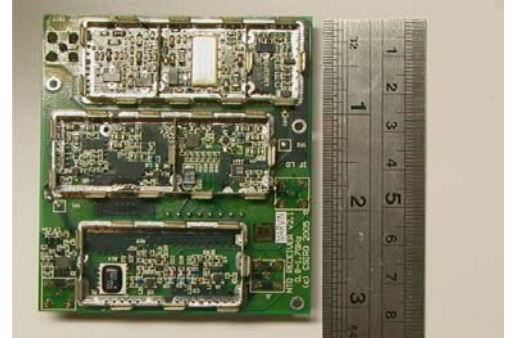


Receiver Design for the NTD Focal Plane Array

Introduction

The New Technology Demonstrator (NTD) requirement of down-converting the 800-1700 MHz RF input to a fixed Intermediate Frequency (IF), which will be the input to the NTD DSP module, has led to the conception and design of the down-converter described in this paper. Together with a Low Noise Amplifier (LNA) in front of it, the down-converter is an important part of the NTD receiver.



Down-converter Performance

RF input: 800-1700 MHz

1st IF: 2484 MHz Centre Frequency, 26 MHz BW

2nd IF: 70 MHz Centre Frequency, 24 MHz Bandwidth

1st LO: 3284-4184 MHz (for 800-1700 MHz RF)

2nd LO: 2414 MHz, fixed

Noise Figure at max gain: 2dB

Image rejection in the RF band:

of 1st IF: > 72dB at 4968 MHz above F₀

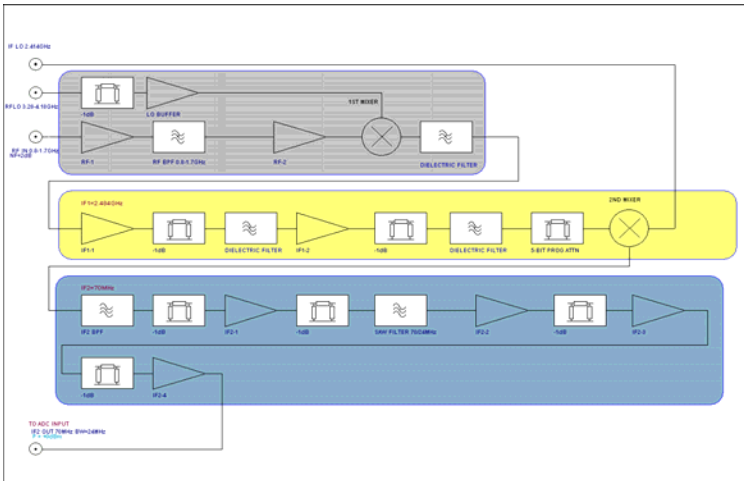
of 2nd IF: > 85 dB at 140 MHz above F₀

3rd order products for 0 dBm power at 2nd IF output (for full range A/D input): -40 dBc

Gain control: 32 dB range, 1 dB steps, using a 5-bit parallel bus. *Max gain:* 67 dB

LNA performance: G=24-30 dB, NF < 0.5 dB

Max system gain, inc. LNA, optimized for 150K input noise power: about 95-97 dB



Concept

A total of 24 down-converters are required to take the signals from the LNAs located with the array of feeds at the focal plane of a 13.7 m diameter parabolic dish reflector antenna. The NTD project consists of 2 such antennas, presently being assembled at the CSIRO Marsfield site. The useful input to each receiver is a very weak signal from distant radio sources. This signal needs to be extracted from a much larger thermal noise signal, typically 100K, picked up by the array of receptors, and a still much larger level of interference (tens of dB greater) created by local broadcast stations, mobile phone towers and other transmitters in this frequency band. This unwanted noise and interference is spread over most of the band, with decreasing energy above 1400 MHz. The challenge NTD faces is doing radio astronomy in a frequency band that is adjacent to powerful local interferers.

The NTD receiver must have a high enough gain to amplify the very weak, useful signal, to a reasonable level. The unwanted signals dominate the power at the down-converter output, and the challenge is to keep the gain of the receiver high enough to amplify the weak signal, while preventing the interference from saturating the amplifiers.

In order to use some of the relatively quiet spectral windows between these strong signals for the measurements, the receiver must have a very good immunity to signals outside, but nearby the desired band. In a practical and low-cost design, a (dual-conversion) receiver does not have a tuned RF filter. Also, the channel definition filter is usually inserted in the 2nd IF path (having a 70 MHz centre frequency in this case), which makes the design simple and allows for a highly selective filter. This way however, strong interferers, before being rejected by the channel filter, have a good chance to generate intermodulation products which "spill" into the channel, although initially they were outside channel's limits.

The adopted solution was to still use dual-conversion architecture, but with the bandwidth of the 1st IF just a bit wider than the channel. This ensures the strong unwanted signals close to the channel are rejected as early as possible in the chain. Also, before the signal reaches the 1st IF filters, the use of a high linearity front-end and 1st mixer for handling the total received power in the 800-1700 MHz band will keep the intermodulation products at a low level.

Because the RF input covers 900 MHz of bandwidth, in order to avoid the image problem it was chosen to up-convert it to a higher 1st IF frequency. The 1st IF frequency was dictated by the availability of 2.484 GHz centre frequency / 26 MHz bandwidth dielectric filters (manufactured by Murata). Choosing a relatively high 2.48 GHz IF frequency puts the 1st IF image far away, at F₀+ 4968 MHz in the RF band. The rejection of this image is eventually better than 72 dB (measured value).

With a bandwidth of 26 MHz for the 1st IF filter, the channel is not affected, while providing good rejection of the unwanted signals close to the channel limits, as well as for the 2nd IF image (for RF signals at F₀+140 MHz). The rejection of the 2nd IF image in the RF band was measured to be better than 85 dB.

The 2nd IF frequency of 70 MHz is dictated by the requirements of the A/D converter. For the channel filter, a 24 MHz bandwidth SAW filter is used.