Alcatel White Box 24GHz Transceiver experiments and modifications

A set of working notes, measurements and comments

PSU

Need to supply :

- -5V up to ~ 30mA for Rx and PA modules
- +5.2V 1A for Rx and Tx mixer
- +6.0V 1A for Power Amp

Interlock +V rails with –V to prevent damage if –Ve is lost
Note, the NMT1212 is not short circuit proof and has max rated current = 83mA. Hence the 100R resistor before

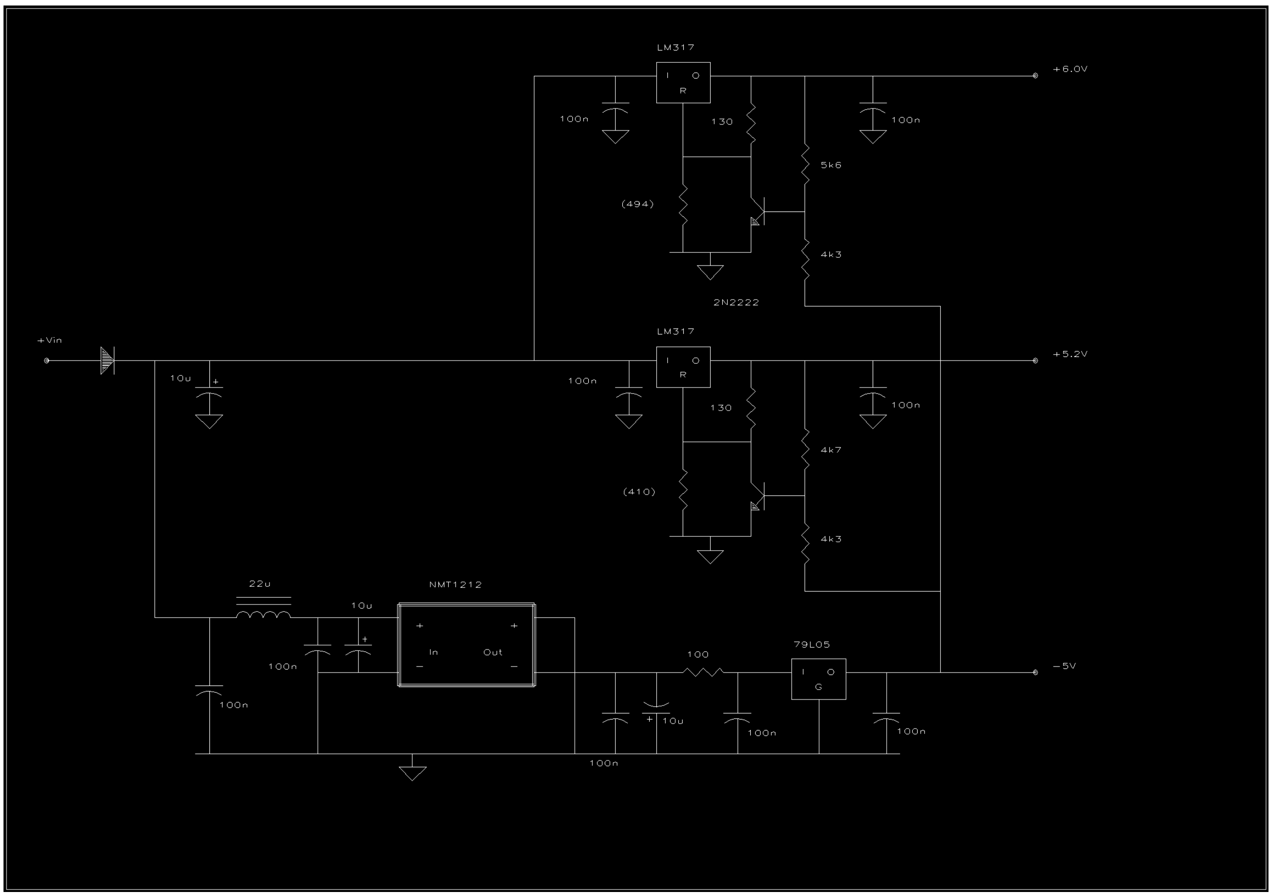

Figure 1   Circuit Diagram of the PSU ,
A higher resolution version with white background can be found at   WhiteBoxPsu.gif

Swapping Sidebands on the GBY125 and GBY111 Receiver modules

First ensure you need to…!

This has already been covered in other documentation, but here is my technique used to swap over the two output ports on the original 90 degree hybrid combiner so the correct image rejection can be achieved.

Remove the 51 ohm resistor from the top right port of the combiner to the through hole – a gap can be seen in Figure 2 showing where it was originally located.   Remove and note the value of the series resistor from the other port (bottom right) to the MMIC input. The gap where this was located can be seen where the copper tape joins the gold plated track.

A new 51 ohm surface mount resistor is placed from the other port to the nearest through-hole, shown just below the combiner. A 0805 or 1206 size device is needed to fit across the gap.

Cut a length of copper self-adhesive tape slightly wider than the existing the tracks on the PCB to make 50 ohm line, and stick on the board as shown. The width should be a bit greater as the added thickness of the adhesive and imperfect contact with the dielectric will introduce a gap and lower Zo. But it is not very critical.
Insert a resistor of the same value as the one removed to complete the path.

Replace the lid of the module using lengths of copper or aluminium tape to secure it, then test…

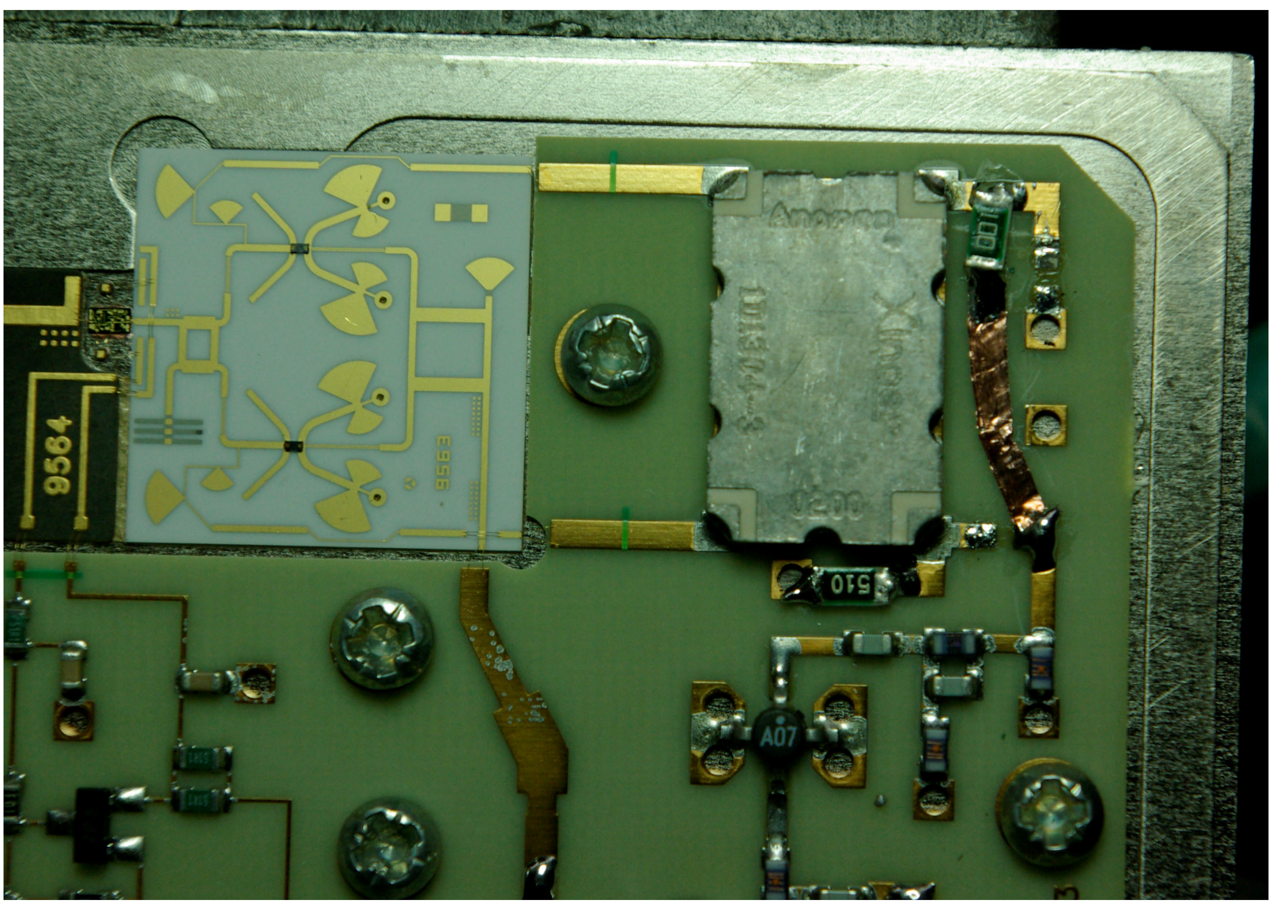

Figure 2 Swapping the 90 Degree hybrid combiner output ports

Test Results with 1296 and 800MHz IF

The Rx module was fed with a local oscillator signal directly from a synthesiser generating +10dBm of 12GHz. A low level test signal was generated by connecting the output from another synthesiser to the multiplier diode inside the test module that is part of the original white box.

This test module can be found connected to the cross coupler on the output of the original White Box hardware between the diplexer and the antenna. It consists of a WR42 input port and two SMA connectors, Internally there are two diodes with associated bias and decoupling. One is configured as a detector for measuring power output – the DC appears on the lower SMA connector (as viewed with the waveguide port on the top and to the right). The other diode is configured as a multiplier / comb generator and was originally used with an input from a dedicated synthesiser in the region of 2GHz to inject a test signal into the receiver path.

By selecting a suitable subharmonic, the rejection of the receiver mixer can be approximately ascertained. The level of 24GHz generated was found to be very dependant on drive level to this multiplier, in a non-linear and not even monotonic way. So it is not possible to completely guarantee that equal power levels at 24Ghz were generated even if drive was kept constant. However, by making several tests at pairs of signal/image subharmonics with different multiplication factors, and with different drive levels, a reasonable average vale can be found. Power levels between 10 to 16dBm appear to be optimum for driving at frequencies up to 1GHz, the maximum capability of the synthesiser.

The IF output level at 1296MHz or 800MHz was measured on a spectrum analyser.
A set of results were also measured at 800MHz IF, close to that originally employed and presumably at the optimum operating point of the coupler.

Table 1 Below shows that around 12dB sideband rejection was observed at 1296MHz.
At 800MHz this rose to 18dB which is in the region of the sort of value that should be expected on an image reject mixer that has no opportunity for individual trimming of the I/Q channels.

Results for 1296MHz IF

Wanted RF 24048MHz
Image 21456MHz
LO/2 Input 11376MHz

Subharmonic test-frequency pairings
961.92 / 858.24 (*25)
801.6 / 715.2 (*30)
668 / 596 (*36)

Average of measured unwanted sideband rejection at 1296MHz **12dB**

Results for 800MHz IF

Wanted RF 24048MHz
Image 22448MHz
LO/2 Input 11624MHz

Subharmonic test-frequency pairings
961.92 / 897.92 (*25)
801.6 / 748.27 (*30)
668 / 623.56 (*36)

Average of measured unwanted sideband rejection at 800MHz **18dB**

Adapting the Rx module for a 144MHz IF

The Minicircuits ADQ-180 is a low cost surface mount quadrature combiner covering the frequency range 120 to 180MHz. It does not have the same pin connections as the original ones used in these modules, but is of a similar size, although slightly thicker.

The first job is to remove the old one. With a sharp knife cut the PCB tracks close to the existing combiner. This is to prevent further damage if the removal process causes them to be lifted – it is essential at all costs that the wire bonds and chip components of the 24GHz hardware are not damaged. These are probably irreparable.

It proved impossible to unsolder the original combiner, even with a large soldering iron bit and maximum temperature setting. The heat conductivity of the microwave substrate is just too high. Instead, while applying heat (soldering iron setting 380C, high, large bit)to the top of the combiner, lever it up with a thin screw driver. Almost certainly the module will bend and break up. Be vicious and use small side cutters to chop away all the bits while applying as much heat to the device as you can, but at the same time being very careful to keep away from the 24GHz components. Eventually you will manage to remove all the remnants from the PCB, leaving no more than a probably damaged grounding track underneath the original unit which by now should now be no more than a few tatters of metal and white plastic on the floor! Photo 3 shows my removal attempt.

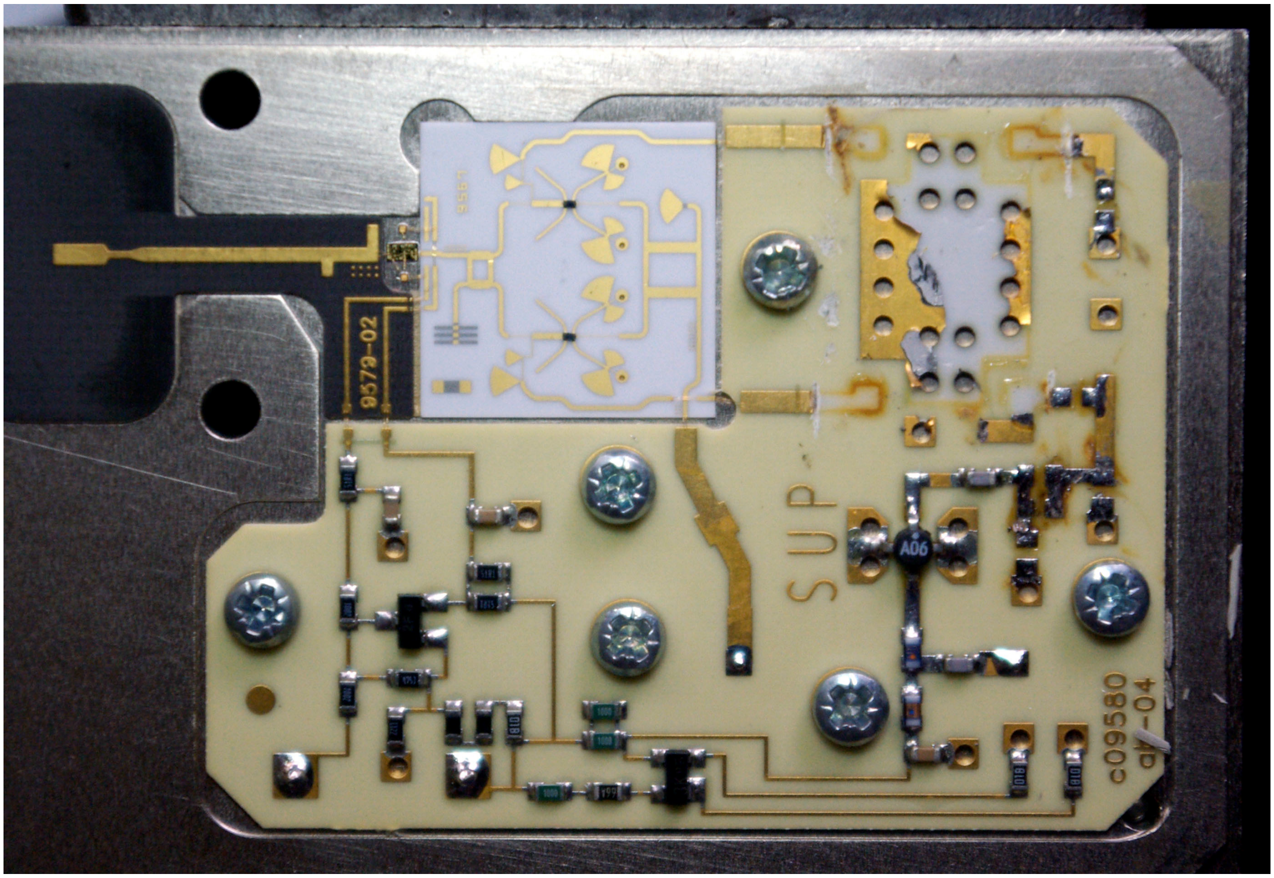

Figure 3 Rx module with the original combiner removed as well as some of the other IF components.

The existing IF amplifier needs modification to work down to 144MHz. Remove all the components around the input to the modamp, even the input coupling capacitor as this has to be replaced with one of a higher value. Also, remove the series inductors and the output coupling capacitor. Replace the two coupling capacitors with 470pF (0805 0r 0402 size) and the bias inductor with a value suitable for 144MHz. 0.33 to 1uH is adequate. Ideally an SMT inductor would be used here, but I didn't have one available and just used a small 3.3uH wire ended one found in the junk box.

As the ADQ-180n has different pin connection to the original, it has to be mounted at a diagonal to preserve reasonable line length matching for each input port. Fortunately it only has to work at 144MHz! A piece of copper tape can be used to extend / repair the damaged groundplane; connect to the nearest two through-holes. The four signal pins on the combiner, pin nos 1,4,5 and 8 at the corners are bent up and the remaining ones soldered to this new ground strip. Photo 4 shows my installation, and is the easiest way to illustrate what is needed.

Wire strips connect the signal ports to the original tracks – take great care when connecting to the 24GHz mixer ports to avoid getting anywhere near the wire bonds. (A wire ended capacitor was used as the input to the modamp, this doubled up as the link rather than installing a SMT capacitor as can be seen in Figure 4).

Use a good magnifying glass (wide aperture 50mm lenses from redundant SLR film cameras are now very cheap and make marvellous magnifiers). A 51 ohm chip resistor on the remaining ADQ-180 port to ground completes the installation.

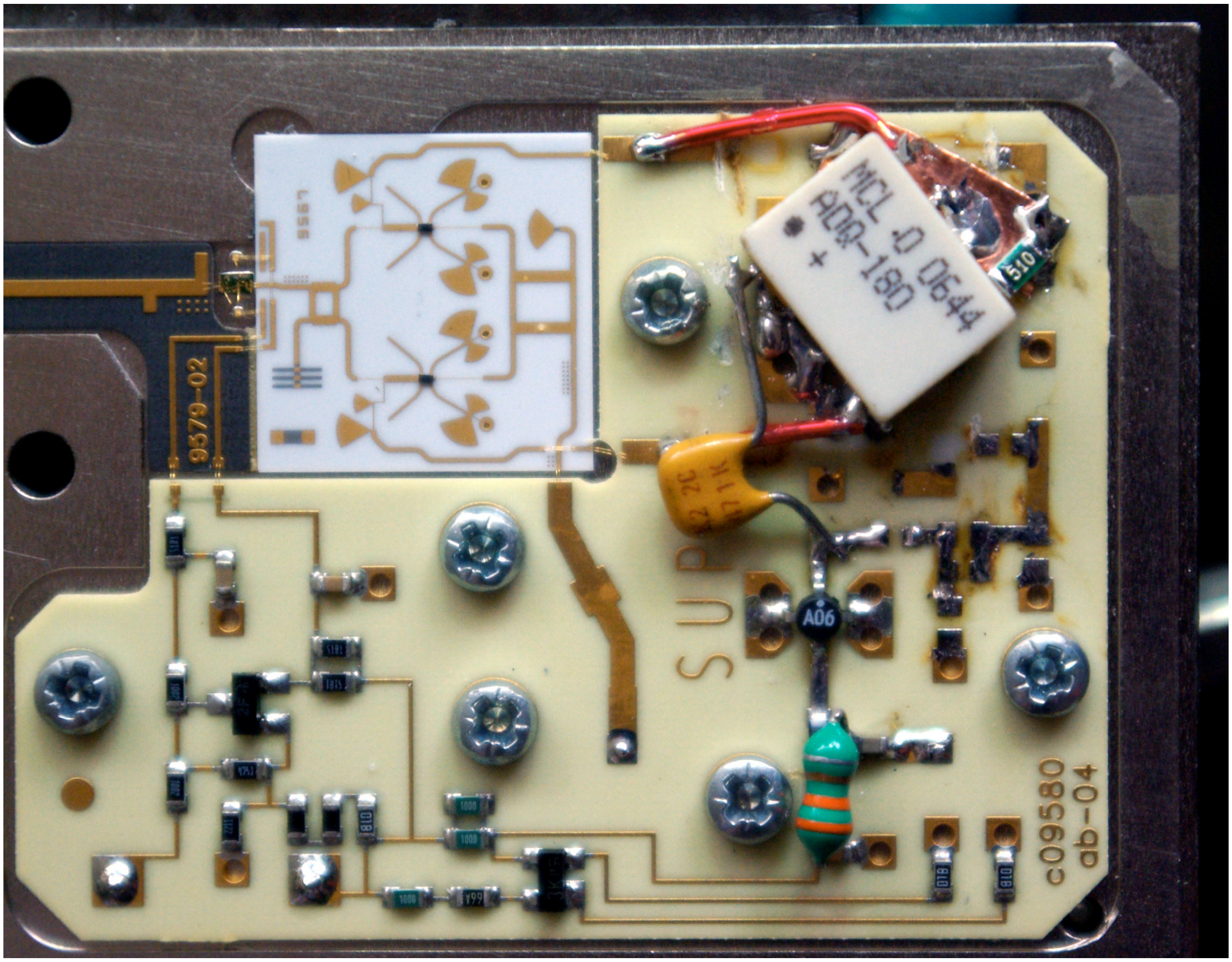

Figure 4 Complete 144MHz IF modification

Test results with 144MHz IF

Wanted RF 24048MHz
Image 23760MHz
LO/2 Input 11952MHz

Subharmonic test-frequency pairings
961.92 / 950.4 (*25)
801.6 / 792 (*30)
668 / 660 (*36)

Average of measured unwanted sideband rejection at 1296MHz 12dB

Again, not a brilliant value of sideband rejection, but probably adequate to remove most of the sideband noise, and it does allow the popular 144MHz IF.