Radiant Broadband Wireless Access Network

Radiant Networks MESHWORKS™ Outdoor Unit – Operational Description

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Status: Issue 2.1
Date: 15 August 2002

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Version	Author	Date	Comments
1.0	A F Hare	9-Aug-02	Contents previously issued in separate docs.
2.0	A F Hare	12-Aug-02	Synthesizer section updated
2.1	A F Hare	15-Aug-02	Channel list re-formatted (see Sec 1.4)

CONTENTS

1 Introduction

1.1 Scope

This document provides a summary of the overall operation of the ODU sub-system of the Radiant Networks Broadband Radio Access Network.

Radome, providing environmental protection to a stack of four drums, each carrying an antenna and capable of rotating independently. Note that rotation only occurs during mesh set-up. Two drums also carry the two transmit/receive modules.

Electronics module, containing:

IF Processor (o/p 4070.5 MHz)

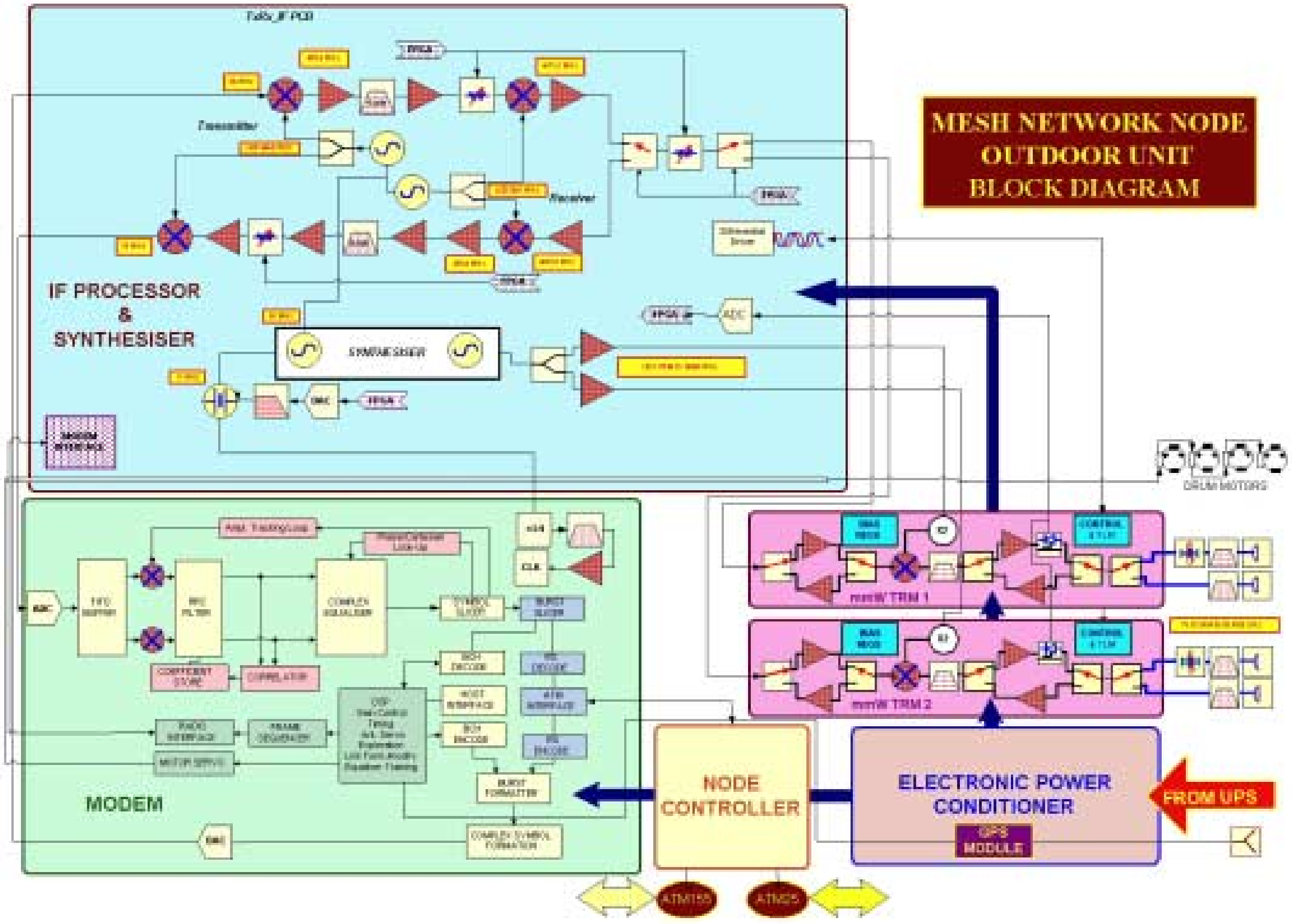
Synthesiser, defining channels (o/p around 12GHz)

Electronic Power Controller, converting 48V DC

Modem (this board includes time-slot framing)

Node Controller, providing interface between management system and node, an ATM switch, data buffering, and all node i/o eg ATM25, ATM155

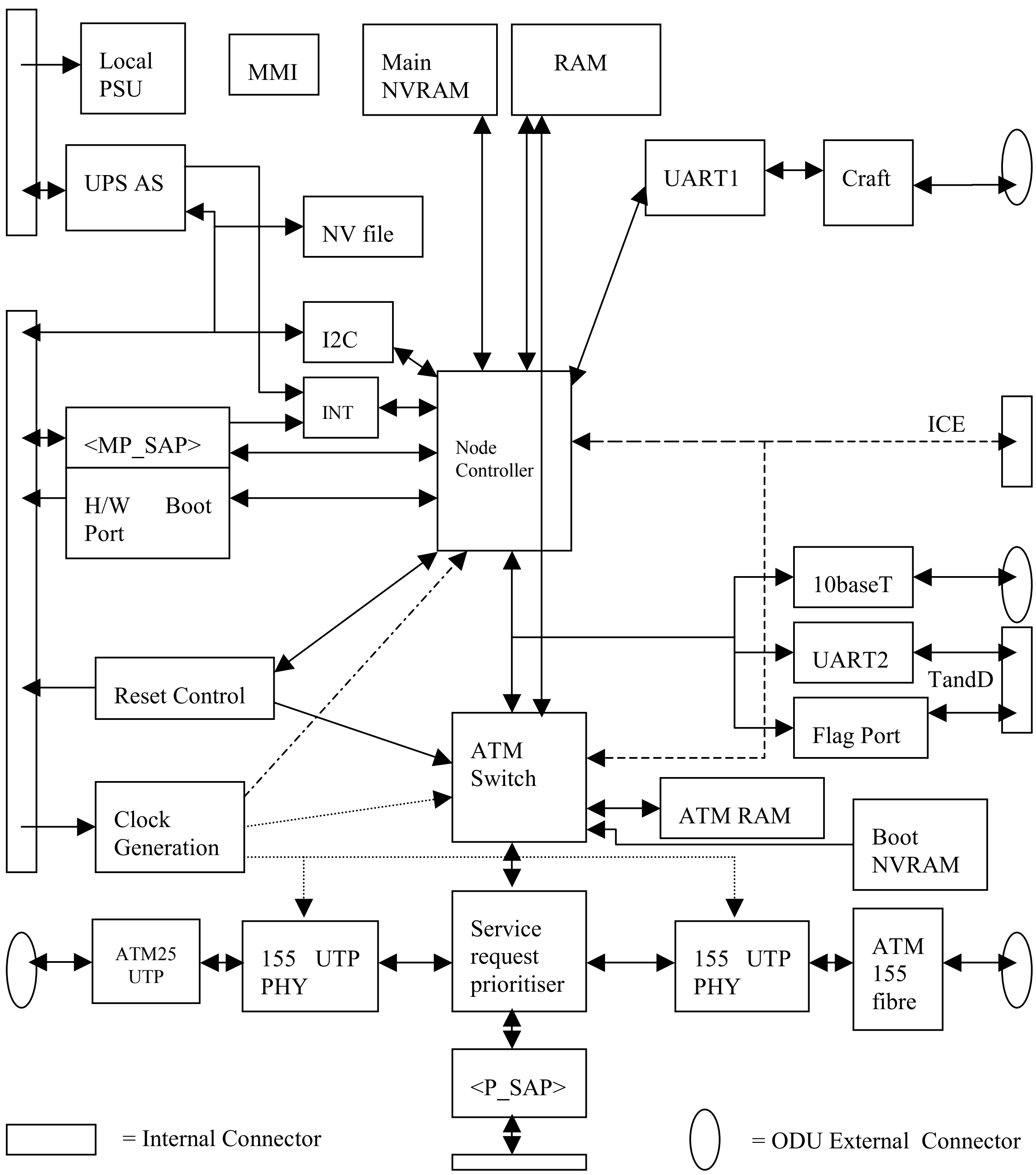
Although much of the detail here is focussed on European regulations, the wider requirements of other markets have been taken into account. In particular, the ODU has been designed to be compliant with the FCC (USA) requirements, especially those for the Local Multipoint Distribution Service (LMDS) - FCC CFR47 part 101. This includes ensuring compliance with radiated emissions up to 100GHz.


MESH NETWORK NODE
OUTDOOR UNIT
BLOCK DIAGRAM
IF PROCESSOR
&
SYNTHESISER
Transmitter
Receiver
SYNTHESISER
FPGA
ADC
DAC
MODEM
FIFO BUFFER
RRC FILTER
COMPLEX EQUALISER
COEFFICIENT STORE
CORRELATOR
SYMBOL SLICER
BURST SLICER
BCH DECODE
RS DECODE
HOST INTERFACE
ATM INTERFACE
BCH ENCODE
RS ENCODE
RADIO INTERFACE
FRAME SEQUENCER
MOTOR SERVO
BURST FORMATTER
COMPLEX SYMBOL FORMATION
DRUM MOTORS
mmW TRM 1
mmW TRM 2
NODE
CONTROLLER
ELECTRONIC POWER
CONDITIONER
GPS
MODULE
FROM UPS
ATM155
ATM25

1.2 Node Controller

The Node Controller carries out, ATM cell switching, configuration management, control, and monitoring functions within the ODU. Block diagram:

The Node Controller carries all the input connectors, either directly: ODU supply input, typically from the UPS; UPS status lines; ATM25 and craft terminal, or indirectly, via daughter boards: ATM155 optical interface and Ethernet & RS232. Functional diagram:



This Node Cotroller is responsible for management of the ODU. It carries out the following activities at the hardware level –

- Ensures that all other blocks within the ODU are reset after power up.
- Obtains configuration and build status from each individual card's NV File.
- Checks the compatibility of all the ODU cards with its program and FPGA configuration files.
- Controls ODU power up self test.
- Configures the FPGAs.
- Monitors the temperature within the ODU at critical points on the cards.
- Monitors the state of the UPS via its alarms port, UPS AS.
- Communicates with the external Craft terminal.
- Configures and controls the ATM Switch processors.
- Controls the Modem and receives status messages from it via the <MP_SAP>.

1.2.1 ATM Switch

The processor in the ATM Switch is responsible for routing traffic between the following.

- External 25Mbs^{-1} interface.
- External 155Mbs^{-1} interface.
- Modem <P_SAP> interface.

Transfer requests from these ports to the switch are controlled by the service request prioritiser.

1.2.2 Boot NVRAM

Primarily used during development to allow code to be loaded from Ethernet rather than the main NVRAM.

1.2.3 ATM RAM

The ATM Switch processor executes from this RAM area. ATM cells are queued in the large shared NC RAM.

1.2.4 Main NVRAM

This is where the main application code images are stored. This includes code to run on the Node Controller, ATM Switch, Modem DSP, and FPGA configuration data for the Modem card, IF card, and NC card. Sufficient space is provided for 2 complete sets in such a way that writing over one image does not affect the other.

1.2.5 RAM

The Node Controller and ATM switch share this volatile storage area. Node Controller code is expanded from NVRAM and placed in this area for it to execute from. The ATM Switch processors code is not in here but in ATM RAM. However the ATM Switch places ATM Cells in this area giving rise to a significant storage requirement.

1.2.6 Local PSU

This block is responsible for filtering the DC coming from the power supply card and attenuating any transient current demands by the NC. It regulates down to the locally required supply rails that are not generated on the PSU Card.

1.2.7 UPS AS

This block indicates that the means of signalling the site UPS alarms and the ODU DC/DC converter alarms is via messages on the I2C bus. An interrupt is raised at every alarm condition.

1.2.8 I2C

This is a serial interface that allows the Node Controller to carry out the following.

- Read manufacturing information such as the build status, serial number, and configuration parameters, from each card in the ODU.
- Monitor temperature at critical locations.
- Read the alarm condition being flagged by the power supply card.

It is a single master implementation of I2C, and is compatible with SMBus.

1.2.9 NV file

This is a serial EEPROM or serial flash device that connects to the I2C bus. It is programmed at manufacture with information about the board that must stay with it. This may include such things as –

- Serial number,
- Variant number,
- Type or size of programmable logic devices,
- Modification status,
- Operating temperature range

1.2.10 INT

This block takes in the edge triggered frame interrupt from the Modem card, via <MP_SAP>, and translates it into a level sensitive interrupt for presentation to the Node Controller. The alarms interrupt from the power supply card is also shown - his is already level sensitive.

1.2.11 <MP_SAP>

The messages for this logical interface are transported over a non-multiplexed 8 bit data bus. Note that the bus is also used on the NC to interface to the ATM PHYs.

1.2.12 H/W Boot Port

This port, a 6 pin serial interface, allows the Node Controller to configure the FPGAs on the Modem card.

1.2.13 Reset Control

At NC power up a reset signal is sent to the ATM switch, Node Controller, UARTs, Flag port, and separate resets are sent to the PHYs', service request prioritiser, and Modem card. The latter reset must also pass through the Modem card to hold any RF circuits inactive. The resets to the PHYs', service request prioritiser, and Modem card are held asserted until the Node Controller clears them.

The Node Controller is able to individually reset, and enable, each of: the Modem card (and thereby the RF cards and GPS unit); Service request prioritiser; and each individual PHY.

1.2.14 Clock Generation

This function block takes in the 4 x symbol rate clock from the Modem card and generates the clocks required for the circuits on the NC. The clocks required are 19.44MHz for the PHYs and 20MHz for the Node Controller and ATM switch.

1.2.15 Craft Interface

This RS232 data link is optically isolated, in order to reject ground potential differences and common mode pick up in the cabling.

1.2.16 UART1/2

This UART1 supports the craft interface. In order to reduce the loading affect on the Node Controller and the shared RAM bandwidth the UART has FIFO buffering. UART2 is used for development debug and manufacturing test.

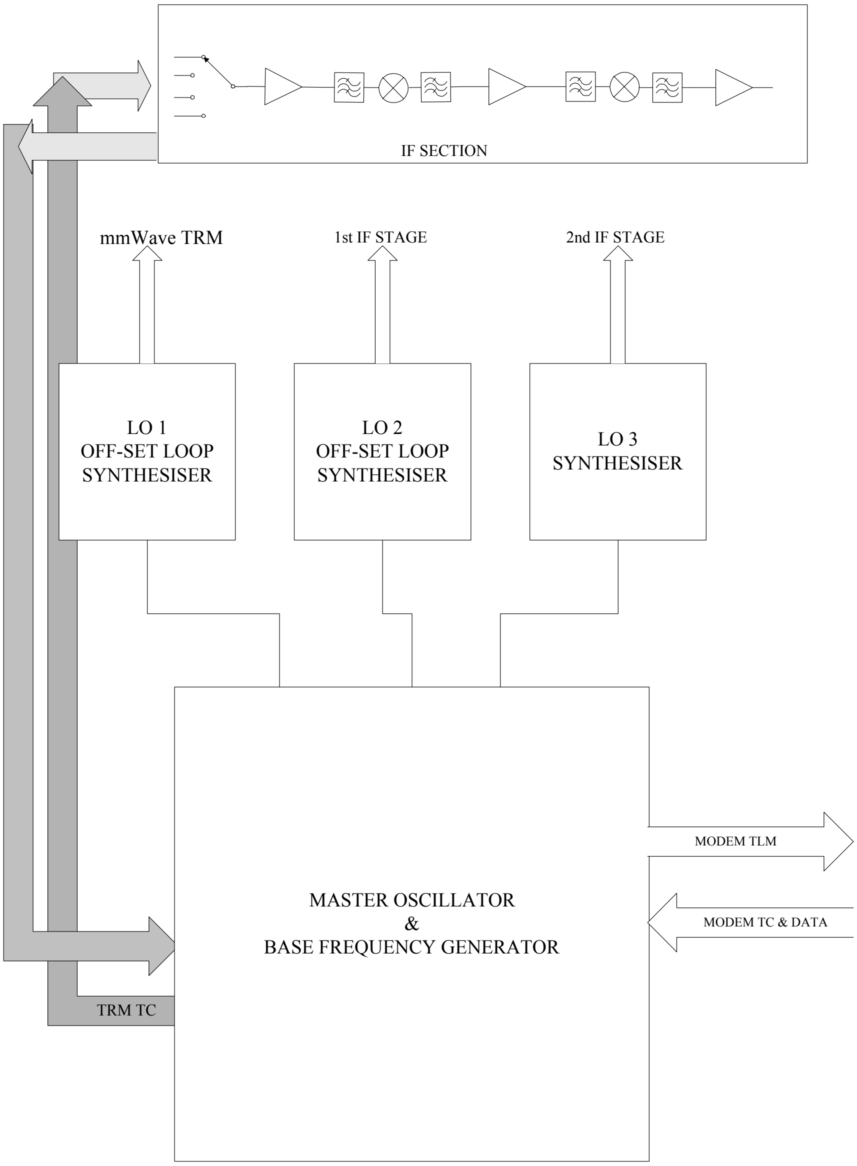
1.2.17 Flag port

A number of LVTTL input and output signals are provided to allow simple signalling between the NC and other equipment via the TandD interface during debug. Both the Node Controller and the ATM switch have access to this port.

1.2.18 155 UTP PHY

These devices interface between the ATM switch and the external data ports.

1.3 IF Processor



Top level IFP and Synthesizer functional block diagram

1.3.1 Transmit IF Up-Converter

The Transmit IF Up-converter takes a 35MHz IF signal from the Modem and translate this to the nominal 4GHz IF frequency required to drive the two transmit/receive mm-wave modules. The bulk of the filtering action of the up-converter is provided by a custom designed SAW filter situated at an IF frequency of 479.5 MHz. Other filters are included in the line-up to provide the required spurious suppression.

The frequency plan of the up-converter therefore consists of an input IF of 35 MHz, translated to an IF of 479.5 MHz and then further translated to 4 GHz.

The gain of the transmit strip is adjustable in such a way as to provide an accurately controlled IF drive signal to the mm-wave module and also to enable variations in this (mm-wave module) to be compensated for. The gain control elements are positioned in the line-up in order to maintain high linearity and low noise in the various gain states. The IF strip includes additional gain control dynamic range in order to compensate for the likely variations in the mm-wave module gain over temperature etc.

1.3.1.1 Spurious Outputs

The SAW filter is used in both transmit and receive paths. Most of the close-in spectral shaping of the transmit signal is performed digitally within the modem and so the responsibility of the IF module is to maintain this close-in spectral shape (by removing internally generated unwanted signals) and to add to the rejection further out.

1.3.1.2 First Conversion

The first transmit mixer takes the IF produced by the DAC and converts it up to 479.5 MHz. A 140 MHz sampling rate has been chosen and the IF is at 35 MHz. Provision has been made for suppressing image and alias signals.

1.3.1.3 SAW Filter

The table and figure below defines the 479.5 MHz SAW filter for the transmit strip only taking into account the fact that some of the artefacts likely are modulated signals i.e. occupying a channel bandwidth

Frequency	Attenuation relative to passband
325.5 - 353.5 MHz	40 dB
395.5 - 423.5 MHz	50 dB
444.5 MHz	40 dB
535.5 - 563.5 MHz	40 dB

Table 1-1 SAW Filter Response Template

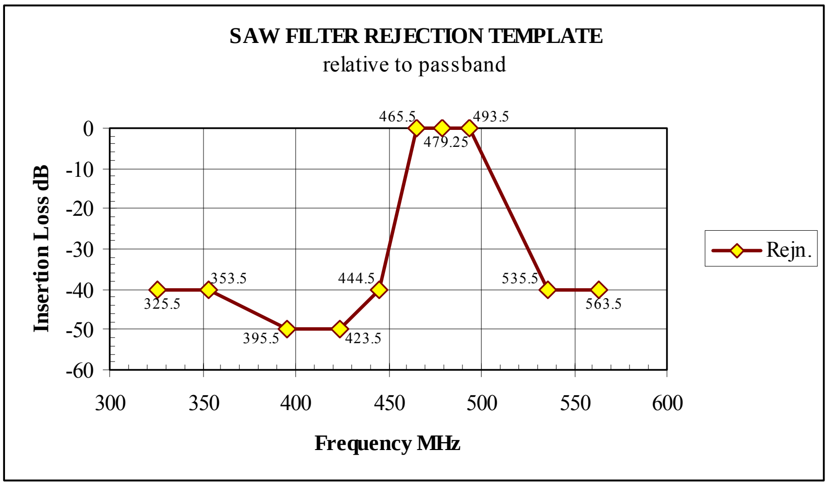


Figure 1-1 SAW Filter Response Template

1.3.1.4 Anti-alias filters

Higher aliases are removed by a filter in the 35 MHz IF with the following performance:

Signal mechanism	Frequency	Output level (ZOH)	Additional Filtering	Level rel. to IF
Main IF output	35 MHz	-0.912 dB	0 dB	0 dB
First Alias	105 MHz	-10.5 dB	10 dB	-20 dBc
Second Alias	175 MHz	-14.8 dB	20 dB	-33 dBc
Third Alias	245 MHz	-17.8 dB	20 dB	-36 dBc
Fourth Alias	315 MHz	-20 dB	30 dB	-49 dBc
Fifth Alias	385 MHz	-21.7 dB	30 dB	-50 dBc
Sixth Alias	455 MHz	-23.2 dB	40 dB	-60 dBc
Seventh Alias	525 MHz	-24.4 dB	40 dB	-60 dBc

Table 1-2 Post DAC Anti Alias Filtering Requirements

1.3.2 Second Conversion

The second conversion from 479.5 MHz to 4067 MHz (Band I) or 4070.5 MHz (Band II) produces further spurious outputs which are suppressed by two filter elements.

1.3.3 Passband Response

The passband of the complete up-converter has a flat amplitude response and a linear phase characteristic in order to avoid introducing modulation distortion, particularly in QAM64 mode. The SAW filter is the major contributor to such distortion.

The following parameters are met at all power control settings.

1.3.3.1 SAW Filter

Passband amplitude ripple $F_0 \pm 10$ MHz	±0.5 dB
Passband phase ripple $F_0 \pm 10$ MHz	$\pm 3^O$

Table 1-3 SAW Filter In-Band Response

1.3.4 Total strip

Parameter	Bandwidth	Requirement
Passband amplitude ripple	$F_0 \pm 10$ MHz	±0.8 dB
Passband amplitude ripple	$F_0 \pm 14$ MHz	±1.5 dB
Passband phase ripple	$F_0 \pm 10$ MHz	$\pm 5^O$
Passband phase ripple	$F_0 \pm 14$ MHz	$\pm 10^O$

Table 1-4 IF Strip Overall In-Band Frequency Response

1.3.5 Output power

The IF module provides two input/output ports which are connected to two transmit/receive mm-wave modules (aka TRMs). Each TRM provides a nominal 41 dB of gain and to give a mm-wave output power in the range -12 to +18 dBm. The IF module takes account of various losses and gain variation (over temperature & across frequency) by providing an output in the range -60 dBm to -10 dBm.

Coarse gain control steps are provided within the IF module to adjust the transmitter output power and to compensate for variations in the total gain of the strip. Fine gain control is provided by the modem in the form of adjustments to the input level. Facilities have been provided to remove unit to unit gain variation using SOT pads incorporated into the IF Module design. This adjustment will only be set by the OEM at the factory, and is not intended to be accessible in the field.

1.3.5.1 Gain control steps

Gain control steps are provided to allow for the transmitter output power range, the gain variation in the mm-wave module and the gain variation in the IF module. As a result extra gain steps are added at the top & bottom of the dynamic range to ensure that IF module gain variation (say ±3 dB) does not prevent attainment of the required output level.

1.4 Synthesizer

The Radiant broadband access system uses mm-wave radio links that form the backbone for data payloads. These RF links require a Digital Modem, Up / Down conversion Tx/Rx IF paths and Frequency Source module (Synthesizer). The frequency source generates the agile Local Oscillator, which drives the mm-wave module Up/Down Converter. The equipment is required to operate in the frequency band 27.5625GHz to 29.4385GHz (Band II) on a 28MHz grid. The channel table will be found on the next page. **For LMDS operation in the USA, the channel table will be restricted to the channels indicated.** Each node is configured with a channel list, further restricting transmission to a subset of the licensed channels.

The assembly consists of an indirect second order type two phase locked loop topology and auxiliary multiplier array. A Voltage Controlled Oscillator tuning from 5.8GHz to 6.4GHz (Band II) is at the core of the main loop followed by fixed times by two multiplier. The VCO is maintained in phase lock, via loop error signal derived from stable reference source of 10MHz. The frequency accuracy of this reference is temperature controlled and electrically trimmed by the reception of standard via GPS. The loop error signal of the main Synthesizer loop is derived by the comparison of a 14MHz signal, which tracks the 10MHz reference source and the pre-scaled VCO via loop ÷N. The main loop ÷N is programmed for the necessary channel allocation requirements via Field Programmable Gate Array. The resultant derived error signal from the Phase Frequency Comparator feeds a programmable Charge Pump and via loop filter controls the VCO set output frequency.

Due to the non-linear aspects within the main synthesizer, a calibration arrangement maintains loop optimisation. Loop Gain Control is used to maintain the second order loop corner at 1.5MHz, for the selected frequency from sampled data embedded within the FPGA image. In contrast, the Acquisition Control aid is given an initial profile based on sampled data, but then learns from the specific VCO response, maintaining fast switching time over operating band with temperature. The wide loop bandwidth in conjunction with loop pre-tuning ensures agility, good Single Side Band Phase Noise performance and reduction to micro-phoney sources.

The Synthesizer frequency coverage produces the Local Oscillator drive to the mm-wave module covering 11.746GHz to 12.684GHz for Band II. This consists of 68 channels on a 14MHz grid, forming a lower and upper band of 32 channels with 4 guard channels placed at mid range (see table on next page).

The complete IFP and Synthesizer board assemblies are mounted in a screen enclosure consisting of milled aluminium box with lid. Both the IFP and Synthesizer boards have surface mounted components mounted on top and underside. The IFP underside components have defined areas individually screened from adjacent circuitry by welled areas in the bottom of milled mating enclosure.

The Synthesizer board assembly is mounted on the opposite side of enclosure with the RF surface facing towards side mounting panel. Individually defined welled areas in this side of enclosure screen the RF circuits from adjacent circuitry.

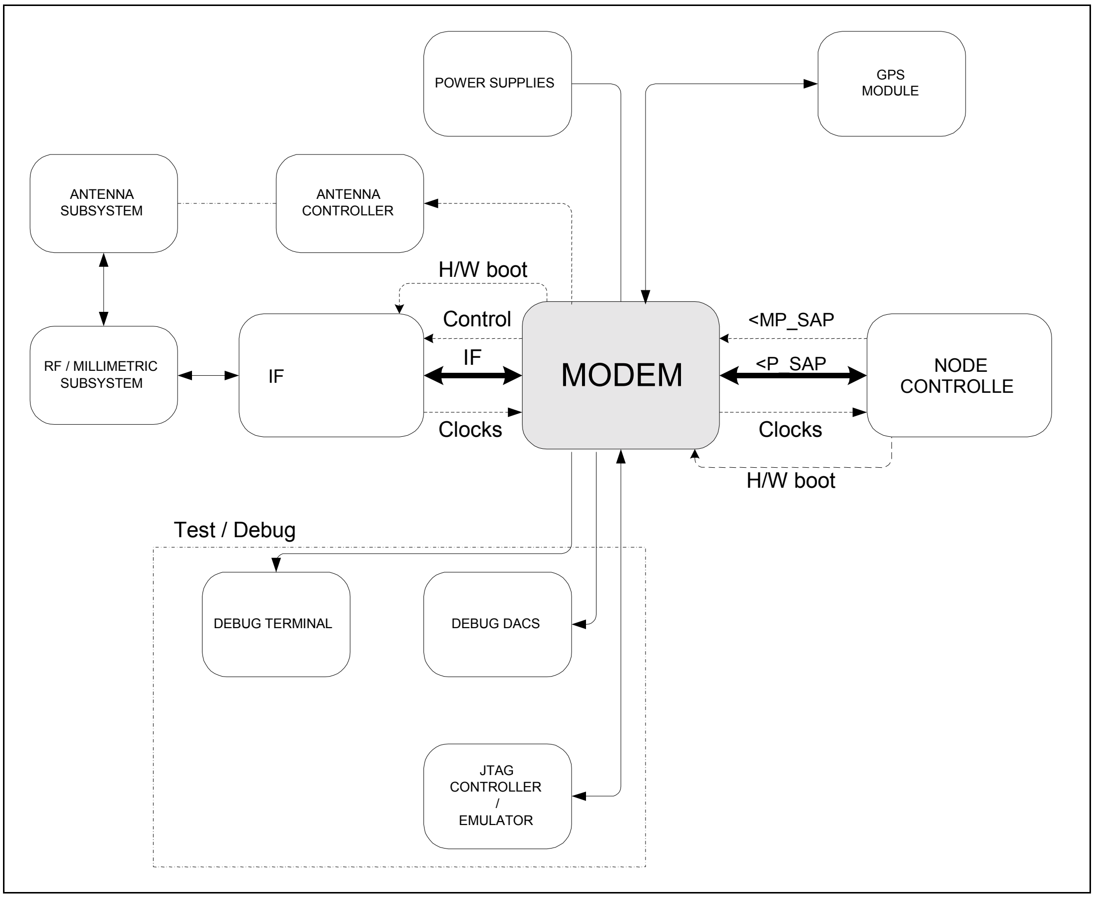
This overall mechanical arrangement enhances the EMC/RFI performance of inter-stage topologies for both the IFP and Synthesizer assemblies.

CEPT Chan. No.	Synth Frequency (GHz)	Chan. Frequency (GHz)	Notes
		*27.5625+0.028*n*	
1	11.7460	27.5625	LMDS
2	11.7600	27.5905	LMDS
3	11.7740	27.6185	LMDS
4	11.7880	27.6465	LMDS
5	11.8020	27.6745	LMDS
6	11.8160	27.7025	LMDS
7	11.8300	27.7305	LMDS
8	11.8440	27.7585	LMDS
9	11.8580	27.7865	LMDS
10	11.8720	27.8145	LMDS
11	11.8860	27.8425	LMDS
12	11.9000	27.8705	LMDS
13	11.9140	27.8985	LMDS
14	11.9280	27.9265	LMDS
15	11.9420	27.9545	LMDS
16	11.9560	27.9825	LMDS
17	11.9700	28.0105	LMDS
18	11.9840	28.0385	LMDS
19	11.9980	28.0665	LMDS
20	12.0120	28.0945	LMDS
21	12.0260	28.1225	LMDS
22	12.0400	28.1505	LMDS
23	12.0540	28.1785	LMDS
24	12.0680	28.2065	LMDS
25	12.0820	28.2345	LMDS
26	12.0960	28.2625	LMDS
27	12.1100	28.2905	LMDS
28	12.1240	28.3185	
29	12.1380	28.3465	
30	12.1520	28.3745	
31	12.1660	28.4025	
32	12.1800	28.4305	
CEPT Guard Band	12.194	28.4585	
CEPT Guard Band	12.208	28.4865	
CEPT Guard Band	12.222	28.5145	
CEPT Guard Band	12.236	28.5425	

CEPT Chan. No.	Synth Frequency (GHz)	Chan. Frequency (GHz)	Notes
		*27.5625+0.028*n*	
1'	12.2500	28.5705	
2'	12.2640	28.5985	
3'	12.2780	28.6265	
4'	12.2920	28.6545	
5'	12.3060	28.6825	
6'	12.3200	28.7105	
7'	12.3340	28.7385	
8'	12.3480	28.7665	
9'	12.3620	28.7945	
10'	12.3760	28.8225	
11'	12.3900	28.8505	
12'	12.4040	28.8785	
13'	12.4180	28.9065	
14'	12.4320	28.9345	
15'	12.4460	28.9625	
16'	12.4600	28.9905	
17'	12.4740	29.0185	
18'	12.4880	29.0465	
19'	12.5020	29.0745	
20'	12.5160	29.1025	
21'	12.5300	29.1305	
22'	12.5440	29.1585	
23'	12.5580	29.1865	
24'	12.5720	29.2145	
25'	12.5860	29.2425	
26'	12.6000	29.2705	
27'	12.6140	29.2985	
28'	12.6280	29.3265	
29'	12.6420	29.3545	
30'	12.6560	29.3825	
31'	12.6700	29.4105	
32'	12.6840	29.4385	

1.5 Modem

Interfaces between the modem and other sub-modules within the ODU:



“Modem” is a misnomer in that the board has many other functions. The main functions are:

- fundamental modem operations of modulation and demodulation
- coding
- implementation of the TDM structure
- link formation and recolouring
- link maintenance : gain, timing and frequency control
- transport of system clock capable of supporting CES

The modem has an intimate understanding of links at the physical layer, but has little comprehension of higher level constructs.

1.6 DC Power Board – the Electronic Power Conditioner (EPC)

The EPC provides the DC power rails for all the electronics in the ODU, in the electronics module and antenna stack. Typically, it is fed with 55V from a remote, mains driven, supply with a 48V battery for back-up in case of mains failure.

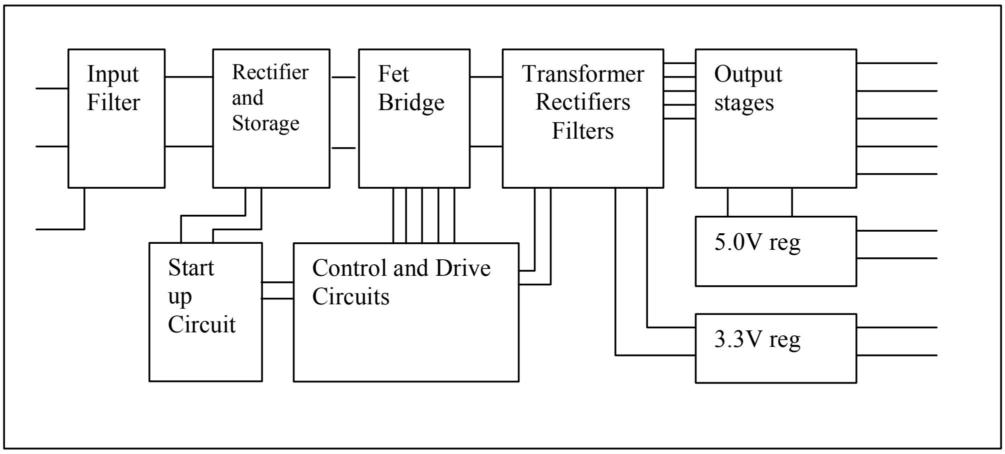
The outputs from the EPC are as in the table below:-

V OUT	I OUT @ 100%	Voltage Regulation, all causes	Load Range	Max. Voltage at 0% load
+3.3V	8A	+/-2.5%	0%-100%	+3.4V
+5.0V	0.4A	+/-2.5%	0% - 100%	+5.25V
+6.5V	8A	+/-10%	20%-100%	+10V
-8.0V	0.6A	+/-10%	50%-100%	-12V
+13.5V	0.5A	+/-10%	50%-100%	+16V
+24V	0.2A	+/-20%	0%-100%	30V

Output ripple and noise 100mV Peak to Peak maximum.

All outputs are to be short circuit protected.

The EPC was designed to work over a wide load range and is quite capable of delivering a total of 100 watts. The current ODU requires about 50 watts. Factory tests take account of this, testing all outputs at typical load values, as well as extremes. EPC block diagram:



The ODU is normally fed with 55.4V from a UPS down a length of cable with significant resistance. In the event of mains failure to the UPS then power is supplied from its 48V battery whose output voltage at the end of discharge might be down to 42V. As the EPC takes in roughly constant power with input voltage then as this falls the input current rises. The EPC is therefore designed to run down to 34V i/p to allow for significant cable voltage drop.

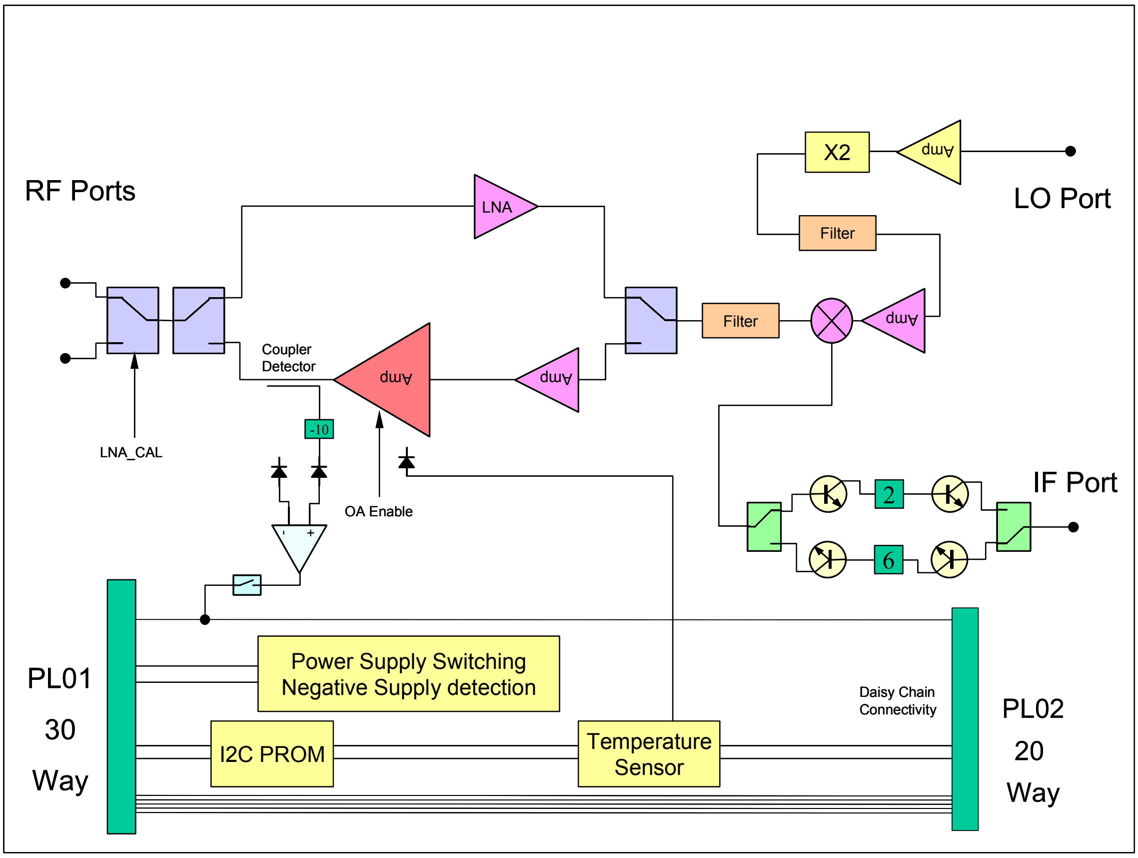
The circuit consists of a full bridge converter with feedback and control taken from the auxiliary rail. Most of the outputs are therefore semi-regulated except for the +3.3V output, which has its own buck regulator.

The bridge circuit is a current mode control, zero voltage switching circuit. The maximum current set for the bridge therefore limits the output power. Output short circuit protection on four of the outputs is provided by Polyswitches, on the 6.5V output an extra current sense transformer progressively shuts down the main convertor if the setting is exceeded and the 3.3V o/p has its own active current limit.

The input circuitry of this supply has been kept floating to allow connection of either input to ground.

1.7 Transmit/Receive Module

The IF/Synthesizer module provides four input/output ports which are connected to two transmit/receive modules located in the drum stack in the radome, each TRM feeding two antennas. The millimetric T/R module is essentially a bi-directional amplifier and frequency converter as shown in the functionality block diagram in, the module is shown in receive mode.



Transmit: The 4070.5 MHz IF enters through a coaxial interface and is routed to the transmit path via a T/R switch. The channelised LO from the Synthesizer ("LO/2") is doubled in the TRM and then used to up-convert the IF signal, which is then amplified before passing through another T/R switch and antenna diversity switch to exit via one of the two waveguide interfaces. A transmit monitor is used during high power calibration to measure the output power but is not used at the low end of the input dynamic range. The receive amplifiers may be turned off during the transmit time-slot to improve isolation.

Receive: RF (~28 GHz) enters the module via one of the waveguide interfaces and is routed to the Low Noise Amplifier in the receive path by the antenna diversity and T/R switches. The signal is down-converted to IF, passes through another T/R switch to the coaxial output. The transmit amplifiers are turned off during the receive time-slot to improve isolation.

Frequency converters: Both converters include image and mixer product filtering as well as driver amplifiers where required. Two separate converters are shown for simplicity.

Local Oscillator: The LO is supplied via a coaxial interface, at half the frequency needed for the conversion, and passes into a frequency doubler.

The ODU is designed to maximize circuit re-use for different frequency bands. To achieve this a fixed IF is used in the millimetric T/R module.

1.7.1 Transmit Performance

1.7.1.1 Frequencies

Frequency	Band 2 (MHz)
IF Input	4,045.5 to 4,095.5
LO/2 Input	11,721.75 to 12,707.75
RF Output = IF + LO	27,500 to 29,500

Table 1-5 Transmit Frequency Plan

The IF signal is a single channel of up to 50MHz. Both transmit and receive operate in the same band (TDD). All specifications apply simultaneously within the same frequency band.

1.7.1.2 LO/2 Power

Half the required local oscillator frequency is available at the LO input to the MM T/R module at a power level of +2dBm +/-2dB.

1.7.1.3 Unwanted Emissions

When a CW signal at IF centre frequency is applied such that the carrier power at output is +20dBm, emissions shall comply with the following spectral masks.

General Spectral Mask	Maximum O/P level
30 to 21200 MHz	-66dBc
21200 to 25000 MHz	-41dBc
25000 to 26700 MHz	-51dBc
26700 to 30400 MHz	-70dBc
30400 to 31500 MHz	-51dBc
31500 to 33000 MHz	-41dBc
33000 to 59000 MHz	-51dBc

Table 1-6 Band 2 Transmit Unwanted Emissions

1.7.1.4 Transmit Monitor

An RF detector is coupled to the transmit power amplifier output, to provide a measure of transmit power. The detector output voltage is amplified and provided at the DC connector. The detector is calibrated by transmitting a known power. Voltage measurements are performed by measuring the difference between V_{OUT} with RF_{ON} and V_{OUT} with RF_{OFF}. In this way detector offsets are removed and the detector calibrated. Note that the known power is achieved by storing calibration data within the TRM during manufacture.

1.7.2 Receive Mode

1.7.2.1 Frequencies

Frequency	Band 2 (MHz)
RF Input	27,500 to 29,500
LO/2 Input	11,721.75 to 12,707.75
IF Output = RF-LO	4,045.5 to 4,095.5

Table 1-7 Receive Frequency Plan

The IF signal is a single channel of up to 50MHz.

All specifications apply simultaneously within the same frequency band.

1.7.2.2 RF Input power Levels

The normal input power range is -30dBm to –81dBm, the nominal operating point is –31dBm. An input overdrive power level of +10dBm will cause no damage.

1.7.2.3 Noise Figure

Noise Figure measured from waveguide input to IF output is less than 9dB over the whole frequency band and temperature range.

1.7.2.4 Unwanted Emissions

When a –23dBm CW RF carrier is applied in combination with the correct CW LO to produce an output at the IF centre frequency, unwanted emissions comply with the following spectral masks.

General Spectral Mask	Maximum O/P level
30 to 3500 MHz	-30dBc
3500 to 4460 MHz	-70dBc
4600 to 50000 MHz	-30dBc

Table 1-8 Receive Unwanted Emissions at IF Port

1.7.2.5 Interfering RF Input Signals

When the performance of a signal in the presence of interference is compared with the performance of the same signal without interference, both the conversion gain and noise floor change by less than 1dB. The interference is described in Table 1-9. The signal shall be any in-band CW RF input signal of –60dBm applied in conjunction with the correct LO to produce an output tone at the IF centre frequency. This specification applies to all valid combinations of RF and LO.

I/P Frequency	I/P power
30 to 27000 MHz	-20dBm
27000 to 30000 MHz	No interfering signal
30000 to 59000 MHz	-20dBm

Table 1-9 Band 2 Receive Input Interfering Signals

1.8 Waveguide Filters

The purpose of the waveguide filter is to augment the filtering offered by the TRM such that the transmit spurious outputs and receive blocking requirements can be met. The waveguide filter is interposed between the TRM output port and the antenna port. A TRM is shared between two antennas. The waveguide filter feeding the lower antenna incorporates a rotary joint, allowing the lower antenna to rotate independently of the upper. In all other respects, the two waveguide filters are identical. The table below summarises the performance achieved for Band 2:

Frequency Band	Minimum rejection
30-21200MHz	> 85dB
21200-24700MHz	> 55dB
24700-26300MHz	> 30dB
26300-27400MHz	> 0dB
27400-29600MHz	Pass-band
29600-30400MHz	> 0dB
30400-31300MHz	> 25dB
31300-33000MHz	> 50dB
33000-50000MHz	> 35dB
50000-60000MHz	> 25dB*

* Met by design

- The maximum insertion loss within the pass-band is 1dB.
- Within the pass-band the maximum amplitude variation shall be 0.5dB pk-pk .
- There is no group delay constraint on this component.
- The minimum return loss in the pass-band of the filter at the waveguide interface is 18dB.

1.9 Antennas

The millimetric stack comprises four stacked drums, each carrying an antenna. Each antenna may be rotated independently of the others. The antenna design is a Ka-band Type 2 plastic twisted reflector, operating in the band 27.5 - 29.5GHz. The antenna is vertically polarized, with a gain of 26.5 +/-1dB.

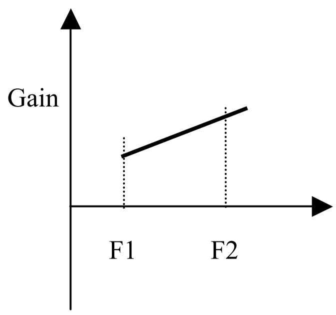
The antenna complies with the following specification:

Azimuth: The azimuth beam width, 2αA at any in-band frequency shall be a minimum of 5 degrees and a maximum of 7 degrees.

Elevation: The elevation beam width, 2αE at any in-band frequency shall be a minimum of 8 degrees and a maximum of 12 degrees.

1.9.1 Gain

The antenna gain of any of the antennas mounted within the radome exceeds the boundaries defined in Table 1-10. The minimum gain levels given in Table 1-10 include any insertion loss introduced by the ODU radome. These figures correspond to maximum radome insertion loss of 1dB. Typical radome insertion loss is 0.5dB or less.



	Frequency	Minimum Gain
Band2, F1	27.5GHz	25.7dBi
Band2, F2	29.5GHz	26.3dBi

Table 1-10 Minimum Gain (antennas within the radome enclosure:quoted gain levels include radome loss)

1.9.2 Cross-Polar Discrimination

The cross-polar discrimination conforms to the boundaries defined in Table 1.11.

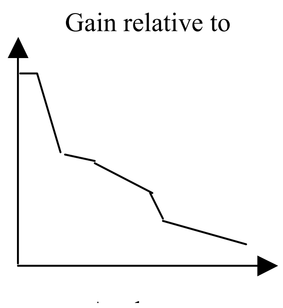
Elevation		Azimuth	
$^{\$}$ Ang	Spec	$^{\$}$Ang	Spec
0	-27	0	-27
$\pm \alpha_E$	-27	$\pm \alpha_A$	-27
$\pm (\alpha_E + 15)$	-30	$\pm (\alpha_A + 15)$	-30
±90	-35	±90	-35
±100	-40	±100	-40
±180	-45	±180	-45

$^{\$}$ $2\alpha_E$ and $2\alpha_A$ are 3dB beam widths in elevation and azimuth planes respectively.

Table 1-11 Cross-polar Discrimination: includes effects of the radome.

1.9.3 Side Lobes

The side lobes conform to the radiation pattern envelopes defined in Table 1-12.



Ref.	Side Lobe (dB)	$^{\$}$ Elevation Angle (°)	$^{\$}$ Azimuth Angle (°)
P0	0	0	0
P1	< 0	$\pm (\alpha_E + 5)$	$\pm (\alpha_A + 5)$
P2	<-20	$\pm (\alpha_E + 15)$	$\pm (\alpha_A + 15)$
P3	<-22	±30	±30
P4	<-30	±90	±90
P5	<-35	±100	±100
P6	<-40	±180	±180

$^{\$}$ $2\alpha_E$ and $2\alpha_A$ are 3dB beam widths in elevation and azimuth planes respectively. See section 2.2.2.

Table 1-12 Radiation Patterns: includes effects of the radome.

1.10 Motor driver board

A motor driver board is located on the back of each antenna. It provides power to the stepper motor located in the same drum, to rotate the drum and antenna. It decodes the (possibly daisy-chained) signals from the Node Controller to determine whether the motor is enabled and how it should be pulsed. The latter involves switching the 24V motor supply.

For drums that support a transmit/receive module (TRM), the board incorporates a feed to a 5V cooling fan. Note that this is activated only when a local temperature sensor exceeds $50^{o}C$.

END OF DOCUMENT