Portable Low THz Imaging Radars for Automotive Applications

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***Abstract*— Compact frequency extenders enable the current generation of portable network analysers to be used in the low THz bands of 150 - 300 GHz. The wide instantaneous bandwidth of these extenders support complex waveforms within systems intended for automotive radars and communication networks. Recent experimental results of such radars intended for atmospheric measurements and autonomous vehicle applications are described.**

I. INTRODUCTION

Autonomous navigation and 'hands-off' driving are anticipated modalities of future vehicles and mobile robots, where smart sensors and advanced processing technologies must establish vehicle "cognition" under all weather conditions. This must include all possible environments for safe driving and the protection of road users. New sensing systems are required to enable automatic optimisation of the vehicle during travel over any terrain. The TeraHertz (THz) portion of the electromagnetic spectrum may be exploited to enable the high definition imaging radar systems needed.
The rapid development of solid state semiconductor THz technologies now allows the implementation of portable short range radars for automotive and other applications. We describe our work at 150 GHz which provided the foundations for THz imaging including the development of essential algorithms and processing software. Preliminary measurements of the automotive environment at 300 GHz have started following the completion of a new portable radar system based on a compact converter pair with VNA[2].

II. RESULTS AT 30 AND 150 GHZ

Recent work at the antenna test range of the University of Birmingham compared radar resolutions at 30 and 150 GHz obtained with standardized targets relevant to an automotive environment under normal atmospheric conditions[1]. The radars had equivalent antenna beamwidths (near 3 deg) and used mechanical scanning to image the scene. Figure 1 details the results obtained from the targets at 30 and 150 GHz as described in Table I below.

Target	***Dimension, per side***	***Range, m***	***RCS dBsm @ 30 GHz***	***RCS dBsm @ 150 GHz***
Tridehral corner reflector	7 cm	7.8	0.6	14
Tridehral corner reflector	14 cm	12	12	26
Heavy rubber 'hump'	2.7m x 7.5cm	9.5	N/A	N/A
Tiles (removed)	60 cm x 4.5 cm	5.4, 6	< 20	< 20

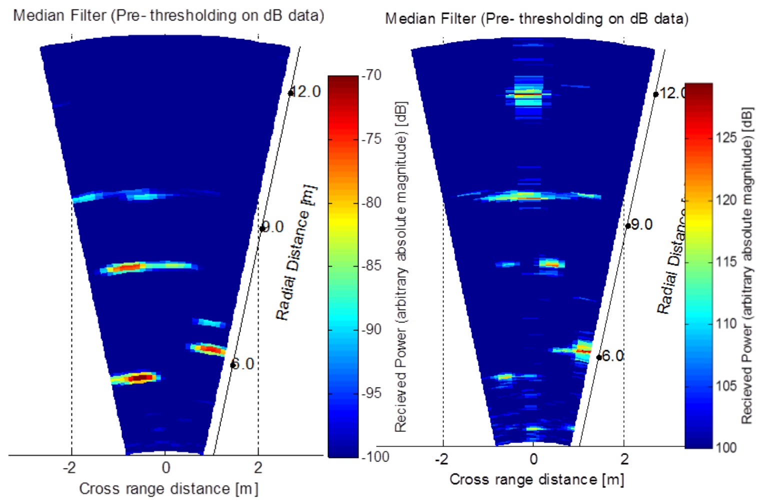

Figure 1. Radar image with calibrated targets (a) at 30 GHz and (b) 150 GHz.

Figure 2 300 GHz Converter Pair with Fieldfox Analyzer

III. PERFORMANCE AND PRELIMINARY TESTS

Measurements of the 300 GHz converters performance confirmed the requirement specifications. Table II below summarizes the results. The converters can be configured for SSB or DSB operation. Figures 3 and 4 detail the measured output power and SSB noise figure respectively. The modules are phase locked to the VNA 10 MHz clock to maintain synchronism.

Table II Performance Summary

Module	LO (GHz)	O/P (GHz)	O/P Power (dBm)	BW (GHz)	NF (dB)
Upconverter SSB	278.0	282 - 298	-15	> 16	N/A
Upconverter DSB	278.0	262 - 298	-13	> 32	N/A
Down converter DSB	278.0	282 - 298	N/A	> 16	< 14.0
Down converter DSB	278.0	262 - 298	N/A	> 32	< 12.0

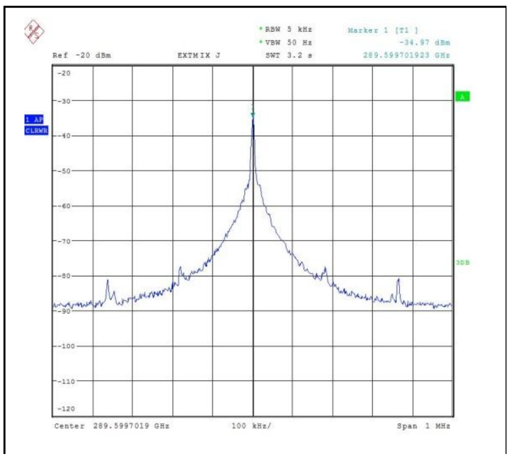

Figure 3 300 GHz Output Spectrum @ -15 dBm

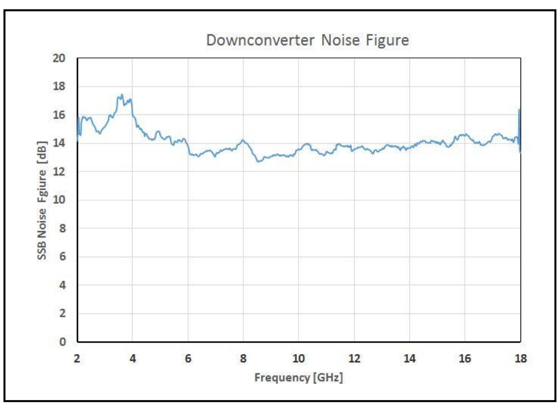

Figure 4 Receiver Noise Figure (SSB)

Preliminary measurements of the automotive environment at 300 GHz have started following the completion of the new portable radar system.

IV. Antenna development

Customized antennas to support imaging tests @ 300 GHz are under development, including a 'pencil' beam lens horn and a sectoral lens horn. The required pencil beam +/- 1.5 deg will be provided by a lens corrected square horn with a WR3 waveguide interface. A sectoral lens horn will produce a wide azimuth (+/- 10 deg) and narrow elevation beam (+/- 2 deg) suited to the antenna range experimental requirements.

Predicted patterns for the narrow beam antenna are shown in Figure 5 and the antenna outline in Figure 6.

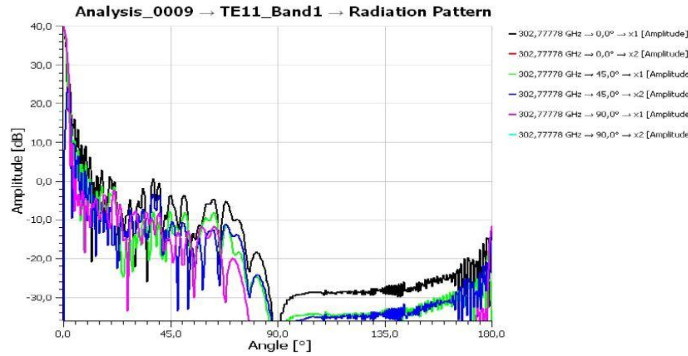

Figure 5 300 GHz Lens Horn Predicted Patterns

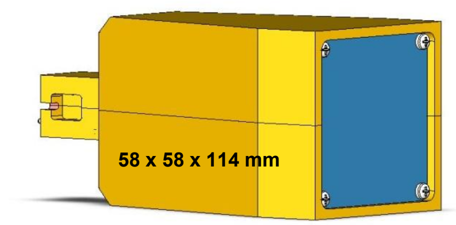

Figure 6 300 GHz Lens Horn Prototype

V. Summary

A portable compact radar for 300 GHz automotive studies has been developed. Performance comparisons with 30 and 150 GHz radars are outlined. Antennas suited to the experimental environment are under development. Provisional measurements related to the automotive environment will be described.

References

[1]. D.R. Vizard, et al, "Antenna Range Evaluations of Low THz Imagers for Automotive Applications", International Conf. Antenna Measurements and Apps. Juan-les-Pins, France APP3.2 Nov 2014.

[2]. www.vivatechmmw.com