Hamilton Astronomical Society

1420 MHz Radio Astronomy Receiver Notes (2006) Preliminary

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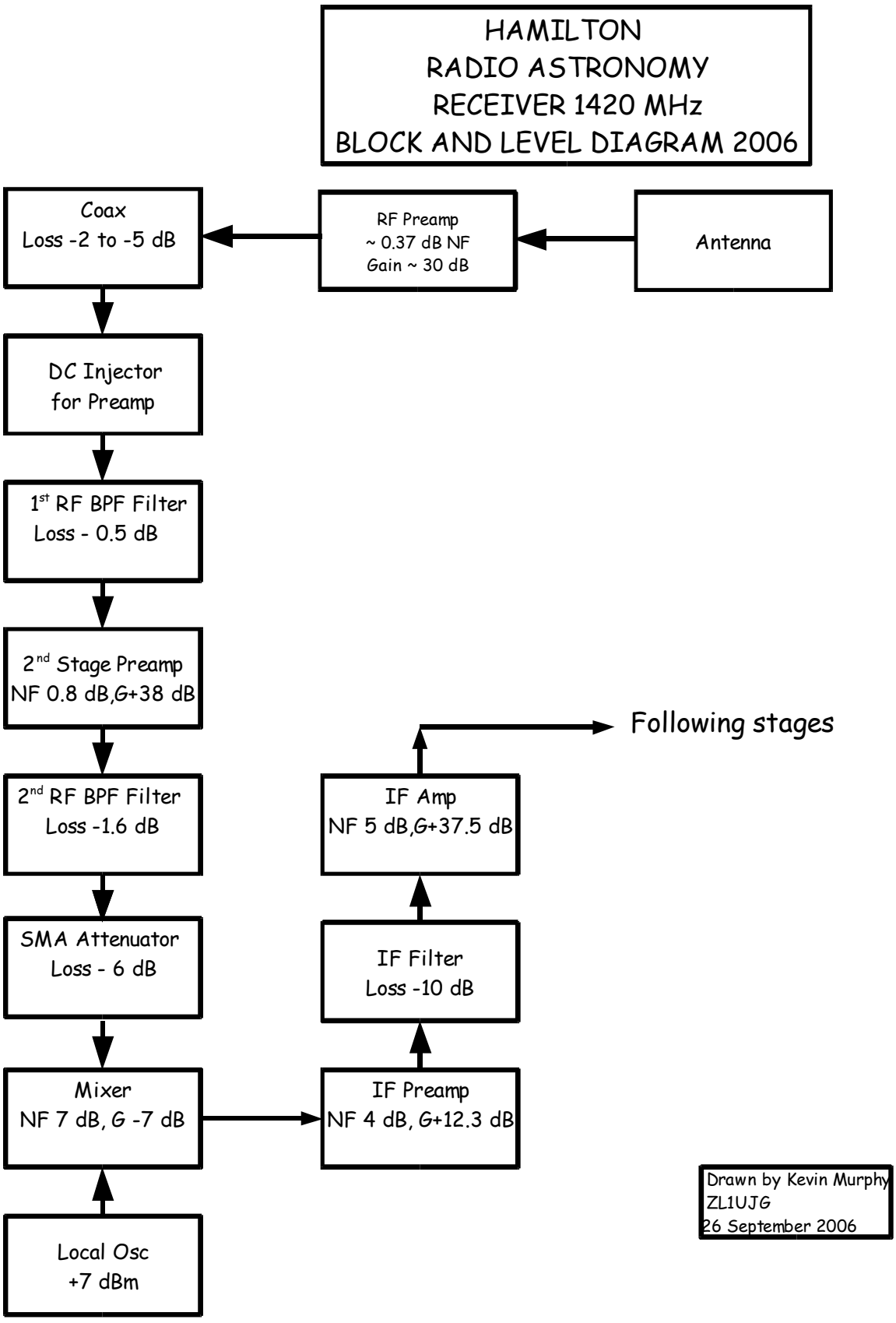


Block diagram of amended 1420 MHz Radio Astronomy Total power Receiver

During August 2006, I, Kevin Murphy joined the Hamilton Astronomical Society. I have decided to park any further work on the 1665 MHz Receiver. This is so that the 1420 MHz system can be made operational in a relatively short time frame of ~ 6 weeks (hopefully).

Robin has built an excellent enclosure for the RX, using ~ 5mm thick aluminium. The unit has been connectorised. Robin is also constructing mounting brackets for mounting the horn feed on the 3 metre dish. The wire mesh dish is not being used.

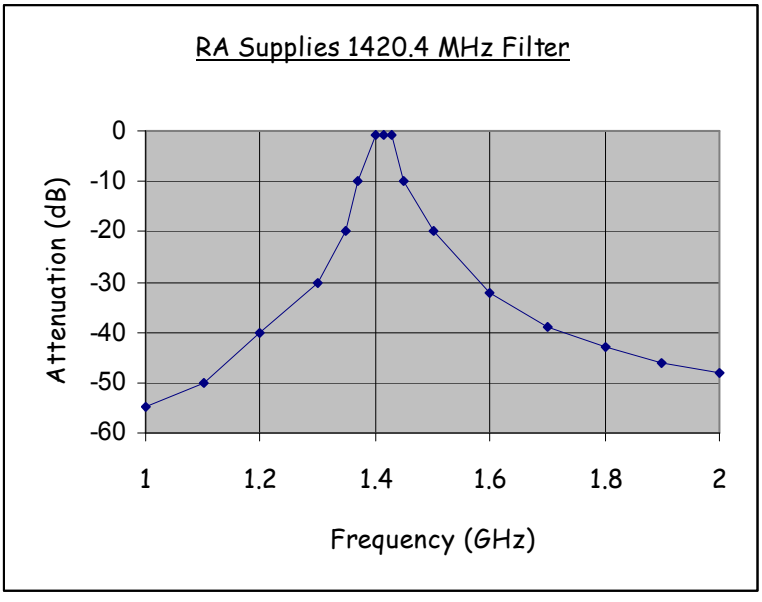
I have reviewed the configuration of the 1420 MHz receiver and will put the existing high gain IF stage after the IF filter and a low gain stage, using a MCL MAV11 MMIC before the IF filter. This will redistribute system gain, and give superior adjacent channel performance. The original configuration as received in 2004 had all the gain before the IF filter, and was not changed during 2004. The amended block diagram is shown on the previous page.

There will be some additional components fitted in the box. A 6 dB attenuator will be fitted before the mixer, to provide a wideband termination to both the mixer and IF filter. There will be a DC injection box for feeding DC up the coax to feed the Radio Astronomy Supplies (RAS) Preamp, which needs small modifications to enable DC feed via the coax. This reduces wiring. The RAS supplied filter (in a copper tube) will also be fitted inside the box. Steven Chibnall has manufactured some aluminium P clips for mounting. (Image on next page)

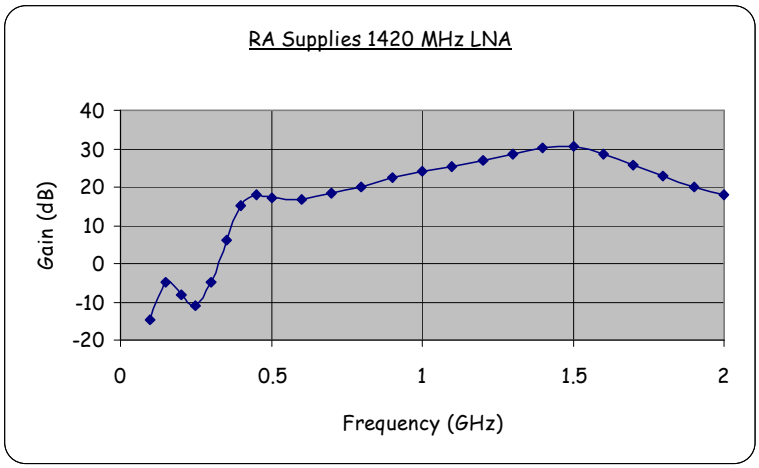
Additional hardware has been purchased for this reconfiguration.
N (m) to SMA (f) adapters 2 off
BNC (m) 4 hole chassis mount 1 off
SMA (m) to SMA (m) adapter 1 off
Teflon feedthroughs, for miscellaneous 70 MHz in/out access
Other hardware used, I have had available or have reused existing parts.

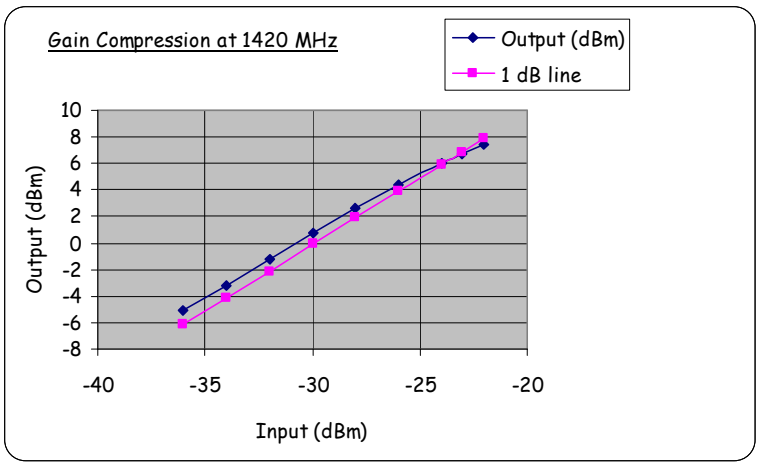
RAS RF filter

The filter was checked for response. The unit looks quite good in the 1 to 2 GHz region. The inband (~ 1.4 to 1.43 GHz) return loss (RL) is ~ 17 dB, and out of band RL degrades to ~ 0 dB, which is expected.
Loss at 1420 MHz is ~ 0.6 dB and image rejection @ 1280 MHz is ~ 32 dB. There are significant spurious responses in the region of 4 to 13 GHz. These may not affect Receiver performance.
The rejection of the PCB filter, (already in the receiver) at 1280 MHz is ~ 24 dB, so the image rejection of these two filters together is ~ 56 dB.



The above picture shows the RAS 1420 MHz filter and associated P clips, with N to SMA adapters.





RAS 1420 MHz Preamp

The 1420 MHz Preamp Noise figure was checked to be ~ 0.37 dB and the gain was checked to be over 30 dB. The frequency response is shown on the adjacent graph.

There is significant gain above and below the band in question. Testing when the overall unit is complete will determine whether this is an issue. There is significant gain in the bands where high levels of signals are present. UHF TV, Cellphone Base,

The antenna would probably be a feedhorn (RA Supplies / SETI) and this will reduce the level of signals below the cutoff frequency of the feed.

Gain compression (-1 dB) was checked and occurred just below + 7 dBm. (5 mW)

6 dB Attenuator

I purchased 3, 6 and 12 dB BNC attenuators from Jaycar to check. They appear to let DC through. Looking at their response, however showed that their attenuation and Return loss degraded significantly above 500 MHz. The 6 dB attenuator gave ~ 8 dB loss at 1.5 GHz They would be OK for use at the 70 MHz IF or below 500 MHz. I have an old Radio Spares 6 dB attenuator, RS 195-2996 from Telegartner, which is rated to 1 GHz. Tests revealed it wasn't suitable for 1420 MHz. Robin said he has some SMA attenuators and will check those

IF Preamplifier

As mentioned previously the high gain preamplifier is being fitted after the IF filter. The mixer ideally should be terminated at all frequencies, such as with an attenuator, however this would reduce gain and deteriorate noise.

A MCL MAV-11 MMIC is being used for the IF preamp. The amplifier has to perform a number of functions such as terminating the mixer and the IF Filter, providing some gain and also some rejection of unwanted frequencies. This IF preamplifier is very similar to that used on the 1665 MHz RX and further information can be obtained from that PDF.

A simple circuit is used on the IF amp input. At higher frequencies signals such as the LO, RF and RF+LO could be terminated with a simple RC network, which provides a load which increasingly tends towards 50Ω at higher frequencies (A monotonic termination.)

At lower frequencies such as the 70 MHz IF, then a series tuned circuit is used to provide some filtering and also reject higher frequency signals. The tuned circuit uses SMD components to provide small size, but the Inductor has a lower Q than conventional components, so the tuned circuit has a slightly higher loss. The overall gain is ~ 12.3 dB and the noise figure is just below 4 dB. This doesn't quite override the IF filter loss and Main IF Amp NF, however the other properties of the preamp however provide an important function. Earlier stage gains more than compensate for the slight deterioration.

The Amplifier has 1 dB gain compression at +18.5 dBm. (~ +6 dBm input). The mixer 1 dB loss compression point is ~ +1dBm on the input (~ -6 dBm output). This is about 12 dB difference.

At 1343.5 MHz (LO) the Amp has -18 dB loss, due to the effect of the series tuned circuit.

A male BNC is fitted for direct connection to the mixer (no adapters). A SMA-f is used on the output.

Filter

The IF filter's BNC connectors has now been replaced by SMA's, as the BNC's and the right angle connectors are the same height as the intended cover. The filter box takes solder and small copper patches were soldered to the box and SMA's then soldered to the copper.

High Gain IF Amplifier.

This is being repositioned in the box. The unit's connectors has been changed and the PCB has been mounted securely. An additional bracket has been fitted for final installation. Measurements of this unit were made in 2004.

Detector/ DC circuitry

Yet to be constructed. I have some suitable circuits from the internet that will be changed slightly. I have the parts

A to D Converter and Skypipe Software

A MAX186 8 input 12 bit Analogue to Digital Converter has been purchased to be used with the Skypipe software. With the free version of the software, one input is available, whereas with the paid up version (US$39.95) all 8 inputs are available simultaneously.