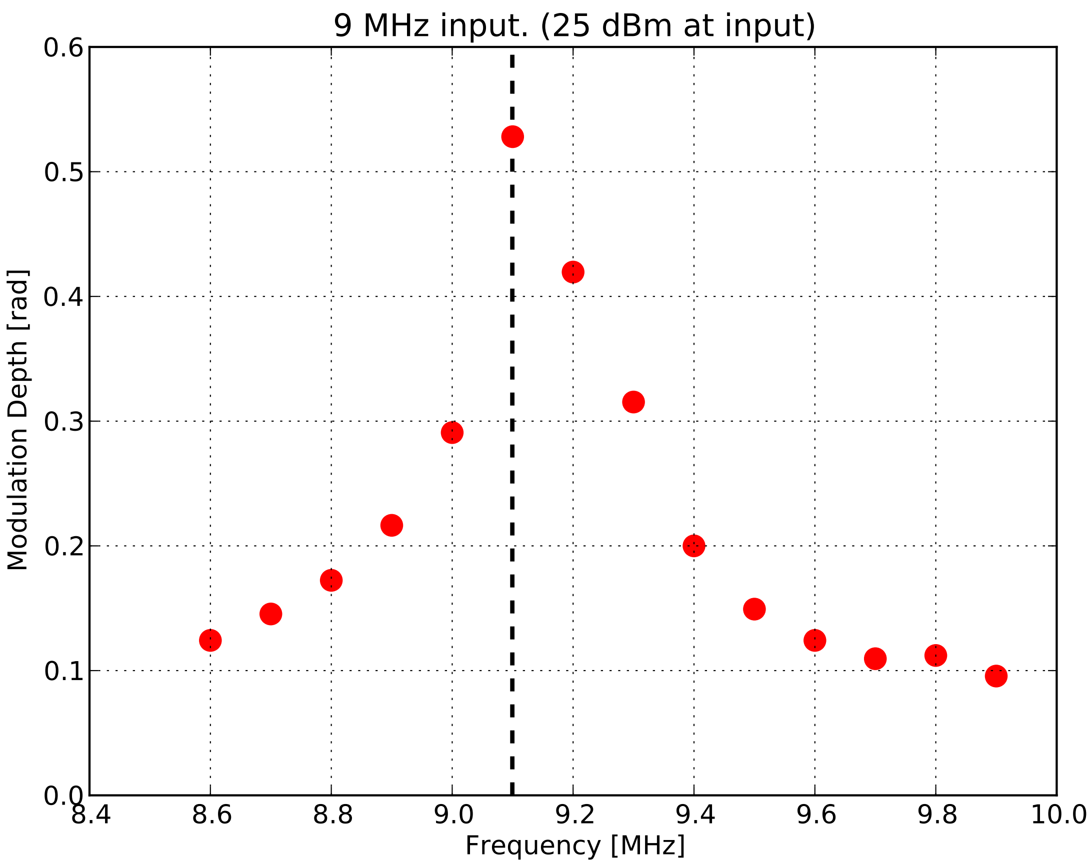

Figure 2: Modulation depth (efficiency) as a function of frequency for the 9 MHz input. The dashed vertical line represents LHO's nominal modulation frequency which is at 9099471 Hz.

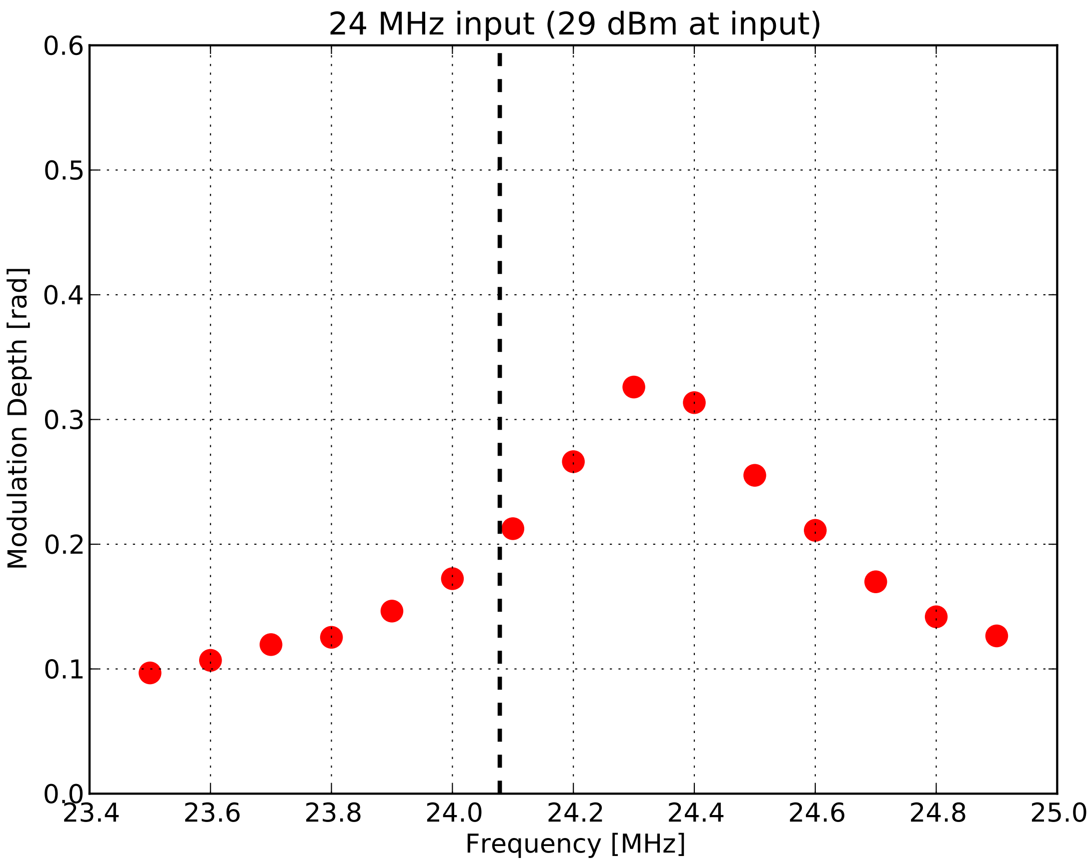

Figure 3: Modulation depth (efficiency) as a function of frequency for the 24 MHz input. The dashed vertical line represents LHO's nominal modulation frequency which is at 24078360 Hz.

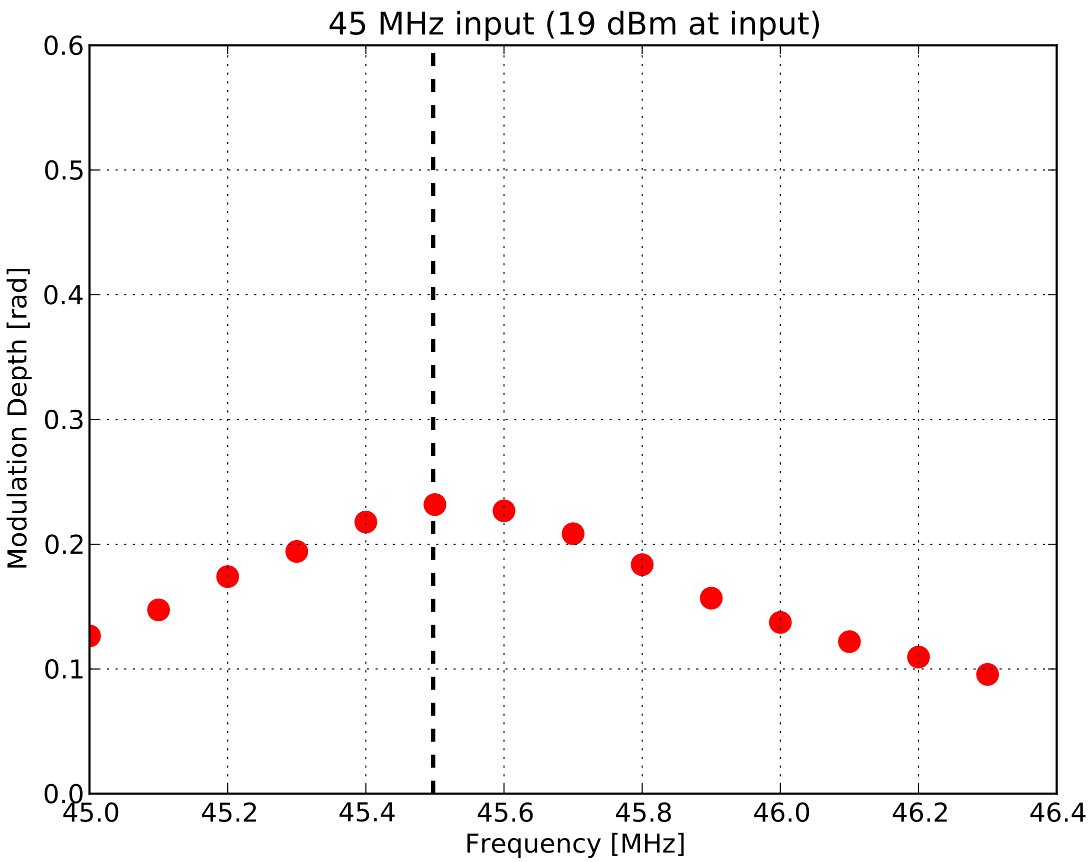

Figure 4: Modulation depth (efficiency) as a function of frequency for the 45 MHz input. The dashed vertical line represents LHO's nominal modulation frequency which is at 45497355 Hz.

3 Impedance measurement

3.1 Setup

The measurement setup for measuring their RF characteristic is shown in figure 5. Since the RF characteristic is of interest at this point, none of the laser light was involved to the measurement. It is purely an electronics measurement.

We used an Agilent RF network analyzer for this measurement. With an aid of an active prove, we directly measured the voltage applied to each RF input as shown in (A) of figure 5. From the measured voltage, we then converted it to their return losses and input impedance by a post analysis. In addition to this measurement, we did measurements of the return losses using another device to double check the results. The setup is shown in (B) of figure 5. We used a FieldFox for this measurement.

3.2 Results

The results are shown in figures 6, 7 and 8. In order to convert the measured input voltage to the input impedance, we used the following equation:

$$Z_{\rm in} = 50\Omega \times \frac{V}{2-V}. \tag{2}$$

This is equation is valid when the impedance prove is calibrated such that it reads 1 (or equivalently 0 dB) when the DUT is 50 Ω.

References

[1] LHO alog 7941, https://alog.ligo-wa.caltech.edu/aLOG/index.php?callRep=7941

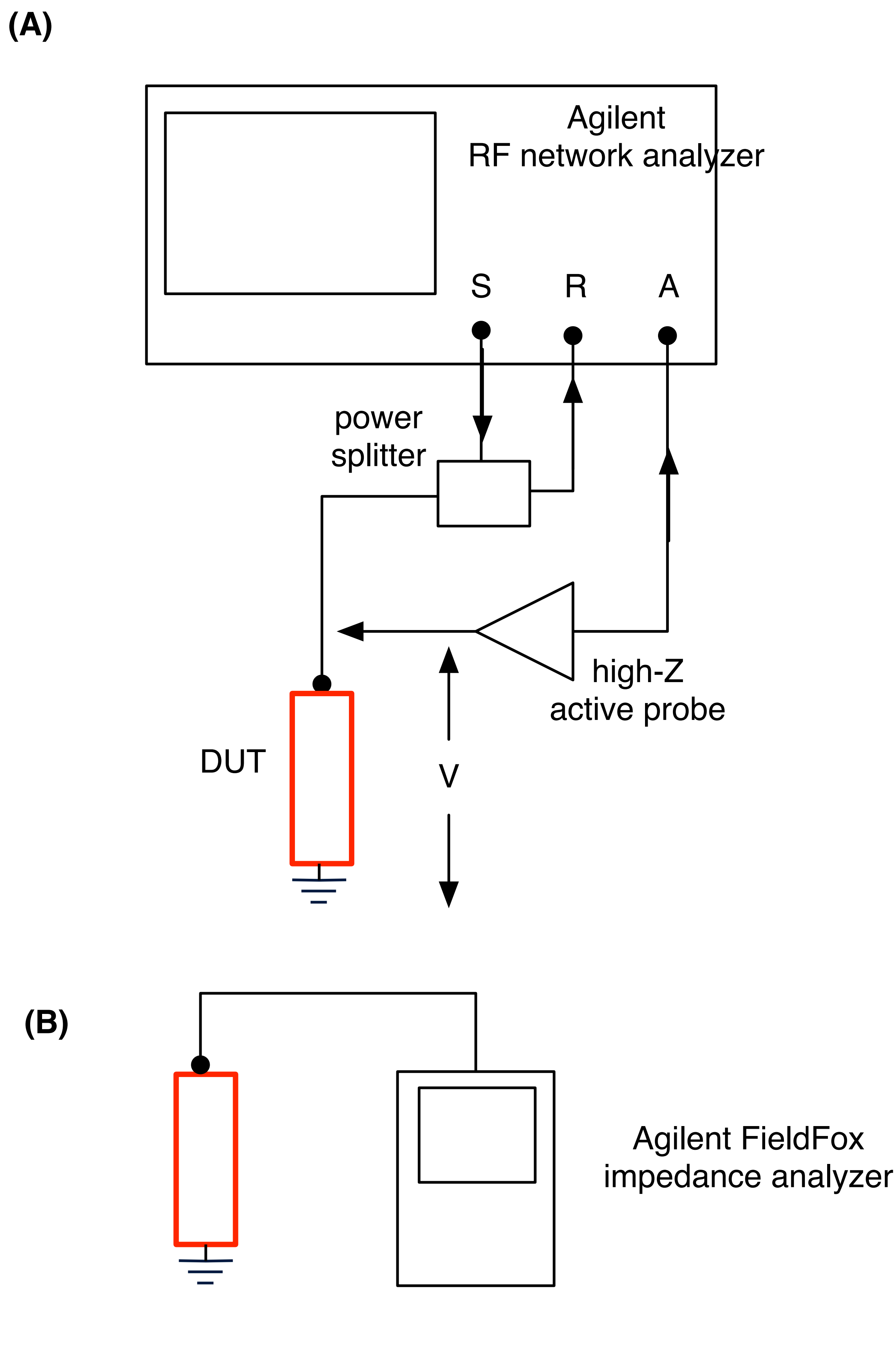

Figure 5: Setup for impedance and return loss measurements.

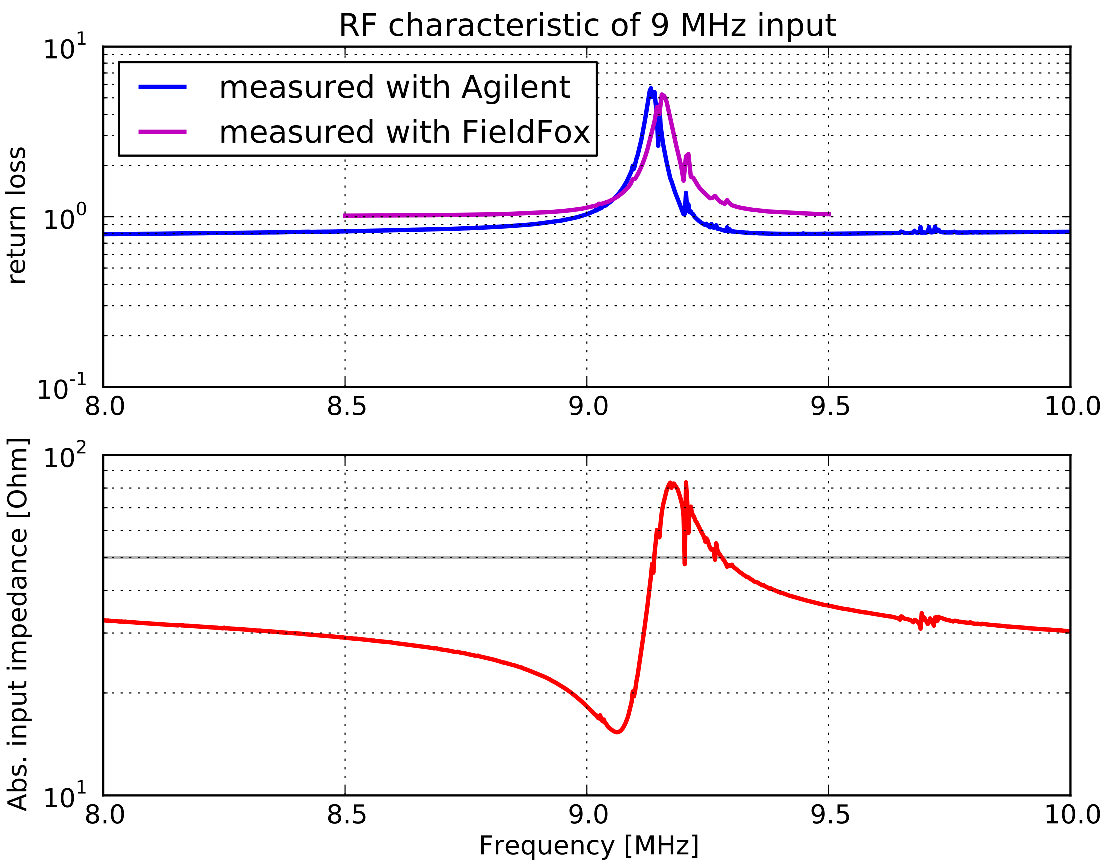

Figure 6: Modulation depth (efficiency) as a function of frequency for the 9 MHz input.

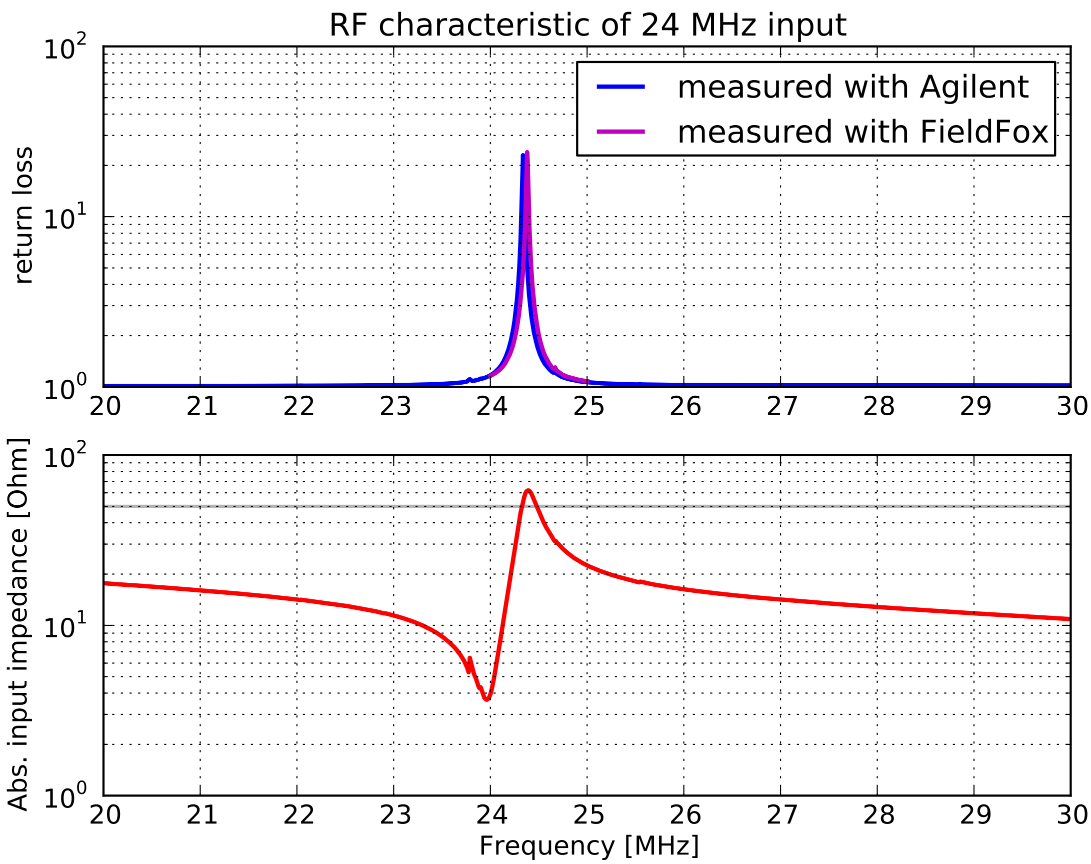

Figure 7: Modulation depth (efficiency) as a function of frequency for the 24 MHz input.

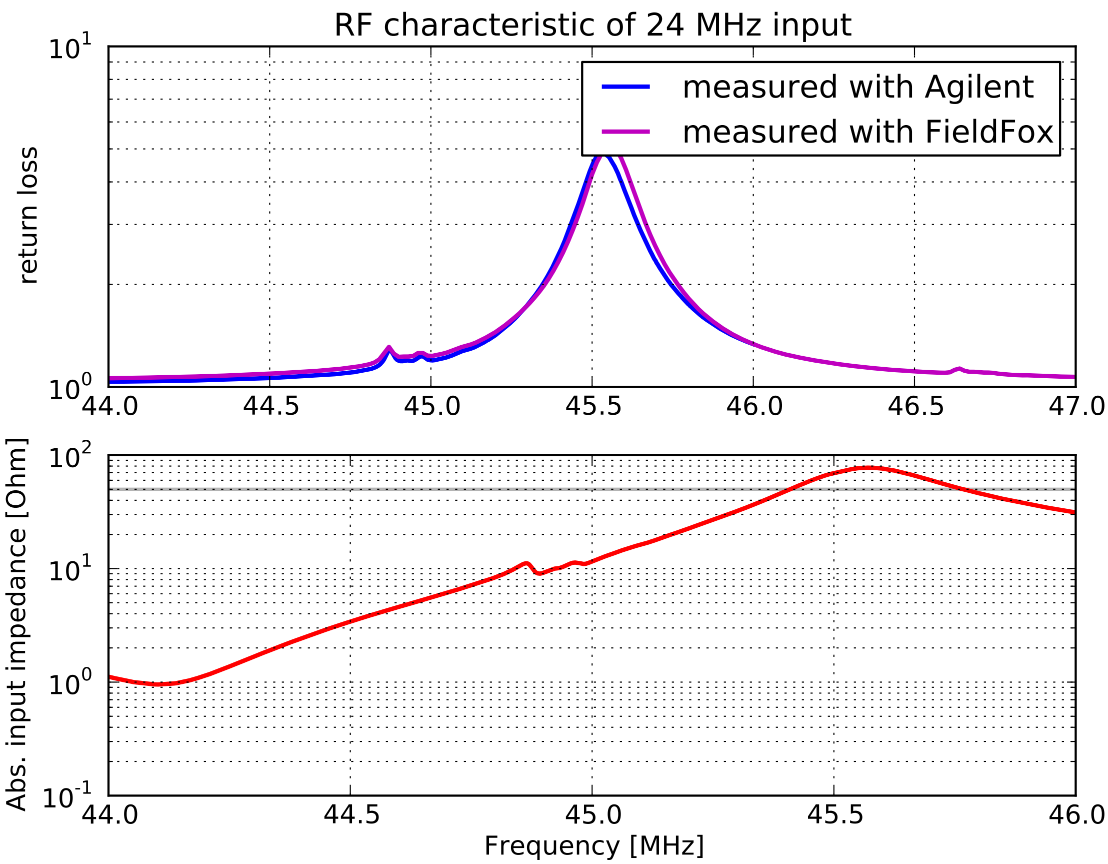

Figure 8: Modulation depth (efficiency) as a function of frequency for the 45 MHz input.