

## 30GHz Holography Receivers

Holography techniques are used to determine the surface accuracy of the antennas at Parkes, Narrabri and Mopra. For the 22m diameter antennas which are to be used at 3mm wavelengths, holography at 30GHz is desirable. The Optus B3 satellite has a suitable beacon (CW signal) at 30.44 GHz.

For a short discussion of expected power levels and signal to noise ratios, please refer to an accompanying note "Holography Instrumentation AT/39.3/093.

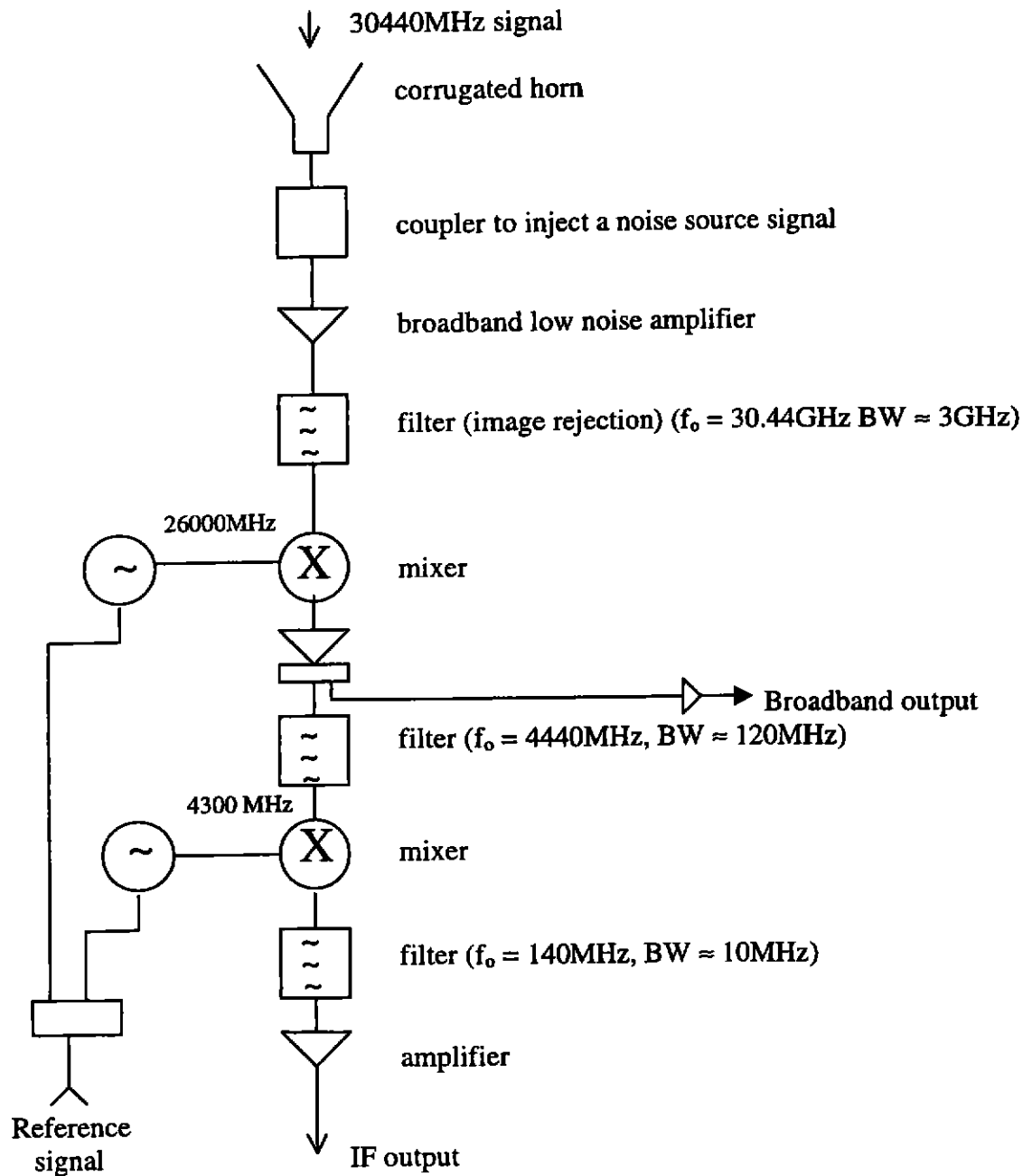
Two receivers are required, using the same components, but a different package. One will be built into an ATNF C/X feed support frame that fits on top of a standard front end frame. (There is no space for permanent installation of this receiver. The C/X, 6/3cm, horn frame may need to be replaced by the 30GHz receiver for the holography measurements).

The other receiver needs to be installed on a 1.2m diameter reference antenna.

It would be desirable to make the receivers self contained, with their own oscillators (perhaps phase locked dielectric resonator oscillators) and power supplies. The connections required would be only 240V mains power, a reference signal (at probably 100MHz) and the IF output (probably 140MHz). In addition, a wideband output at the first IF frequency should be made available. This could then be connected to the standard conversion system in the Narrabri and Mopra antennas if the receivers were to be used for astronomical observations.

About two years ago, I looked at several possibilities for a suitable conversion scheme. Following is the one that I thought was the best option.

A block diagram follows:



### ***Filter specifications for this design***

(a) RF Filter

Centre frequency 30.44GHz.

Image band is centred on 21.56GHz.

WR28 waveguide has a cutoff frequency of 21.1GHz.

Therefore a piece of this waveguide will not attenuate the image band.

(WR28 is used for the band 26.5-40GHz).

A section of WR22 waveguide (cutoff frequency is 26.4GHz) would attenuate the image band. Alternatively, a bandpass filter, of about 3GHz bandwidth, would be suitable. This is the preferred option.

(b) 1<sup>st</sup> IF filter

Centre frequency: 4400MHz

Bandwidth: approx. 120MHz

Fractional bandwidth: 2.7%

Image band: 4160MHz.

A 4<sup>th</sup> order filter (0.04dB ripple) would have approx 50dB image rejection.

An evanescent mode filter design would be suitable.

(c) 2<sup>nd</sup> IF filter

Centre frequency: 140MHz

Bandwidth: approx 10MHz

Fractional bandwidth: 7.1%

A 3<sup>rd</sup> (of 4<sup>th</sup>) order filter would be suitable.

A comb line design would be desirable. The centre frequency could then be changed fairly easily if desired.

The filter is needed to reduce the noise bandwidth.

Following are two signal level budget sheets, one for the reference antenna, and the other for a 22m diameter antenna. They contain a list of the components that then may have been suitable. Now that a broadband output is desired, it would be better if the IF amplifier following the first conversion had wider bandwidth, perhaps to 8GHz. (A 4 to 8GHz amplifier would be better than the suggested Cougar one).

Note also that the first oscillator may need to be a 13GHz oscillator, followed by a doubler/amplifier. (Although I have data for a 26GHz phase locked DRO, they may not be available).

The rotary joint may be needed. The 30GHz beacon is linearly polarised. The system needs to be designed so that the receiver polarisation angle may be aligned to that of the beacon.

ATNF have a feed design for the 22m antennas. The 1.2m reference antenna is a cassegrain system with the feed provided.

George Graves  
19<sup>th</sup> April, 1999

*Ref:JWB/gam:10-99*

30GHz beacon ref

1.2 m Diameter Antenna

Q-Band  
at 30.44 GHz

Beacon (dBm) = -120

LNA, RF & IF Module

| Component Name       | Make          | Device                   | Gain dB typ | Noise K | B Width Mhz | 1 dB Comp. Point | Level Below 1dB Comp. | Spectral power dBm/MHz | Power level (total) dBm | T sys  | ΔTsys    |
|----------------------|---------------|--------------------------|-------------|---------|-------------|------------------|-----------------------|------------------------|-------------------------|--------|----------|
| Background           |               |                          |             | 2.70    | 14000.00    |                  |                       | -134.3                 | -92.8                   | 2.70   | 2.7000   |
| Atmosphere           |               |                          |             | 10.00   | 14000.00    |                  |                       | -127.6                 | -86.1                   | 12.70  | 10.0000  |
| Feed legs            |               |                          |             | 3.00    | 14000.00    |                  |                       | -126.6                 | -85.2                   | 15.70  | 3.0000   |
| Spill-over           |               |                          |             | 6.00    | 14000.00    |                  |                       | -125.2                 | -83.8                   | 21.70  | 6.0000   |
| Horn loss & w' guide |               |                          | -0.20       |         | 14000.00    |                  |                       | -123.3                 | -81.9                   | 35.37  | 13.6673  |
| Transition           |               | Circular to rectangular  | -0.02       |         | 14000.00    |                  |                       | -123.3                 | -81.9                   | 35.45  | 0.0822   |
| Coupler              |               | (for noise injection)    | -0.10       |         | 14000.00    |                  |                       | -123.4                 | -81.9                   | 35.87  | 0.4166   |
| Transition           |               | Waveguide to K-connector | -0.10       |         | 14000.00    |                  |                       | -123.4                 | -82.0                   | 36.29  | 0.4263   |
| LNA                  | Miteq         | J54-26004000-2.5-8P      | 28.0        | 200.0   | 14000.00    | 8.0              | 53.5                  | -86.9                  | -45.5                   | 256.60 | 220.3079 |
| Rotary joint         | Sage          | 351                      | -0.7        |         | 14000.00    |                  |                       | -87.6                  | -46.2                   | 256.69 | 0.0885   |
| Transition           |               | K-connector to Waveguide | -0.1        |         | 14000.00    |                  |                       | -87.7                  | -46.3                   | 256.70 | 0.0139   |
| Isolator             | M/A-Com       | 2-28-400                 | -0.4        |         | 14000.00    |                  |                       | -88.1                  | -46.7                   | 256.76 | 0.0587   |
| Filter               | ATNF          | 3GHz @ 30.44GHz          | -2.0        |         | 3000.00     |                  |                       | -90.1                  | -55.3                   | 257.15 | 0.3904   |
| Isolator             | M/A-Com       | 2-28-400                 | -0.5        |         | 3000.00     |                  |                       | -90.6                  | -55.8                   | 257.28 | 0.1291   |
| Mixer                | M/A-Com       | 5-28-790                 | -6.0        |         | 3000.00     |                  |                       | -96.6                  | -61.8                   | 260.82 | 3.5381   |
| IF Amp               | Cougar        | AS5066-SMA               | 18.5        | 350     | 3000.00     | 21.0             | 64.2                  | -78.0                  | -43.2                   | 266.52 | 5.7025   |
| Power splitter       |               | (for broadband output)   | -3.5        |         | 3000.00     |                  |                       | -81.5                  | -46.7                   | 266.60 | 0.0827   |
| Filter (BPF)         | ATNF          | 120 MHz @ 4.44 GHz       | -0.5        |         | 120.00      |                  |                       | -82.0                  | -61.2                   | 266.62 | 0.0182   |
| IF Amp               | Cougar        | AS5066-SMA               | 18.5        | 350     | 120.00      | 21.0             | 63.7                  | -63.5                  | -42.7                   | 266.82 | 0.2023   |
| Mixer                | Marki         | M1-0208LB                | -6.0        |         | 120.00      |                  |                       | -69.5                  | -48.7                   | 266.83 | 0.0071   |
| Attenuator           | Inmet         | 12A-3                    | -3.0        |         | 120.00      |                  |                       | -72.5                  | -51.7                   | 266.84 | 0.0094   |
| Filter (LPF)         | Mimi-circuits | SLP-550                  | -0.5        |         | 120.00      |                  |                       | -73.0                  | -52.2                   | 266.84 | 0.0023   |
| IF Amp               | Q-Bit         | QB717                    | 21.0        | 290     | 120.00      | 22.0             | 53.2                  | -52.0                  | -31.2                   | 266.86 | 0.0211   |
| Filter (BPF)         |               | 10 MHz at 140 MHz        | -1.0        |         | 10.00       |                  |                       | -53.0                  | -42.8                   | 266.86 | 0.0000   |
| IF Amp               | Q-Bit         | QB262                    | 28.0        | 1200    | 10.00       | 27.0             | 41.8                  | -25.0                  | -14.8                   | 266.87 | 0.0009   |
| Cable                | Andrew        | FSJ1-50                  | -1.0        |         | 10.00       |                  |                       | -26.0                  | -15.8                   | 266.87 | 0.0000   |

Beacon level is approx -31.6 dBm  
Noise power is approx -16.0 dBm

Cable Link

| Component Name | Make   | Device   | Gain dB typ | Amp Noise K | B Width Mhz | 1 dB Comp. Point | Level Below 1dB Comp. | Spectral power dBm/MHz | Power level (total) dBm | T sys  | ΔTsys  |
|----------------|--------|----------|-------------|-------------|-------------|------------------|-----------------------|------------------------|-------------------------|--------|--------|
| Cable          | Andrew | FSJ1-50A | -10.0       |             | 10.00       |                  |                       | -36.0                  | -25.8                   | 266.87 | 0.0000 |

30GHz beacon 22m

22 m Diameter Antenna

Q-Band  
at 30.44 GHz

Beacon (dBm) = -95

LNA, RF & IF Module

| Component Name      | Make          | Device  | Gain dB typ | Noise K | B Width Mhz | 1 dB Comp. Point | Level Below 1dB Comp. | Spectral power dBm/MHz | Power level (total) dBm | T sys  | ΔTsys    |
|---------------------|---------------|---|-------------|---------|-------------|------------------|-----------------------|------------------------|-------------------------|--------|----------|
| Background          |               |   |             | 2.70    | 14000.00    |                  |                       | -134.3                 | -90.8                   | 2.70   | 2.7000   |
| Atmosphere          |               |   |             | 10.00   | 14000.00    |                  |                       | -127.6                 | -85.6                   | 12.70  | 10.0000  |
| Feed legs           |               |   |             | 3.00    | 14000.00    |                  |                       | -126.6                 | -84.8                   | 15.70  | 3.0000   |
| Spill-over          |               |   |             | 6.00    | 14000.00    |                  |                       | -125.2                 | -83.5                   | 21.70  | 6.0000   |
| Horn loss & w'guide |               |   | -0.20       |         | 14000.00    |                  |                       | -123.3                 | -81.7                   | 35.37  | 13.6673  |
| Transition          |               | Circular to rectangular (for noise injection) | -0.02       |         | 14000.00    |                  |                       | -123.3                 | -81.7                   | 35.45  | 0.0822   |
| Coupler             |               | Waveguide to K-connector                      | -0.10       |         | 14000.00    |                  |                       | -123.4                 | -81.7                   | 35.87  | 0.4166   |
| Transition          |               | JS4-26004000-2.5-8P                           | -0.10       |         | 14000.00    |                  |                       | -123.4                 | -81.8                   | 36.29  | 0.4263   |
| LNA                 | Miteq         |   | 28.0        | 200.0   | 14000.00    | 8.0              | 53.4                  | -86.9                  | -45.4                   | 256.60 | 220.3079 |
| Rotary joint        | Sage          | 351   | -0.7        |         | 14000.00    |                  |                       | -87.6                  | -46.1                   | 256.69 | 0.0885   |
| Transition          |               | K-connector to Waveguide                      | -0.1        |         | 14000.00    |                  |                       | -87.7                  | -46.2                   | 256.70 | 0.0139   |
| Isolator            | M/A-Com       | 2-28-400                                      | -0.4        |         | 14000.00    |                  |                       | -88.1                  | -46.6                   | 256.76 | 0.0587   |
| Filter              | ATNF          | 3GHz @ 30.44GHz                               | -2.0        |         | 3000.00     |                  |                       | -90.1                  | -55.2                   | 257.15 | 0.3904   |
| Isolator            | M/A-Com       | 2-28-400                                      | -0.5        |         | 3000.00     |                  |                       | -90.6                  | -55.7                   | 257.28 | 0.1291   |
| Mixer               | M/A-Com       | 5-28-790                                      | -6.0        |         | 3000.00     |                  |                       | -96.6                  | -61.7                   | 260.82 | 3.5381   |
| IF Amp              | Cougar        | AS5066-SMA                                    | 18.5        | 350     | 3000.00     | 21.0             | 64.1                  | -78.0                  | -43.1                   | 266.52 | 5.7025   |
| Power splitter      |               | (for broadband output)                        | -3.5        |         | 3000.00     |                  |                       | -81.5                  | -46.6                   | 266.60 | 0.0827   |
| Filter (BPF)        | ATNF          | 120 MHz @ 4.44 GHz                            | -0.5        |         | 120.00      |                  |                       | -82.0                  | -58.8                   | 266.62 | 0.0182   |
| IF Amp              | Cougar        | AS5066-SMA                                    | 18.5        | 350     | 120.00      | 21.0             | 61.3                  | -63.5                  | -40.3                   | 266.82 | 0.2023   |
| Mixer               | Marki         | M1-0208LB                                     | -6.0        |         | 120.00      |                  |                       | -69.5                  | -46.3                   | 266.83 | 0.0071   |
| Attenuator          | Inmet         | 12A-3   | -3.0        |         | 120.00      |                  |                       | -72.5                  | -49.3                   | 266.84 | 0.0094   |
| Filter (LPF)        | Mini-circuits | SLP-550                                       | -0.5        |         | 120.00      |                  |                       | -73.0                  | -49.8                   | 266.84 | 0.0023   |
| IF Amp              | Q-Bit         | QB717   | 21.0        | 290     | 120.00      | 22.0             | 50.8                  | -52.0                  | -28.8                   | 266.86 | 0.0211   |
| Filter (BPF)        |               | 10 MHz at 140 MHz                             | -1.0        |         | 10.00       |                  |                       | -53.0                  | -33.1                   | 266.86 | 0.0000   |
| IF Amp              | Q-Bit         | QB262   | 28.0        | 1200    | 10.00       | 27.0             | 32.1                  | -25.0                  | -5.1                    | 266.87 | 0.0009   |
| Cable               | Andrew        | FSJ1-50                                       | -1.0        |         | 10.00       |                  |                       | -26.0                  | -6.1                    | 266.87 | 0.0000   |

Cable Link

Beacon level is approx -6.6 dBm  
Noise power is approx -16.0 dBm

| Component Name | Make   | Device   | Gain dB typ | Amp Noise K | B Width Mhz | 1 dB Comp. Point | Level Below 1dB Comp. | Spectral power dBm/MHz | Power level (total) dBm | T sys  | ΔTsys  |
|----------------|--------|----------|-------------|-------------|-------------|------------------|-----------------------|------------------------|-------------------------|--------|--------|
| Cable          | Andrew | FSJ1-50A | -10.0       |             | 10.00       |                  |                       | -36.0                  | -16.1                   | 266.87 | 0.0000 |