Using Ku-Band LNBFs for Radio Astronomy - NRARAO

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Abstract – ***There are a number of different model Ku-Band LNBFs available for use for 12 GHz radio astronomy. These are relatively inexpensive – from approximately AUD$10 for DRO single output/low band models to about twice that for PLL models. A general description of the different Ku-band models for the Australian market and their possible use for radio astronomy is discussed. It should be noted that the information presented here is not novel, but follows in the footsteps of previous efforts by many other parties.***

I. INTRODUCTION

Here is another example of how the re-purposing of consumer products can mean adequate performance at a reduced cost compared with specialised equipment. The large market for TVRO satellite equipment means that fairly complex technology has been subjected to mass-production principles, producing good performance equipment at a low cost. When used for their intended purposes, the selection of a suitable LNBF is straightforward, as a local satellite TV dealer will have the models matched to the local market. However, when used for radio astronomy, the models suitable for local satellite reception may not be suitable for radio astronomy. In that case purchasing from international markets can be a better option.

II. KU-BAND FREQUENCIES

The Ku-band frequencies beamed to the Australian footprint mostly range from 11.7 GHz to 12.75 GHz. Prime examples include Optus D1, Optus D2 and Optus C1/D3.

This band (11.7 GHz – 12.75 GHz) is the higher of two Ku-band ranges used for satellite TV. The lower range extends from 10.7 GHz to 11.7 GHz. None of the Australian prime examples given above operate in the lower Ku-band range.

Essentially the Ku-band satellite range is divided into 4 sections as the lower and higher ranges are effectively divided further by vertical and horizontal polarisations (typically 20 dB to 30 dB isolation). So we have low range vertical, low range horizontal, high range vertical and high range horizontal.

III. EXAMPLES OF LNBFs FOR AUSTRALIA

To operate in both Ku-band ranges an LNBF must be able to switch LO frequencies to ensure the IF output frequencies fall into the 950 MHz to 2150 MHz input frequency range of satellite receivers. These type of LNBFs are called 'universal'. The following are some examples of LNBF configurations available locally and deemed suitable for Australian market.

For 'universal' LNBF types, the selection of polarisation is done by varying the power supply voltage – typically 11.5 V – 14V for vertical, 16 V – 19 V for horizontal.

Selection of the low and high ranges is done by applying a 22 kHz continuous tone on the power supply. The absence of tone selects the lower range, while the presence of the tone selects the higher range.

LNBF Description	LO (GHz)	Input Freq. (GHz)	Output Freq. (MHz)
1. Universal	9.75	10.7 – 11.7	950 – 1950
	10.6	11.7 – 12.75	1100 – 2150
2. Standard	11.3	12.25 – 12.75	950 - 1450
3. Standard	10.7	11.7 – 12.75	1000 - 2050

Table 1: Example LNBF Configurations for the Australian Region

The above examples utilise a Dielectric Resonator Oscillator (DRO) for the local oscillator (LO) and so have frequency stability specifications of the order of ±300 ppm. Higher stability designs using a quartz crystal oscillator (typically 27MHz) and a phase-locked loop (PLL) and are, at the moment, more expensive. Typical stability specifications are about ±10ppm.

Figure 1: Typical LNBFs

IV. SELECTION OF A SUITABLE LNBF

The criteria for selection of a suitable LNBF for radio astronomy is dependent on the type of project to be undertaken. Some examples are given below of projects associated with observation of the Sun at 12 GHz.

i. Antenna beam pointing and LNBF alignment.
ii. Simple drift scan.
iii. Intensity Interferometry.
iv. Coherent Interferometry.

For project i. (e.g., for checking mounting hardware and calibration of azimuth and elevation indicators) the stable signal from a satellite would be the most useful source – being much easier to use than the moving source presented by the Sun. Therefore, at this location in Australia, an LNBF which covers the higher Ku-band would be the most suitable. Although a 'universal' LNBF (1. in Table 1) covers the higher range, it would be necessary to supply the 22 kHz continuous tone superimposed on the power supply to switch the LNBF to that mode. Perhaps the 'standard' LNBFs (2. and 3. in Table 1) would be better choices as these cover the higher range without a 22 kHz tone.

For project ii. (simple solar drift scan) a 'universal' type would be suitable as the default lower input frequency range (10.7 GHz – 11.7 GHz) is sparsely-populated with satellites in this region (Australia) and so the level of desense may be lower. A simple power supply of 12 V would be all that is needed.

For project iii. (intensity interferometry) a 'universal' type would again be suitable for the same reason. For this project two sets of a dish and LNBF combination are required. For some types intensity interferometers a PLL type of LNBF would be advantageous to limit the difference in LO frequencies.

For project iv. (coherent interferometry) there is a requirement to either phase-lock the two LNBFs or bring out the Ku-band signals before the LO point and mix externally (not a simple task). Although phase-locking the two LOs is not a trivial task it may have a greater probability of success than the Ku-band tap and external mixer approach. A PLL type of LNBF using a 27 MHz quartz crystal oscillator, which could be replaced by a common external 27 MHz source for phase-locking, should be suitable. Such LNBFs are available from international sources and are becoming less expensive as they become more common.

LNBF Description	LO (GHz)	Input Freq. (GHz)	Output Freq. (MHz)
Standard PLL	10.75	11.7 – 12.2	950 - 1450

Table 2: Example Single LO PLL LNBF from International Seller

An example of this type of LNBF as shown in Table 2 is available from an international seller for AUD$11. The purchase cost of two LNBFs is increased by postage fees to be a little more than AUD$40 in total (AUD$20 each).

V. CARE AND FEEDING OF LNBFs

When using LNBFs for the intended purpose of receiving TVRO signals, the task of providing a power supply is a simple one. The satellite receiver passes DC power through the signal cable to the LNBF. The DC voltage is switched between about 13 V and 18 V to select vertical and horizontal polarisation respectively. A 22 kHz continuous tone is superimposed on the DC supply to switch the LO to the high range if required. When using the LNBFs for radio astronomy there is usually a need to provide a custom power supply in the absence of a satellite receiver. Most often in this arrangement no 22 kHz tone is supplied, so, in the case of 'universal' LNBFs, operation is in the lower input frequency range of Ku-band. Where 'standard' single LO LNBFs are used the operating input frequency range is dependent on the model as shown in Table 1 and Table 2.

The selection of either vertical or horizontal polarisation is largely irrelevant in amateur radio astronomy applications, although for interferometry (especially in the case of coherent interferometry) matching the polarisation of the two dish/LNBF combinations would be prudent. In general the 12 GHz signals detectable by a modest amateur radio astronomy setup would show little change when the angle of the receiving probe is rotated. As such the power supply voltage can be anywhere in the range of 12 V to 19 V thereby either selecting vertical or horizontal polarisation. An exception to this polarisation in-consequence might be that offset dish feeds could have slightly different gains depending on the orientation of the receiving probe w.r.t. to the dish itself. A knowledge of the beam pattern from the LNBF might show an advantage for a particular orientation of the receiving probe. It is the opinion of the author that such differences are slight, however, this is an opinion only and is not been tested. In any case the dishes used by the author are elliptical with the larger dimension being the vertical one. Thus the shortening due to the offset angle of the face of the dish to the observed source is compensated for – and in the case of the particular dishes at hand, over-compensated for.

VI. USING SATELLITE FINDERS TO FEED LNBFs

For projects i. and ii. as mentioned above, it is possible to use inexpensive analogue satellite finders as the means to feed DC power to LNBFs. Of course it is possible to construct separate bias-T interfaces to supply power, but satellite finders of the simple analogue type already tap off the DC supply present on the RF cable supplied by a satellite receiver.

Figure 2: Analogue Satellite Finders

Now in the case of using the LNBFs for radio astronomy, as mentioned previously, there might not be a suitable satellite receiver at hand. However, it is possible to open the case of an analogue satellite finder and apply DC power from a custom supply. There is a built-in bias-T network in both of the models of analogue satellite finder in possession of the author and applying power to the finder's electronics feeds that power back out to an LNBF attached to the finder.

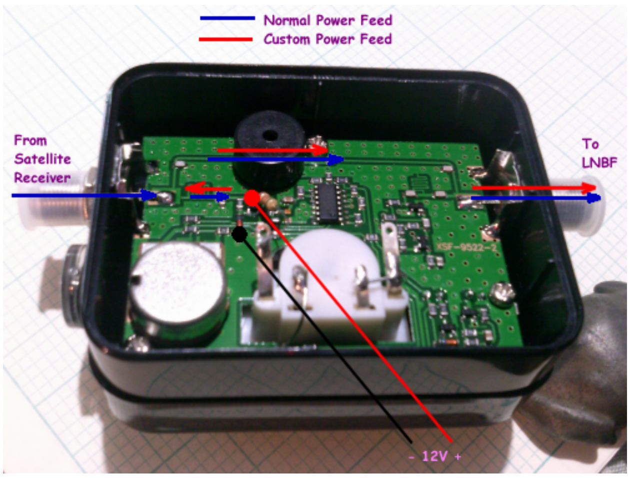

Figure 3: Satellite Finder with Custom Power Supply

V. CONCLUSION

The Ku-band TVRO consumer equipment can be utilised for 12 GHz radio astronomy providing ready access to useful technology at a reasonable price. Subsequent notes will detail actual systems and observational results.