76 GHz Transverter Upgrade
Using the New
DB6NT MKU 76 G2 Transverter

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Introduction

Last fall, several of us decided to make purchase of the new DB6NT transverter for 76 GHz. The new DB6NT design takes advantage of newer MMIC technology in this frequency range. Most notable is the use of image reject mixers for both receive and transmit. The new transverter also includes a PA that is specified at greater than 250 mW output. Noise figure is specified at about 8 dB which is still a considerable improvement over a simple passive diode mixer.

The 76 to 81 GHz Band

Europe has settled on 76032 MHz as the weak signal portion of the band while a good portion of the US has always been at 78192 MHz. In California, the chosen segment of the band has been closer to 80 GHz based on availability of components. Our EME activities of several years ago took place on 77184 MHz based on optimum performance of RW3BP's TWT. Recent regulations in the US have also limited our EIRP to 315W EIRP as we share the 76 to 81 GHz band with collision avoidance.

Integration

My first 76 GHz transverter used individual discrete components including homebrew tuned filters to cover the 77184 MHz segment that was used for initial EME tests with RW3BP[1]. The transverter used a 2m IF which necessitated very high Q filters with very narrow bandwidths. I was optimistic that the new DB6NT transverter would be able to cover a wider portion of the 76 GHz to 81 GHz of the band without the need to retune filters. Image reject mixers use unique phasing of the RF and LO signals to provide a nominal 20 dB of image rejection over some wider bandwidth than can be provided by filters thus allowing the use of direction conversion to 2m.

I started out by integrating the DB6NT transverter with a WA1MBA preamplifier and a WR-15 waveguide switch[2][3]. I also have a coupler in the transmit path to monitor power output. I use the DB6NT LO MKU LO 8-13 PLL with a power divider to feed the 76 GHz transverter and for possible higher bands.

The DB6NT LO has numerous preset frequencies including the 9486 MHz required for the 76 GHz transverter. The LO has the ability to store 2 additional user programmed frequencies. Since my original 76 GHz transverter was set up for 77184 MHz for EME tests with RW3BP, I decided to store 9630 MHz as F1. I also set up F2 as 9756 MHz to allow operation on 78192 MHz. With the proper "bridging" of programming pins on the DB6NT LO, I can switch between the 3 segments with a 3 position wafer switch.

A picture of my completed 76 GHz transverter is shown in Figure 1. Although the placement of the DB6NT transverter may seem unusual, my long term plan is to add a higher power amplifier which would push the transverter to the left. I would then add a corresponding piece of

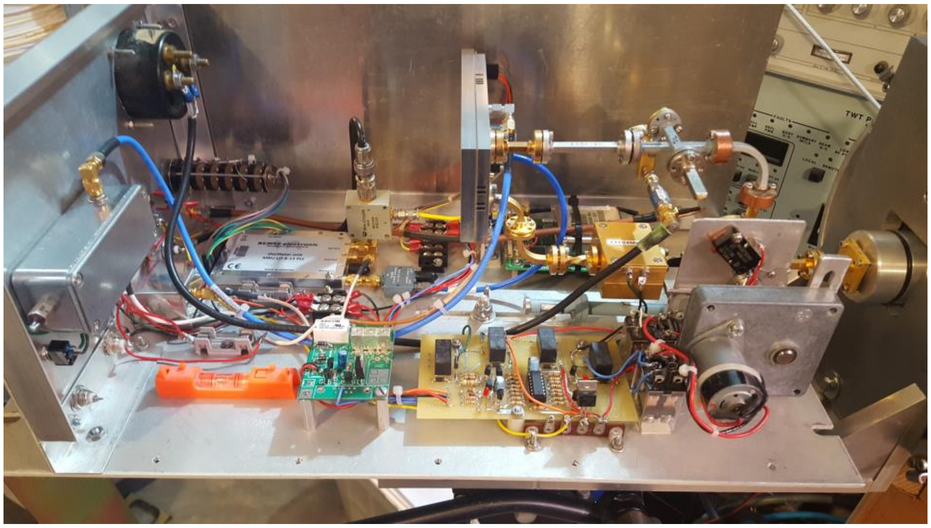

Figure 1 Completed 76GHz Transverter

waveguide to the receive path to keep everything aligned. The transverter is assembled on a standard 10.5 inch by 19 inch (26.7 cm x 48.3 cm) rack panel with slots milled down the middle to allow the completed assembly to be installed on my 2.4m offset fed dish for moon noise and sun noise measurements.

Performance

I started out by testing the DB6NT transverter as a complete system on all 3 band segments. Keep in mind, the DB6NT transverter is only specified at 76032 MHz. I was interested in making 3 sets of measurements. Most importantly was measuring the output power followed by image rejection and then noise figure.

I used an HP432A power meter with a Millitech 45744H-1100 WR-15 head with a correction factor at 75 GHz. I also have a Quinstar QAF-E30000 30 dB WR-15 attenuator which I measured the loss as accurately as I could with my HP8757 scalar analyzer at the 3 frequencies of interest. At the waveguide relay antenna port, I was able to measure 275mW at 76032 MHz. Measuring the output power directly at the TX port of the DB6NT transverter provided the results shown in Table 1.

Freq (MHz)	Power output
76032	333 mW
77184	318 mW
78192	250 mW

Table 1 DB6NT transverter, Power output vs Frequency

On the receive side, I measured noise figure with an HP8970B noise figure meter and a Noisecom model NC 5115 WR-15 noise source with a Hughes 45114H-1000 WR-15 isolator. The ENR has been established to be 15.3 dB at 77 GHz.
My DB6NT transverter is specified at a minimum of 28 dB conversion gain and noise figure less than 8.2 dB. Using the 2m IF port with transverter IF gain set at a maximum, I measure the performance shown in Table 2. As you can see the performance is very good.

Freq (MHz)	Conv Gain	Noise Figure
76032	28.1 dB	6.13 dB
77184	27.4 dB	5.75 dB
78192	26.9 dB	6.02 dB

Table 2 DB6NT transverter, 2m IF gain at max

Decreasing the DB6NT transverter IF gain to its minimum results in a transverter conversion gain near unity and the transverter noise figure will rise several dB. I then added in the WA1MBA LNA which has about 30 dB gain and then set the transverter IF gain at minimum with the results shown in Table 3.

Freq (MHz)	Conv Gain	Noise Figure
76032	31.7 dB	4.67 dB
77184	28.2 dB	4.09 dB
78192	26.7 dB	4.22 dB

Table 3 DB6NT transverter, w/ WA1MBA LNA 2m IF gain at minimum

Adding in the WR-15 waveguide relay completed the system. Table 4 shows the results.

Freq (MHz)	Conv Gain	Noise Figure
76032	31.5 dB	4.99 dB
77184	27.5 dB	4.69 dB
78192	25.4 dB	5.06 dB

Table 4 DB6NT transverter, w/ WA1MBA LNA, WR-15 waveguide relay 2m IF gain at minimum

One of the major selling factors of the new DB6NT transverter is its' image rejection on both receive and transmit thereby minimizing the need for additional filtering in the RF paths. DB6NT specifies the image rejection to be 20 dB typical at 76032 MHz. For testing purposes, I use an ST Microwave 6139-6288-00 multiplier that has a female SMA on the input and a male 3.5 mm connector on the output. The module runs off of +8V. On 47 GHz it works nicely as a weak signal source when driven by my HP8340A in the 23.5 GHz frequency range. It is also capable of generating a nice 76 GHz weak signal when driven as a X3 multiplier from the HP8340A. In fact it generates a nice bench signal without the need for the +8V source. I simply put a 3.5mm to WR-28 adapter on the multiplier output and set it a few inches away from the waveguide switch opening. Crude but it works. I used my Elecraft KX-3 and P-3 Panadapter to make the measurements. I then generate the “real” frequency for a reference and then generate the “image” frequency. The real and image frequencies are separated by twice the IF or 288 MHz. The results are very good as shown in table 5. The receive image rejection is greater than 20 dB over all 3 frequency bands. I have not looked at the image rejection on transmit but expect it to be very similar.

Freq (MHz)	Image Rejection
76032	26 dB
77184	30 dB
78192	22 dB

Table 5. DB6NT transverter Receive Image Rejection

Other points of interest

The Monitor Output at Pin 9 on the transverter provides a convenient point to confirm one is putting out power. However it does not appear that the detected output voltage is connected to the forward port of a directional coupler as confirmed by the fact that the voltage changes with different loading on the output port. In my completed system, I measure about 1.9v at full power on 76032 MHz. The diode is most likely just measuring RF voltage on the output line.

The DB6NT LO provides a 116 MHz out at the “REF OUT” port and is intended to be used with the 2m to 10m mixer which is also included in the 76 GHz transverter. In the interest of minimizing the chance of “injury” to the 76 GHz transverter, I decided to use the “IF OUT” port at 2m and the low power option at the “IF/IN” port and drive the transverter with the W1GHZ Miniverter- F which Paul designed for the Flex-1500. I just use the 116 MHz LO to drive the Miniverter. Since the Elecraft KX-3 does not have a low power transmit port, I added a Downeast Microwave TC board at 28 MHz to interface the KX-3 to the Miniverter. If for some reason I run too much 10m IF power in, I will only harm the IF board and not the 76 GHz transverter. I call it cheap insurance. I also ran the PTT line out the IF port to the KX-3 using Bias Tees to minimize forgetting to hook up the PTT line.

The Test

After having spent years building equipment for 77 GHz which finally led up to my copying Sergei RW3BP off the moon, I had yet to make a 2 way QSO on 77 GHz. In March 2019, Tony K8ZR came down to Dallas and we both took off towards Phoenix, AZ where Barry VE4MA was spending his winter. On March 8, I had my first QSOs on 78192 MHz with VE4MA and K8ZR. We then moved to DM43ee and worked W7QQ and N0IO who were in DM33wo at a distance of 66km. The final test took place on March 9th, when VE4MA, K8ZR, and myself moved to DM42ok56ig atop Mt. Lemmon at 9000 ft. near Tucson while N0IO and W7QQ were set up in DM33rn26sp. We had 59 signals on SSB at a distance of 207 km. Success!

Conclusion

The DB6NT transverter has more than met my expectations. Its power output, image rejection and noise figure are superb.

Thanks to VE4MA and K8ZR for reviewing.

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References

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