Multifunction 62-66 GHz Dual Channel, Dual Band Phase Sensitive Transceiver

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ABSTRACT

In paper we present a dual channel, dual band phase sensitive transceiver designed to operate in a number of modes in the paired frequency range 62 and 66 GHz assigned for broadband wireless applications. The physical structure of the transceiver is described and its ability to function as (i) an IF beamsteered transceiver, (ii) a monostatic direction finding sensor, (iii) an angle of arrival receiver system, and (iv) a self tracking transceiver.

INTRODUCTION

A block diagram of the transceiver is shown in Figure 1(a), a photograph is shown in Figure 1(b). The system is comprised of 11 GaAs MMIC's mounted on a brass carrier and also includes patch antenna arrays fabricated on a Taconic^{TM} TLX Substrate. Figure 2 shows a measured radiation pattern of one of these antenna arrays. Here a 3dB beamwidth of 18° was observed with a slight squint from boresight, which was assumed to be caused by the proximity of the feed lines to the patch elements[3]. Interconnections between MMICs and the Taconic^{TM} board were carried out using wire bonding. A 64 GHz local oscillator signal for the mixers was derived from an external 32 GHz source fed to a MMIC doubler chain. Antennas 1 and 2 form a dual channel receiver at 65.5 GHz, Antennas 3 and 4 form a dual channel 62.5 GHz transmitter. An intermediate frequency of 1.5 GHz is used with the intention of using external baseband processing circuits such that the system forms a transceiver or self tracking retrodirective array.

The choice of frequencies (62.5/65.5 GHz) enables the transceiver to operate in a base station configuration according to European Radio Communications Office allocations [1]. Here paired frequencies are selected for base station to mobile to basestation mm-wave broadband wireless links for Pico cell applications. This paper will concentrate on the potential modes of operation as measured for the 65.5 GHz channel. This functionality is duplicated at 62.5 GHz enabling operation in a paired transceiver mode.

IF BEAMSTEERING AND MONOSTATIC DIRECTION FINDING MODES

IF beamsteering was performed using the setup of Figure 3(a). In this configuration, a 65.5 GHz signal was applied to the patch antennas using a horn antenna. Beamsteering was performed by rotating the transceiver patch antennas to the required angle θ and adjusting the phase shifter setting ϕ to produce a maximum 1.5 GHz IF signal on the spectrum analyser thus allowing the system to operate in; mode (i), an IF beamsteered transceiver. To allow the system to operate in; mode (ii), as a monostatic direction finding sensor [2], the settings of the phase shifter for a minimum IF signal were also noted. The phase shifter settings plotted against angle of arrival are shown in Figure 4(a) where beamsteering is seen to occur between -15° - 0°. Due to the fact that each element of the steered array is a four element patch array, which has a reasonably narrow beamwidth (18° 3dB beamwidth) and an intrinsic squint [3], beamsteering over a wide angular coverage was not expected.

In order to further prove the validity of the system to operate in; mode (ii), a monostatic direction finding sensor, Figure 4(a) shows the values of the nulls which were obtained at various angles of arrival. To provide a common point of reference for the measurements, the null values shown are the difference between the absolute null and absolute peak values obtained at each angle of arrival. This plot shows that nulls of up to -20 dB may be obtained. This makes the system suitable for sensing a target at a particular angle of arrival by detecting a null in the IF signal, thus satisfying mode (ii) operation.

OPERATION AS AN ANGLE OF ARRIVAL SYSTEM

Angle of arrival was measured for the downconverter antenna array using the setup of Figure 3(b). Here, the phase difference between the two antenna elements was measured at the 1.5 GHz IF using a Microwave Transition Analyser (MTA). The results of this experiment are shown in Figure 5 where good agreement with a simple theoretical prediction using isotropic antennas, equation (1) was observed between angles of arrival of -10° to 5°. This proves that the system could be used in mode (iii) an angle of arrival receiver system, over a reasonably wide coverage provided the relationship between the actual and measured angles of arrival are known beforehand.

$$\alpha = -\left(\frac{d\,Sin\,\theta}{\lambda}\right) * 360 \qquad (1)$$

d = Distance between antenna elements (centre-centre)
θ = Actual Angle of Arrival
α = Predicted Angle of Arrival

CONCLUSIONS

A dual channel, dual band, phase sensitive transceiver designed to operate in a number of modes in the paired frequency range 62 and 66 GHz has been shown to function as: (i) an IF beamsteered transceiver, (ii) a monostatic direction finding sensor, (iii) an angle of arrival receiver system, and also has the capability of operating as (iv) a self tracking transceiver. The device presented should find application in a variety of mm-wave broadband wireless links for Pico cell applications, and for mm-wave sensor applications.

REFERENCES

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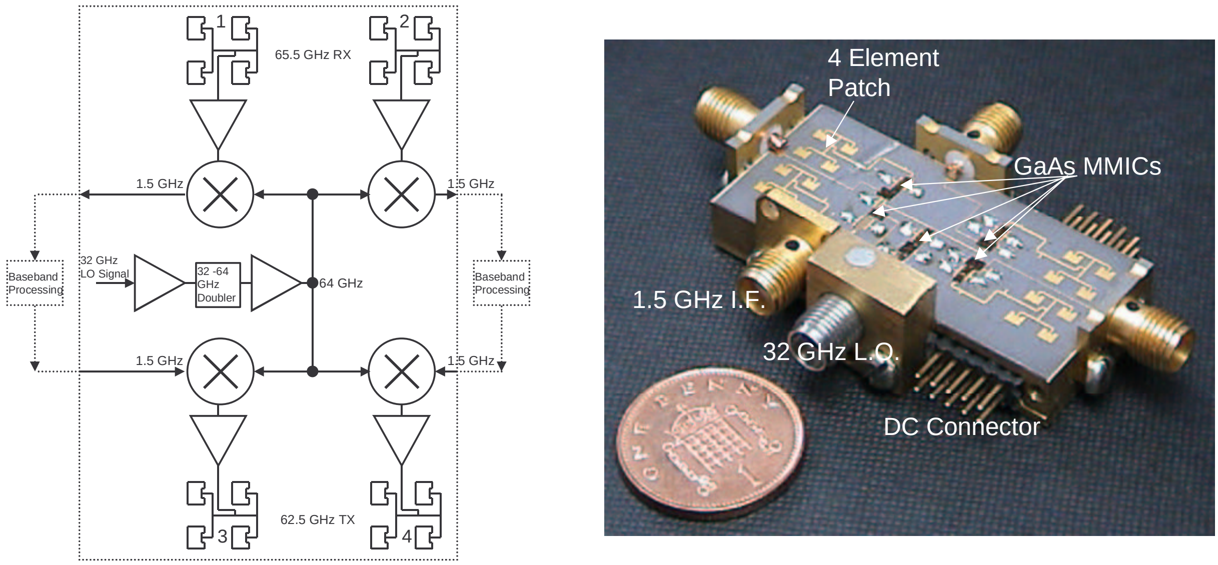


(a) Transceiver Block Diagram **(b) Photograph of Transceiver**

Figure 1 Transceiver Architecture

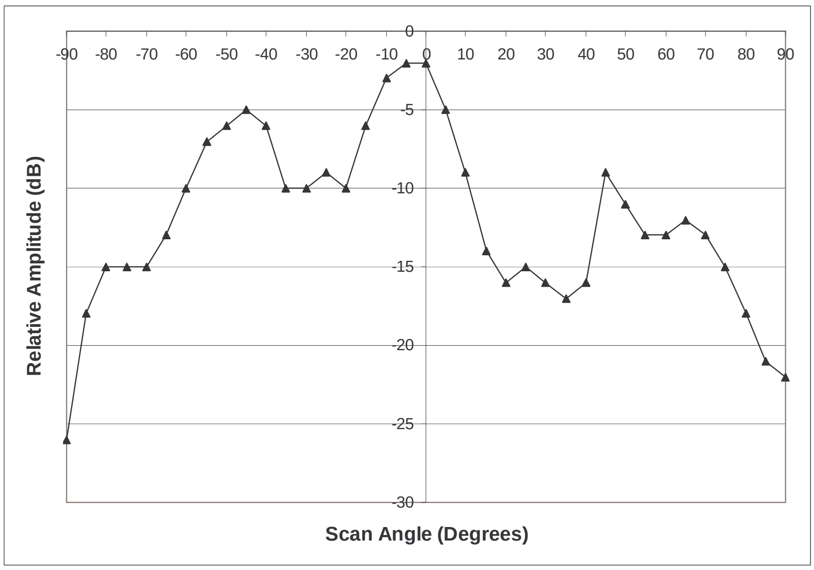
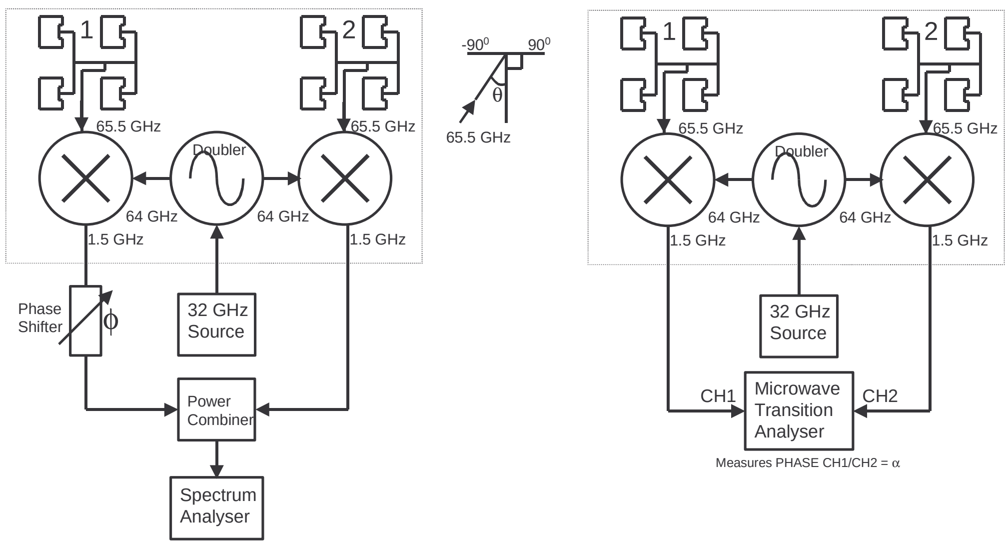
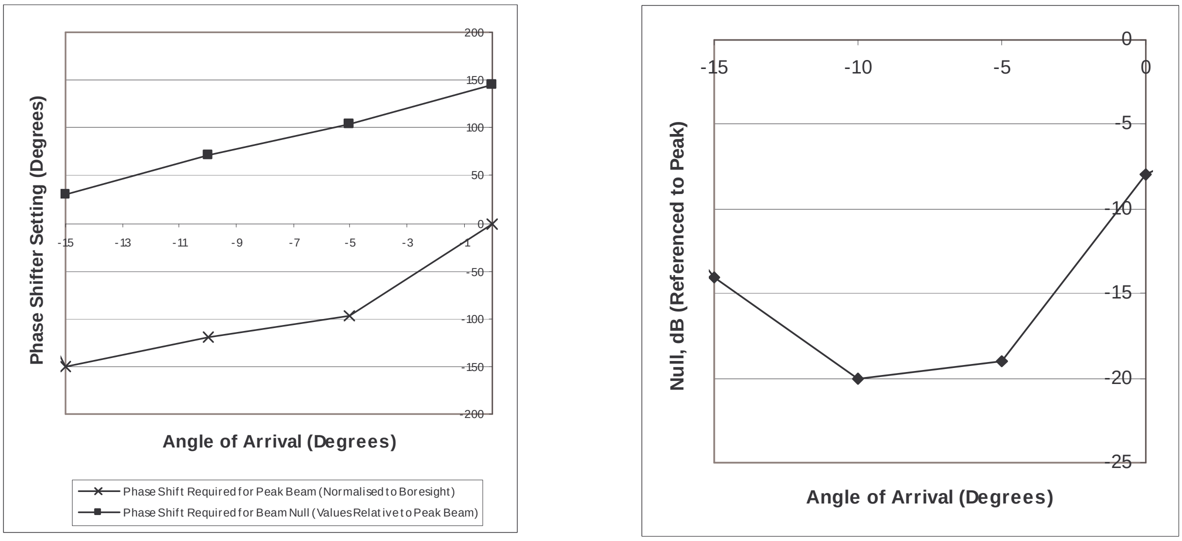


Figure 2 Radiation Pattern for 65.5 GHz 4 Element Patch Array



(a) IF Beamsteered Receiver/ Monostatic Direction Finding System **(b) Angle of Arrival Receiver**

Figure 3 Operating Mode Architecture Definitions



(a) Angle of Arrival Vs Phase Shifter Setting for Peak/Null IF Signal

(b) Values of Null in dB (Referenced to Peak Values)

Figure 4 Operating Mode Verification

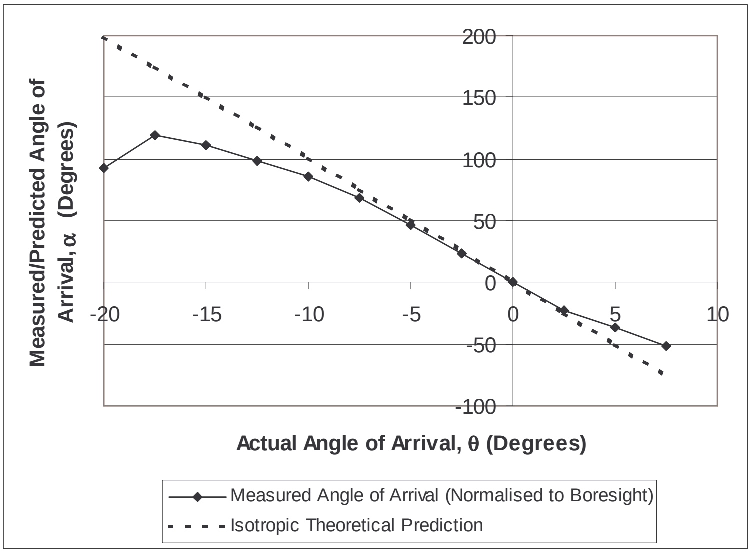


Figure 5 Phase Results Between Antennas 1 and 2 Measured at 1.5 GHz IF