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Millimeter-wave RF Power measurements of a Commercial Photomixer

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Abstract

The results of a measurement of a commercial photomixer are reported. These measurements were made to verify the suitability of the photomixer for use in the ALMA photonic LO reference scheme.

1 Introduction

Millimeter-wave power generation by heterodyne of two lasers into a photomixer is a technique that is being developed for use in millimeter-wave radio astronomy as a means of supplying a simple and widely tunable local oscillator source[1]. Currently, the ALMA baseline plan is to incorporate such a system with the tunable photomixer source supplying the reference to which oscillator-multiplier chains will be phase-locked. Whether used as a direct local oscillator source, or as a local oscillator reference such as in the ALMA baseline plan, there is considerable interest in increasing the available output power and pushing the photomixer operation frequencies higher. The commercial device that we have tested has a very good power-bandwidth characteristic, with a measured power of -13.9 dBm at 109 GHz, and good response across the whole 75-110 GHz waveguide band.

2 Measurement of commercial device

A commercial photomixer from U2T of Berlin, Germany, was purchased in chip form, and measurements were made at the NRAO in Tucson. The chip is a PIN photodetector with an optical waveguide input that uses distributed absorption of the incident light and has a coplanar waveguide RF output port. Although it is a commercial device, its performance is competitive with the best research-grade devices. The design of the chip is described in several publications [2, 3, 4, 5]. Datasheets and further product information is available at the web site [6].

The setup for the measurement is shown in Figure 1. A fiber laser is used as one source, and an external cavity diode laser (ECDL) followed by an erbium-doped-fiber-amplifier (EDFA) is used as the second source. A polarization rotator is used to take out any vector misalignment of the two fields in the device. Light is coupled to the device by butt-coupling of a standard single-mode fiber. Use of a lensed fiber is not required because the chip is designed with a mode transformer integrated into the optical waveguide for optimum coupling to single mode fiber. The device is biased and RF power is extracted by a commercial coplanar-waveguide to WR-10 waveguide probe transition.

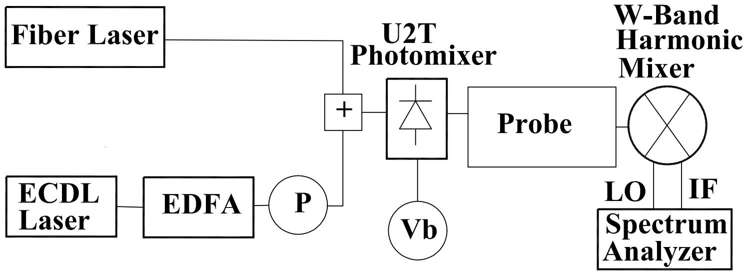

Figure 1: Test Setup for Heterodyne Measurement of U2T photomixer. ECDL: external cavity diode laser; EDFA: erbium doped fiber amplifier; P: polarization controller; +: power combiner; Vb: bias to photomixer; Probe: coplanar waveguide to WR-10 adapter probe.

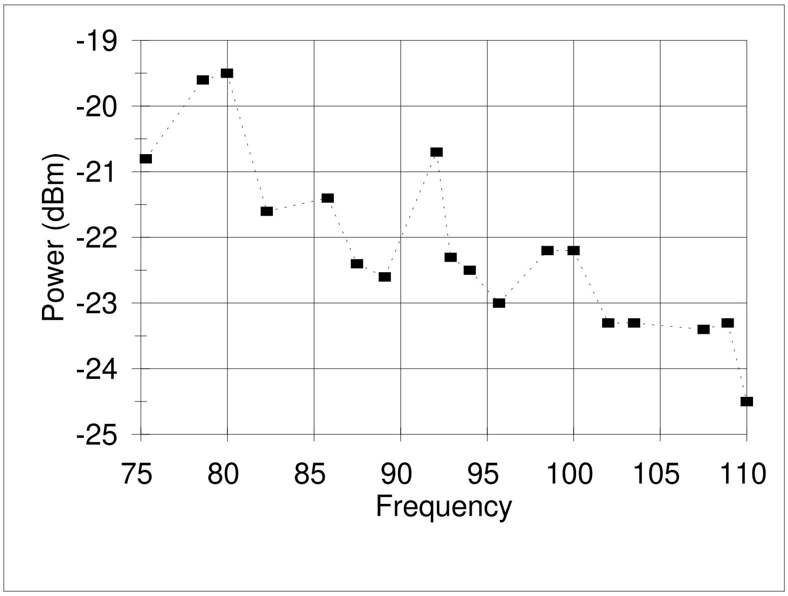

Figure 2: Power output vs. frequency for u2t photomixer across full WR-10 waveguide band. Input optical power is 4.6 mW, photomixer DC bias is -2.0 volts, 1.1 mA. The power level shown is at the input of the harmonic mixer.

The output frequency was measured using a calibrated HP harmonic mixer and HP8563E spectrum analyzer.

Figure 2 shows the measured RF output power vs. frequency of the photomixer from 75 to 110 GHz. The loss in the harmonic mixer is taken out of the data, but not the loss of the probe, which is about 1.3 dB. The plot is not smooth and contains frequency ripple which is believed to be mainly due to the poorly matched output of the device. Nevertheless, the RF output power decreased only by 3-4 dB across the band from 75-110 GHz. This measurement was done below the device saturation level. The DC current was 1.1 mA and the bias on the device was -2.0 volts. The optical input level was 2.3 mW at each of the two wavelengths. Maximum optical input power level is rated at 10 mW per laser.

Next the output was tuned near 110 GHz, and the input to the device was increased to investigate

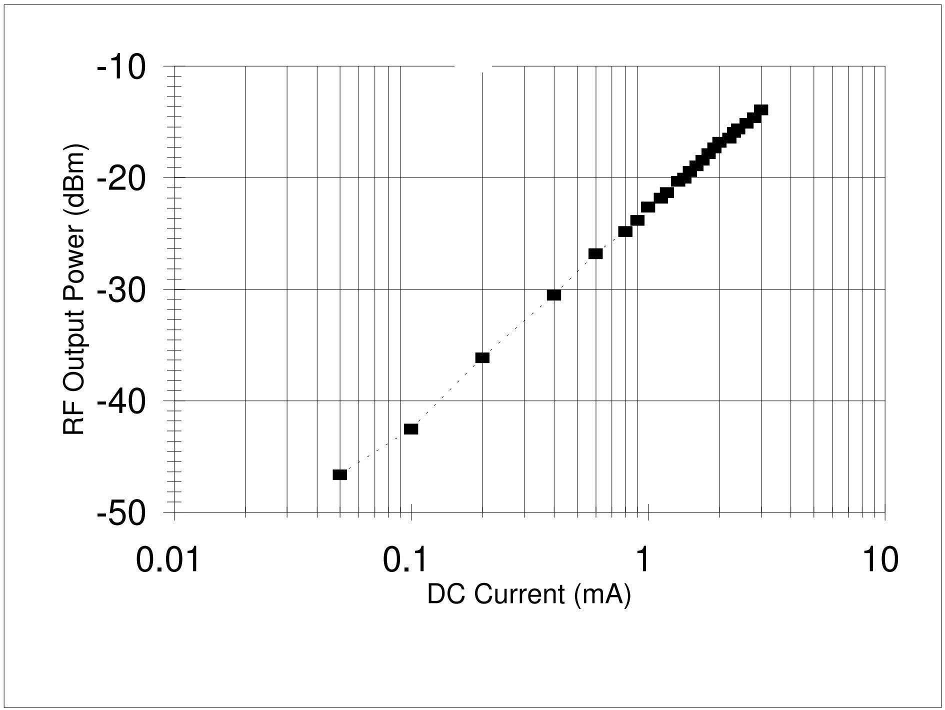

Figure 3: Output power vs. input level at 109 GHz. Responsivity is approximately 0.24 mA/mW after coupling loss.

the limit of the device output power. Figure 3 shows the resulting plot of output power versus device DC current, as the level of the input light was increased. A maximum power level of -13.9 dBm at 109 GHz was measured, with the device DC current at 3.0 mA and the optical input 6.4 mW from each source. The input level could not be increased any further, so higher RF output levels may be obtainable from this device. The plot reveals that the device is not saturated or significantly compressed. A plot of the heterodyne beatnote at 110 GHz is shown in Fig. 4.

The device worked at higher frequencies as well, but calibrated measurements above 110 GHz were not made. Using the W-band (75-110 GHz) probe and harmonic mixer, output from the device was measured all the way to 175 GHz. In all likelihood, the power falls off substantially above 120 GHz, but we do not know how fast the rolloff is.

3 Conclusions

The calibrated RF output power from a commercial photomixer device has been measured to 110 GHz. The device has sufficient output power to drive an SIS mixer at least to 110 GHz, and will easily fulfill requirements for providing an LO reference for ALMA to at least 120 GHz. The next step will be taken as a cooperative effort between the NRAO-Tucson and groups at Rutherford Appleton Lab and the University of Kent-Canterbury in Great Britain to design and build a package that integrates the device, the fiber, a bias connector, and the WR-10 output waveguide into one unit.

References

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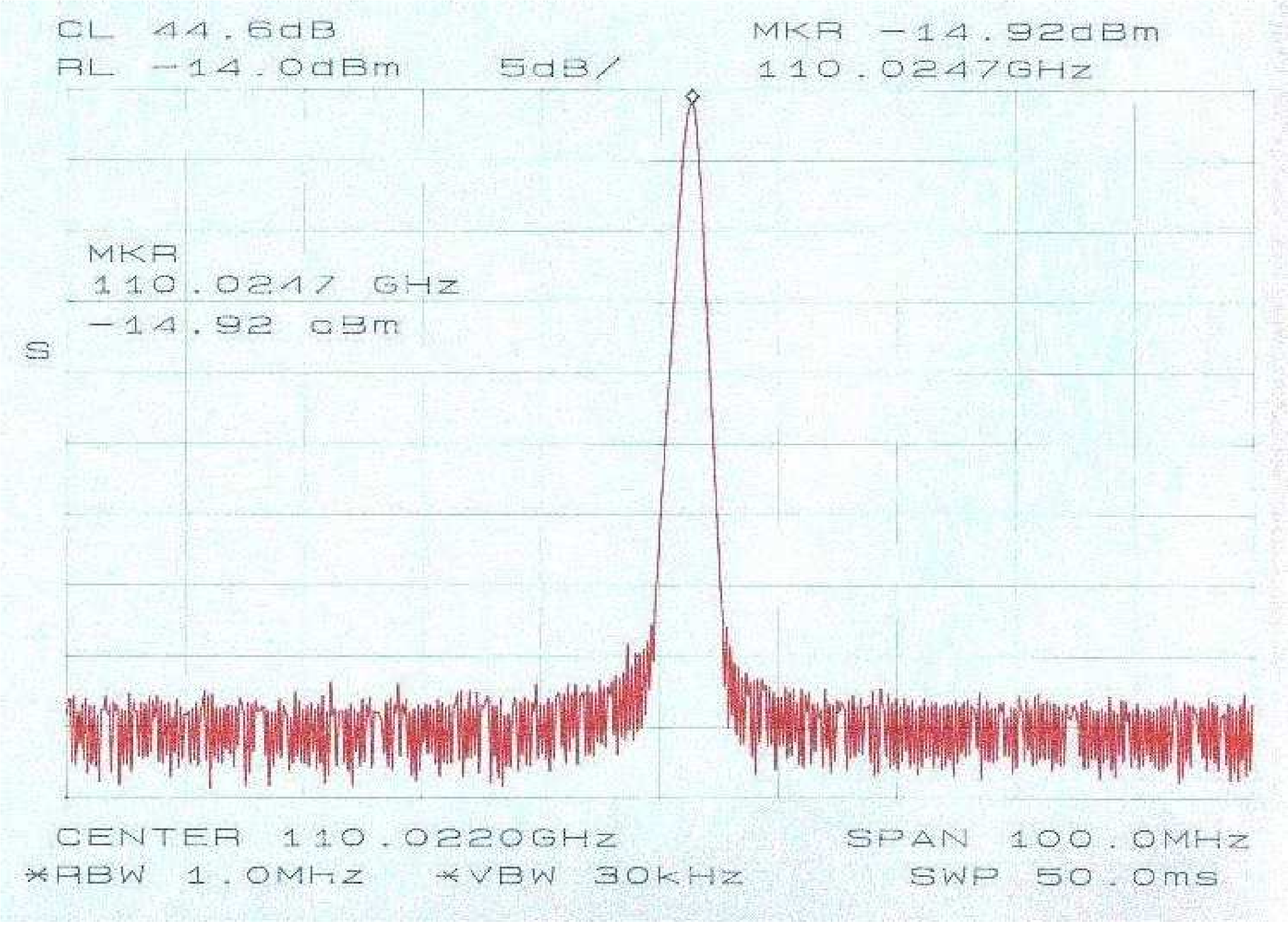

Figure 4: Output spectrum from laser heterodyne and u2t photomixer at 110 GHz