Atacama
Large
Millimeter
Array

North American Front End Integration Center Test and Measurement System Design

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Change Record

Version	Date	Affected Section(s)	Change request #	Reason/remarks
A01	2005-01-18	All	-	First Draft (GAE + KC).
A02	2005-02-14	All	-	Comments from AP.
A03	2005-03-02	various	-	Following comments from HR.
A04	2005-04-28	1.4, 3.4, 3.5, 4	-	Additions from AP.
A05	2005-07-27	Table 1 Various 3.5, Fig 2 Fig 7	-	Addition Japanese bands. Changed frequency ranges of sources to avoid IF. Corrected typos, latest version of figures.
A06	2005-07-29	Fig 4	-	Latest version of figure.
A07	2007-09-07	3.6 and fig 7	-	Update of signal sources for beam measurement phase removal scheme

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1 INTRODUCTION

1.1 Purpose

This document gives an overview of the design of the Front End Test and Measurement System.

1.2 Scope

The following table shows a partial view of the ALMA product tree [AD1] at "module" and "unit" level for the ALMA Front End sub-system products that are to be measured by the Test and Measurement System described in this document. Those products belonging to the FE sub-system that are not to be measured by the system described in this document are clearly identified in Table 1.

Product Tree level 1		***Product Tree level 2***		***Product Tree level 3***		***Remarks***
Product No.	***Product Name***	***Product No.***	***Product Name***	***Product No.***	***Product Name***	
40.00.00.00	Front end					
		40.01.00.00	Warm optics			
		40.02.00.00	Cartridges			
				40.02.01.00	Frequency band 1 cartridge	Not in baseline
				40.02.02.00	Frequency band 2 cartridge	Not in baseline
				40.02.03.00	Frequency band 3 cartridge	
				40.02.04.00	Frequency band 4 cartridge	Japan
				40.02.05.00	Frequency band 5 cartridge	Not in baseline
				40.02.06.00	Frequency band 6 cartridge	
				40.02.07.00	Frequency band 7 cartridge	
				40.02.08.00	Frequency band 8 cartridge	Japan
				40.02.09.00	Frequency band 9 cartridge	
				40.02.10.00	Frequency band 10 cartridge	Not in baseline
		40.03.00.00	Cryostat			
				40.03.01.00	Dewar	
				40.03.02.00	Cryocooler	
				40.03.03.00	Vacuum pumps	
				40.03.04.00	Cryostat electrical infrastructure	

Product Tree level 1		***Product Tree level 2***		***Product Tree level 3***		***Remarks***
Product No.	***Product Name***	***Product No.***	***Product Name***	***Product No.***	***Product Name***	
		40.04.00.00	Front end auxiliary sub-systems			
				40.04.01.00	Front end power supply sub-system	
				40.04.02.00	Bias electronics sub-system	
				40.04.03.00	Front end M&C sub-system	
		40.05.00.00	Front end chassis			
				40.05.01.00	Front end mechanical structure	
				40.05.02.00	Front end cabling	
		40.06.00.00	Front end integrated calibration & widgets			
				40.06.01.00	Vane calibration sub-system	Not to be measured by this system
				40.06.02.00	Solar protection	Not to be measured by this system
				40.06.03.00	Polarisation widgets	Not to be measured by this system
		40.07.00.00	Water vapour radiometer			Not to be measured by this system
		40.08.00.00	Front end IF			
				40.08.01.00	IF switch sub-system	
		40.09.00.00	Front end specific test, construction & service equipment			Not to be measured by this system
				40.09.01.00	SIS mixer fabrication equipment	Not to be measured by this system

Product Tree level 1		***Product Tree level 2***		***Product Tree level 3***		***Remarks***
Product No.	***Product Name***	***Product No.***	***Product Name***	***Product No.***	***Product Name***	
				40.09.02.00	SIS mixer test equipment	Not to be measured by this system
				40.09.03.00	Front end test fixture	Not to be measured by this system
				40.09.04.00	Cartridge test dewars	Not to be measured by this system
				40.09.05.00	Cartridge RF test fixtures	Not to be measured by this system
				40.09.06.00	Front end service vehicle	Not to be measured by this system
		40.10.00.00	First local oscillator			
				40.10.01.00	First LO frequency sources	
				40.10.02.00	Warm frequency multipliers	
				40.10.03.00	First LO PLL unit	
				40.10.04.00	Band selection	
				40.10.05.00	First LO interconnects	
		40.11.00.00	Warm Cartridge Assembly			

Table 1

1.3 Applicable documents

The following documents are included as part of this document to the extent specified herein. If not explicitly stated differently, the latest issue of the document is valid.

Reference	*Document title*	*Date*	*Document ID*
[AD1]	ALMA Product Tree	2004-01-26	ALMA-80.03.00.00-001-M-LIS
[AD2]	ALMA Environmental Specification	2003-12-14	ALMA-80.05.02.00-001-B-SPE
[AD3]	ALMA System: Electromagnetic Compatibility (EMC) Requirements	2003-12-12	ALMA-80.05.01.00-001-B-SPE
[AD4]	ICD between Antenna and Front End	2003-11-26	ALMA-34.00.00.00- 40.00.00.00-B-ICD
[AD5]	ICD between Front End/WVR and Back End/LO & Time	2003-10-07	ALMA-40.07.00.00 -50.03.00.00-A-ICD

	Reference		
[AD6]	ICD between Front End/IF and Back End/IF Downconverter	2003-10-10	ALMA-40.08.00.00 -50.01.01.00-A-ICD
[AD7]	ICD between Front End and Computing/Control software	2003-09-26	ALMA-40.00.00.00 -70.35.25.00-A-ICD
[AD8]	ICD between Front End/Cryostat and Computing/Control software	2003-10-01	ALMA-40.03.00.00 -70.35.25.00-A-ICD
[AD9]	ALMA System: Electrical Design Requirements	2003-12-14	ALMA-80.05.00.00-005-C-SPE
[AD10]	ALMA Power Quality (Compatibility Levels) Specification	2003-12-15	ALMA-80.05.00.00-001-C-SPE
[AD11]	Standards for Plugs, Socket-outlets, and Couplers	2003-12-15	ALMA-80.05.00.00-004-B-STD

Table 2

In the event of a conflict between one of the applicable documents referenced above and the contents of this document, the contents of the applicable document shall be considered as a superseding requirement.

1.4 Reference documents

The following documents contain additional information and are referenced in this document.

Reference	*Document title*	*Date*	*Document ID*
[RD1]	List of acronyms and glossary for the ALMA project	2003-04-23	ALMA-80.02.00.00-004-B-LIS
[RD2]	Design of the ALMA Front End System	2004-02-28	FEND-40.00.00.00-029-B-DSN
[RD3]	Front End Test measurement system specifications	2004-09-03	FEND-40.00.00.00-xxx-A-xxx
[RD4]	Specifications for a Tilt Table for the Front End Integration Center	2004-06-30	FEND-40.09.03.00-001-A-SPE
[RD5]	Front End Sub-System for the 64-Antenna Array Technical Specification	2005-04-26	ALMA-40.00.00.00-001-A05-SPE
[RD6]	Front End Test and Measurement System Software Requirements Specification	2005-03-11	FEND-40.09.03.00-004-A-SPE
[RD7]	Front End Test and Measurement System Software Design Description	2005-04-08	FEND-40.09.03.00-005-A-SPE

Table 3

1.5 Acronyms

A limited set of basic acronyms used in this document is given below. A complete set of acronyms used in the ALMA project can be found in reference [RD1].

ALMA	Atacama Large Millimetre Array
DSB	Double-SideBand
EMC	Electro-Magnetic Compatibility
FESS	Front End Support Structure
FETMS	Front End Test and Measurement System
FLOG	First LO Offset Generator
ICD	Interface Control Document
LO	Local Oscillator
RF	Radio Frequency
RFI	Radio Frequency Interference
SSB	Single-SideBand
WVR	Water Vapour Radiometer
2SB	Dual Side Band separating

2 FRONT END DESCRIPTION

2.1 Front End Definition

Front End is a low-noise cryogenically cooled ten-band receiver that converts radio frequencies ranging from 31.3 GHz to 950 GHz to intermediate frequencies in the range from 4 to 12 GHz (see [RD2]).

The Front End sub-system includes:

Cryostat

This accommodates ten band-specific cartridge assemblies and provides cryogenic services. It includes a built-in cooler and its associated compressor and controller. It also provides vacuum services.

Front end chassis

Attached to the cryostat this structure accommodates and protects the front end electronic and support equipment.

Tertiary optics

Attached to the top of the cryostat, these couple the beam from the sub-reflector into each of the ten cartridge assemblies. This includes vacuum windows and infrared blocking filters.

Calibration and other optics

Devices that are placed directly in the input radio beam of the receiver and which include (but are not limited to) a calibration system, components that can be inserted into the beam such as quarter wave plates for the reception of circular polarisation, and attenuators for solar observations.

Water vapour radiometer

Attached to the FESS this is a stand-alone unit used to monitor the atmospheric water vapour.

Cartridge assemblies

There are ten assemblies, each covering a single band. The assemblies include all the components required for the low-noise conversion of the RF signal to the intermediate frequency.

IF switch assembly

This routes and conditions the IF output signals from all the cartridges to the four front end IF output connectors.

Monitor and control assembly

The local monitor and control system allows the remote control of all the Front End functions and provides extensive remote diagnosis capability, with an appropriate interface to the general ALMA Monitor and Control bus.

Local oscillator reference switch assembly

Routes and conditions the optical local-oscillator reference signal to the first local-oscillator chains in each of the cartridge assemblies.

FLOG splitter assembly

Routes and conditions the First LO Offset Generator signal to the first local-oscillator chains in each of the cartridge assemblies.

Power supply

Converts main power supplied by the antenna to clean DC power used in the front end.

The Front end assembly does not include calibration devices located outside the receiver cabin (including any built into the sub-reflector).

The overall system design drawing (current revision G) is located in the system engineering section (80.04) of the ALMA EDM [RD2] .

2.3 Tests to be performed

The overall tests of the front end required to be made by this test system are given in [RD3].

3 FRONT END TEST AND MEASUREMENT SYSTEM COMPONENT DESCRIPTION

A top level diagram of the system is given in Figure 1. It consists of the FE mounted on the tilt mechanism and the components necessary to measure:

1 Noise temperature
2 Sideband ratio
3 Beam patterns (near-field)
4 Phase stability
5 IF pass-band
6 Amplitude stability

The receiver and scanner, on the tilt table, should all be enclosed in a temperature stable environment.

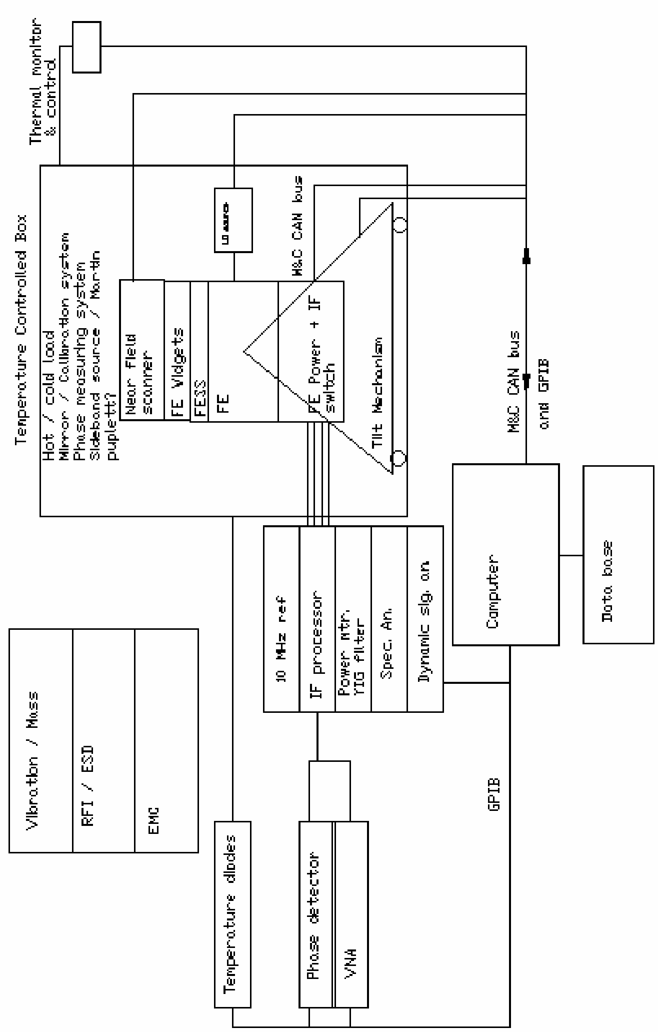


Figure 1 Schematic diagram of the FEIC test and measurement system.

Figure 2 gives a block diagram of the measurement system. It consists of a 10 MHz reference, from an Agilent E8257D-540 synthesizer, which is amplified and split out to drive all the other oscillators. These include the FLOOG which drives the various cartridge LO PLL's, with a phase shifter necessary for the phase stability measurement. The E8257D-540 LO is also tapped off and used to drive a harmonic mixer, on each cartridge LO, for the frequency reference source. These are all shown in the center of the diagram. A second E8257D-540 at the top of the diagram drives the beam measuring range source. This also acts as the source for the phase stability measurements and as a sideband source. As can be seen several sources are needed to operate over all the bands, and will be described further below. A third E8257D-540 (or low frequency equivalent) is used as the low frequency reference for the Vector network analyzer (VNA), which is needed for beam pattern measurements. This synthesizer is internal to the VNA. The E5500 is also used to measure the phase noise of the complete LO (including final multiplier) which will not be performed by the LO group.

These components have been chosen to enable phase stability measurements to be made that are compatible with the LO group's measurement system.

Also shown at the bottom right of the diagram are the components necessary to measure the amplitude stability (Dynamic signal analyzer 35670A), pass-band ripple, interference and general trouble shooting (Spectrum analyzer E4408B), and noise temperature and sideband ratio (Power meter E4418B with E4412A head). The noise temperature measurement needs the hot/cold load and chopper shown at the top right. A Cryotiger system will be used for the cold load to remove the necessity of refilling liquid Nitrogen during the large number of measurements that will need to be made. This will require the design of a small cryostat and RF load, which can be mounted on the near-field range.

Further components would be required if repeated measurements are required for EMC, ESD/RFI and vibration (these will not be necessary if these are only to be measured on the first cartridge at external facilities).

It should be noted that the high frequency cables from the E8257D-540's to the LO and source, the IF cable from the receiver and the low frequency cable from the FLOOG to the PLL must be very phase stable (versus temperature and flexure – due to the tilting of the FE).

One of the major tasks involved with this system is the computer control of all the components to enable, as far as possible, automatic measurements to be made (given the large number of measurements that need to be taken).

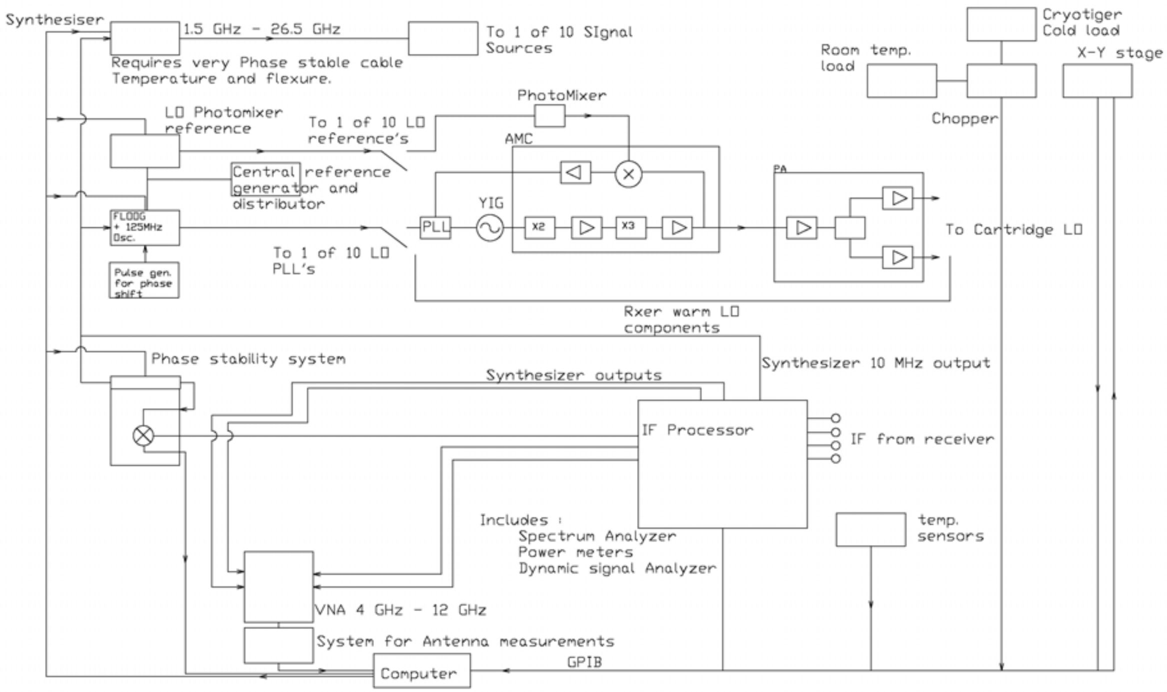


Figure 2 Block diagram of the measurement system.

3.3 IF processor

The components of the IF Processor rack system are shown in Figure 3. The system will consist of the IF Processor chassis and its associated power supply, UPS, computer and monitor, and all necessary test equipment. The test equipment will include an Agilent dynamic signal analyzer (3570A), spectrum analyzer (E4408B) and dual power meters (E4418B/E4412 sensor), signal generator (E8257D), as well as a bank of six controllers (11713A) for setting switch and attenuator configurations in the IF processor chassis. Figure 4 shows a typical rack layout and demonstrates the capacities of the Schroff cabinets (20,000 Series) used. Final component arrangement will be determined by thermal constraints and control accessibility.

The IF processor chassis will handle four simultaneous signal paths: the upper and lower sidebands for each of two polarizations from the receiver band being measured. It was determined that a four-channel processor would provide optimal data throughput versus system cost, as this configuration takes advantage of the commonality of measuring and control systems as well as a several redundant signal paths.

Figure 5 summarizes typical power levels at specified points in the IF processor block diagram, which is shown in Figure 6. The signal level of each channel may be adjusted by means of 0-90 and 0-11dB programmable attenuators so as to present optimum levels to the power meters (typically -30dBm) as well as to the spectrum analyzer and the detector/dynamic signal analyzer combination.

Refer to Figure 6 for a brief description of signal flow through the processor. After cable and line equalizer loses, the IF processor chain will see an input level of approximately -29dB. Coaxial transfer switches can route the input signals directly to the power meters at this point, bypassing the processor chain. Following this, a switching network consisting of low-pass filters at 8 and 12 GHz allows the signals to be routed appropriately to facilitate either 4-8 GHz or 4-12 GHz total power measurements. Otherwise, the low-pass filters may be bypassed. Next, a chain of Miteq amplifiers and Agilent 84904/06K attenuators provide the means of adjusting signal levels to compensate for losses associated with switching functions - such as YIG filters or a second IF down-converter - in and out of the processor path. .

An antenna/phase switching network allows the signal at this point to be routed to a separate receiver system for measuring beam patterns (near-field), as well as phase stability. Following this, 2-18GHz mixers and filter combinations allow the option of converting the IF signal to a 2GHz wide 2nd IF for further power measurements. The local oscillator for these mixers is supplied via an Agilent E8257D signal generator. The output of this generator will be switched as necessary to also supply a reference frequency to a vector network analyzer used in beam and phase measurements. (The E8257D also supplies the 10MHz reference signal which will be used through the front-end test and measurement system.) Following this a pair of dual-tracking YIG filters, 4-12GHz, provide a 15MHz 3dB-bandwidth signal necessary for noise temperature and sideband ratio measurements. The YIG filters will be digitally programmable via a 12-bit TTL bus, which is supplied by an ICS Electronics GPIB-controlled parallel digital bus interface. A set of transfer switches allow the YIG filters to be bypassed.

A final switching network routes the processed signal to either: the dynamic signal analyzer (for amplitude stability), the spectrum analyzer (for pass-band ripple, interference measurements, and general troubleshooting), or power meters (for noise temperature and sideband ration measurements).

An 8743B crystal detector and INA101 video amplifier provide the DC level signal to the dynamic signal analyzer.

The IF processor system will be contained in two 19"wide x 70"high x 36"deep (useable space) enclosed cabinets. The cabinets will be fan-cooled and constructed to present an EMI-shielded cage so as to reduce interference from external sources. Both racks will operate at 230V 50Hz and will be power conditioned by an APC Smart-UPS RT5000VA RM230V. The UPS with battery backup will provide an extended runtime of approximately 40 minutes during power outages, assuming rack power consumption of 2.3 kW. This figure includes the power requirements of a rack-mounted computer and monitor. The IF processor system will be temperature stabilized.

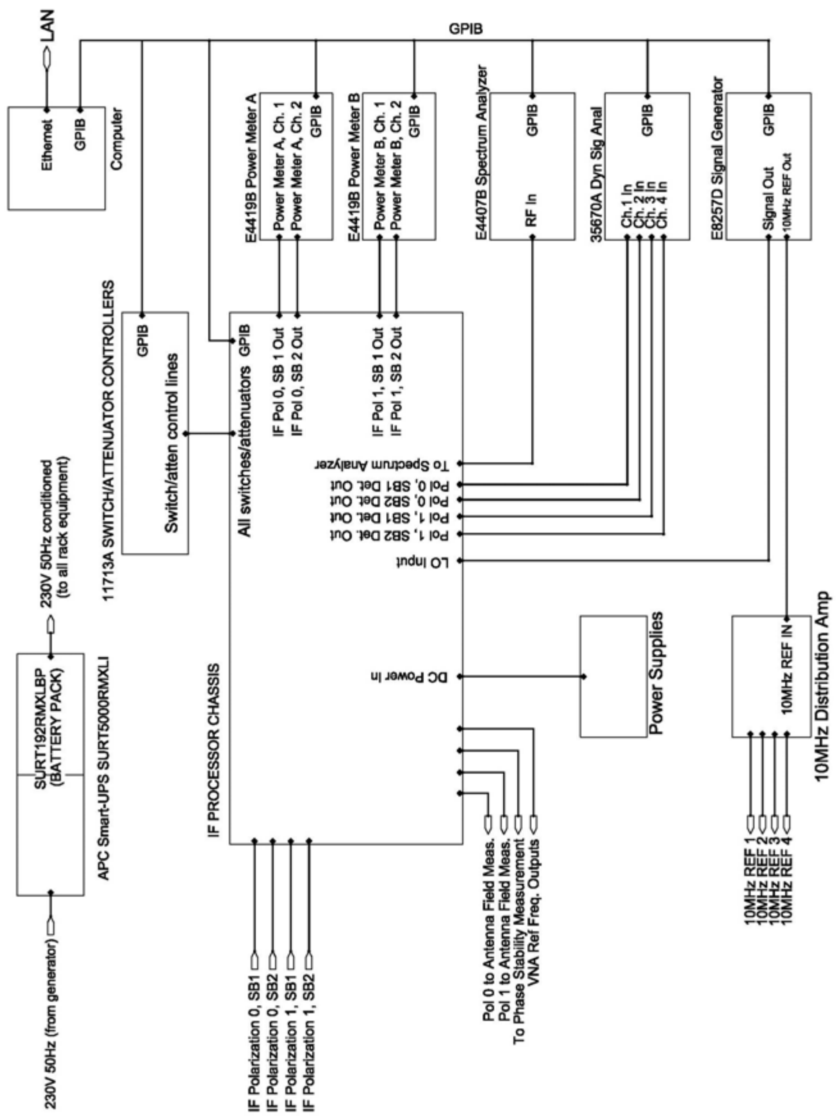


Figure 3

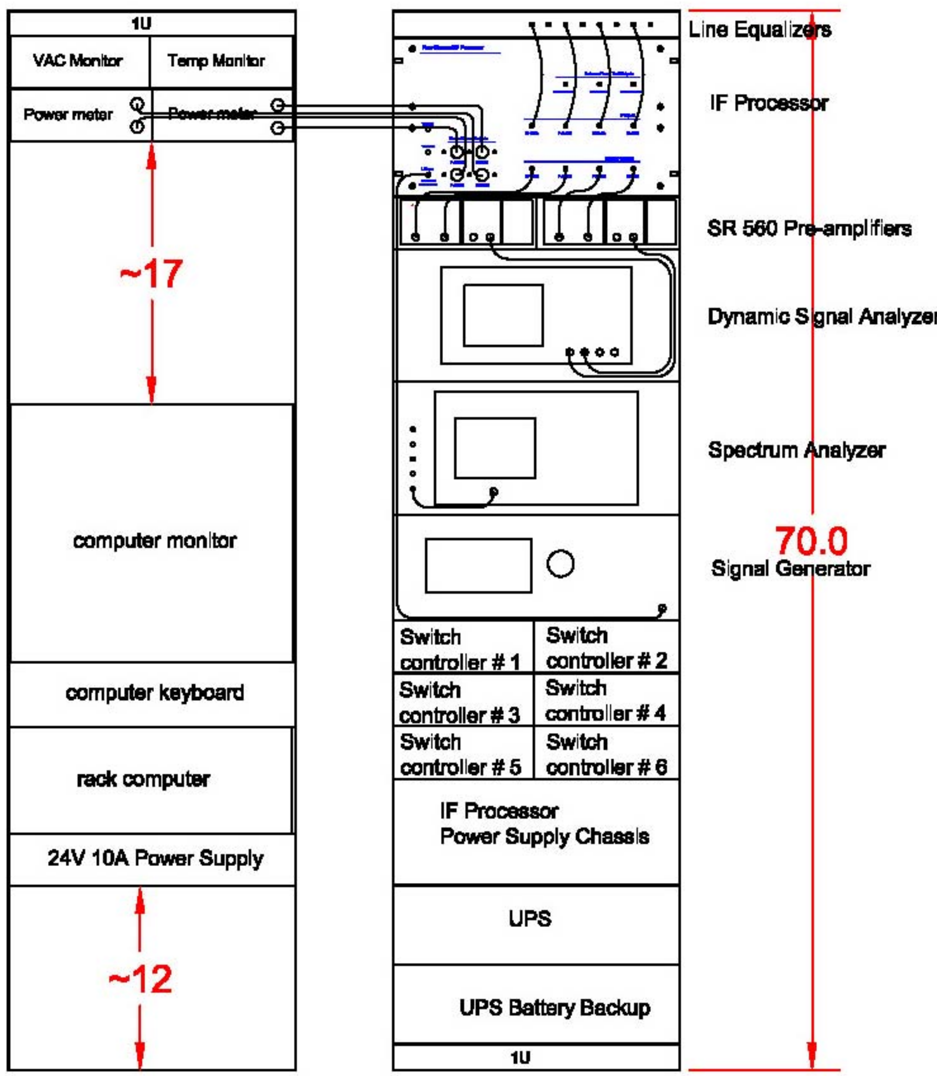
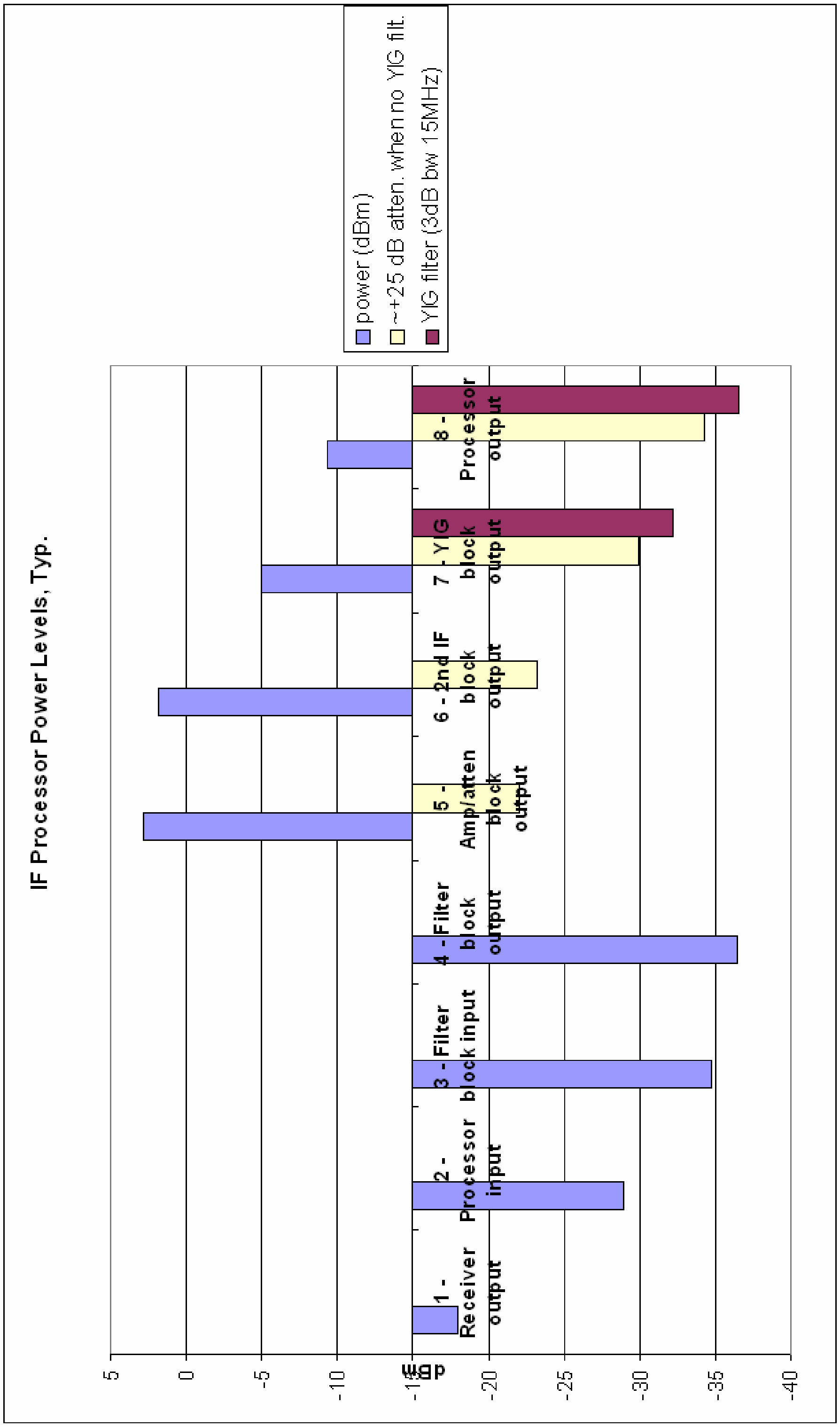


Figure 4 Dimensions in inches



IF Processor Power Levels, Typ.
power (dBm)
~+25 dB atten. when no YIG filt.
YIG filter (3dB bw 15MHz)
dBm
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1 - Receiver output
2 - Processor input
3 - Filter block input
4 - Filter block output
5 - Amp/atten block output
6 - 2nd IF block output
7 - YIG block output
8 - Processor output

Figure 5

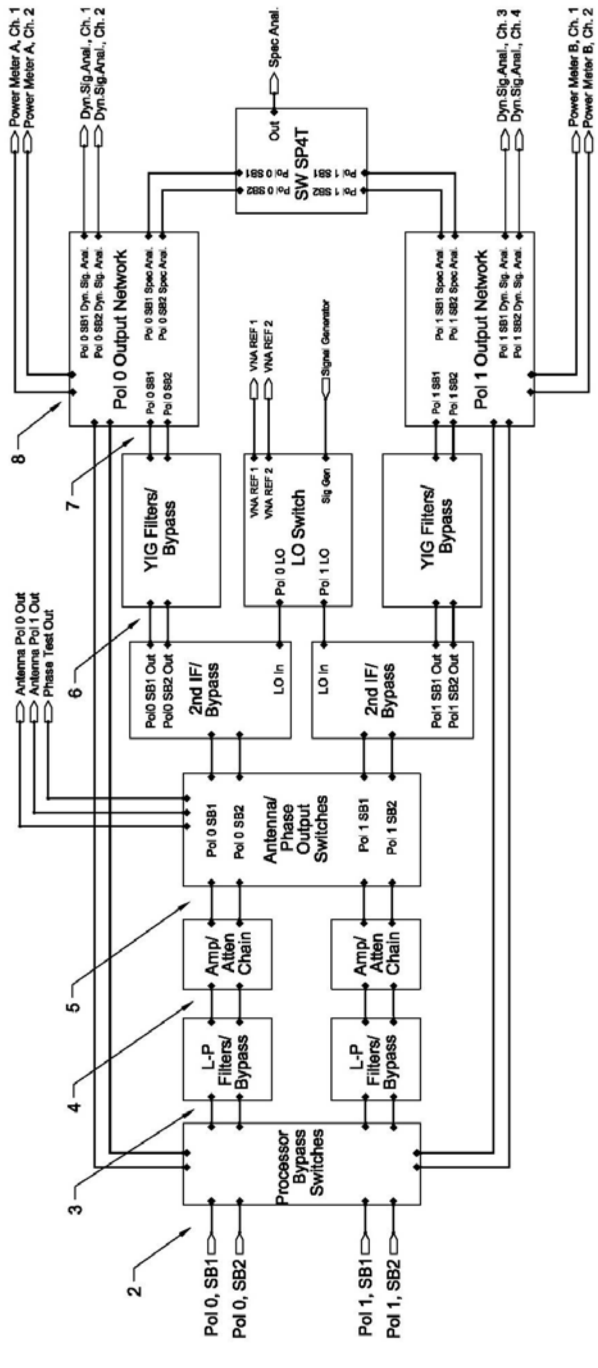

Power Meter A, Ch. 1
Power Meter A, Ch. 2
Dyn.Sig.Anal., Ch. 1
Dyn.Sig.Anal., Ch. 2
Spec Anal.
Dyn.Sig.Anal., Ch. 3
Dyn.Sig.Anal., Ch. 4
Power Meter B, Ch. 1
Power Meter B, Ch. 2
SW SP4T
Out
Pol 0 SB1
Pol 0 SB2
Pol 1 SB1
Pol 1 SB2
Pol 0 Output Network
Pol 1 Output Network
VNA REF 1
VNA REF 2
Signal Generator
YIG Filters/ Bypass
LO Switch
Pol 0 LO
Pol 1 LO
Sig Gen
Antenna Pol 0 Out
Antenna Pol 1 Out
Phase Test Out
2nd IF/ Bypass
LO In
Pol0 SB1 Out
Pol0 SB2 Out
Pol1 SB1 Out
Pol1 SB2 Out
Antenna/ Phase Output Switches
Amp/ Atten Chain
L-P Filters/ Bypass
Processor Bypass Switches
Pol 0, SB1
Pol 0, SB2
Pol 1, SB1
Pol 1, SB2
2
3
4
5
6
7
8

Figure 6

3.4 Beam measuring system

The beam shape and pointing will be measured using a near field scanner attached to the FESS just above the warm optics.
This system is designed to measure;

Pointing to 0.5 mrad
Secondary edge taper 10.5 +/- 0.5 dB
Co and Cross polar patterns for both polarizations
Focus position +/- 100mm
Polarization alignment

Scanner specifications

Construction	Aluminum box frame
Drive system	Precision stepper motor
Scan Area	0.9 x 0.9 m
Mount	3 point mount to FESS
Weight	Approx 50 Kg.
Orientation	Horizontal, Vertical, and tiltable.
Planarity	0.15 mm RMS typical over full range, 0.02 over each beam.
Resolution (x, y)	0.02 mm
Position repeatability	0.02 mm over 200 mm area within scan area.
Scan speed	0.1 m/s
System controller	NSI with parallel I/O and GPIB interface
Workstation	Pentium PC with Windows
Stepper motor power amp	EIA 19” rack mounted
Power	100-240 VAC 47/63 Hz, 500 W.
Probe station max load	8 Kg.
Probe station	Rotatable for both polarizations. 100 mm Z travel, accuracy 0.005 mm.
Software	Allows scripting for batch control. Controls all RF equipment (VNA), positioners, planar on the fly position correction and probe pattern correction. Software also makes near to far field transformations.
Motion tracking interferometer	Plus software. Corrects for thermal motion of probe, and any tilts in the mounting.

3.5 Phase measuring system

The phase measuring system takes one of the possible outputs from the IF processor, after the amplifiers to obtain the required signal levels, and uses an Aeroflex PN 9000 phase noise measurement system with PN 9341 phase detector. The signal is down converted from the 4 to 12 GHz range to the input frequency range of the PN 9000 with an integrated PN 9276 down converter. The down converter is driven by an integrated PN 9100 low phase noise synthesiser.

The down converter takes 1.7 to 26.5 GHz inputs

The PN 9276 performance at 4.34 to 8.68 GHz is

SSB phase noise in dBc/Hz at

1 Hz offset	-36
10 Hz	-66

100 Hz	-87
1 kHz	-112
10 kHz	-118
100 kHz	-118
1 MHz	-136
10 MHz	-156

The PN 9000/9276 system performance is given below.

Frequency range 0.002 to 1.8 GHz,
Offset analysis 0.01 Hz to 1 MHz,
Noise floor in dBc/Hz at

1 Hz offset	-130
10 Hz	-140
100 Hz	-150
1 kHz	-160
10 kHz	-168
100 kHz and beyond	-168

Spurious level -110 dBc

The VNA can be used to measure long term phase drift but due to it's phase noise floor can not measure the phase noise (jitter).

Phase noise of VNA in dBc/Hz at

1 kHz offset	-60
10 kHz	-70
100 kHz	-90
1 MHz	-106

Giving a predicted measurable phase jitter of greater than 10,000 femtosec (fS) from 1 kHz to 1 MHz.

3.6 Sources

Figure 7 gives a block diagram of the signal sources for all bands. These sources are used for the beam measurements, sideband ratio measurements and for the phase noise measurements.

The signal is generated by a 10 to 40 GHz low phase noise synthesizer which is phase locked to the system 10 MHz reference generator (which is internal to the LO chain source synthesizer). This signal is then multiplier by the relevant factor and either used directly or is used to drive a VDI multiplier (copies of those used in the LO chain). The final signal is then coupled by open ended waveguide, or, a 25 dB standard gain pyramidal horn, to increase the signal to noise. This system is needed to insure that a reference signal can be generated at any frequency within the operating range of the relevant receiving band. As can be seen some bands require two source chains to cover the whole band (these are shown by the coupled color blocks on the right hand side of the figure). In order for these sources to be used with the phase removal system, the multiplication factors for each chain have to be the same as those used in the cartridges (warm and cold multipliers).

These sources will need to be mounted on the beam measuring system by hand to enable the measurements to be made. Changing frequencies within some bands and changing bands will require the source chains to be manually exchanged.

Cables for the FEIC beam measuring range. UFB197C from Micro-coax [Micro-coax, 206 Jones Boulevard, Pottsdown, PA 19464-3465. www.micro-coax.com], are rated at 1 degree of phase shift (at 10 and 18 GHz) for a cable wrapped around a 50.4 mm diameter mandrel. Other cables with even lower phase changes with flexure are available.
This is significantly sharper than any bends required in the near field beam measuring range (given a good design which takes this into account). Thus we can use approximately 0.5 degrees of phase shift over the scan (approx 40 mm for each band).
Multiplied up to 950 GHz (factor approx 50) this gives 25 degrees (22 microns). This leads to an error on the direction of the beam of 22 microns / 40 mm = 0.55 mrad. No round trip path compensation is required.

As a further comment, if the beam measuring range sources are mounted on the tilt mechanism there is no flexure with tilt angle, so there is no change of phase with tilt angle.

The phase error introduced on the 10 MHz cable will be extremely small.

A cold load and a chopper will also be mounted on the beam measurement system to enable system noise performance to be checked. This will need to be mounted simultaneously with the signal sources to enable sideband ratios to be measured (see relevant section in [RD3]).

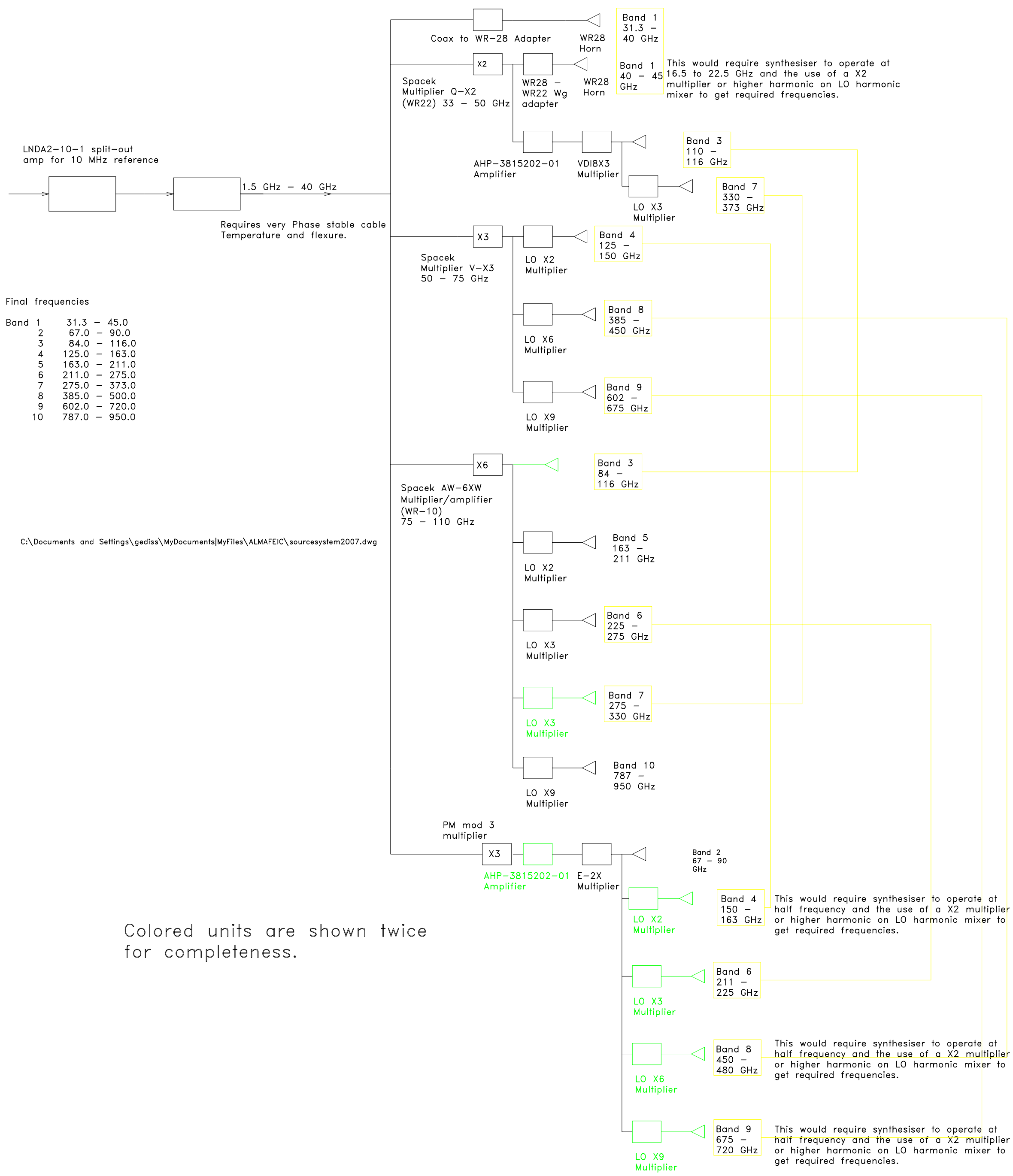


Figure 7 Block diagram of the signal sources.

3.6.1 Synthesizers

The synthesizers for the proposed FEIC phase stability test system were Agilent models 70427A. These are now obsolete and have been replaced by the N5507A which has the same specifications.

The problem with these synthesizers is the 600 MHz frequency step size. While frequencies can be found to drive the LO's for all bands (at least 3 frequencies within each band) combinations required to drive the LO's and the signal source for the phase measurement system with an offset somewhere in the bands IF range can not be found for band 7 and above.

I have been working with Agilent on possible alternatives. These are the 70428A (now N5508A) with 100 MHz step size but a considerable increase in cost, or a E8257D-540 which has slightly worse phase jitter, a 1 Hz step size, but a lower price.

Table 4 gives the predicted Phase Jitter in femtosec (fS) from the various sources, which will be the minimum that can be measured. These are always well above the noise floor of the E5505A test set.

Model #	1 Hz to 1 MHz fS	10 Hz to 1 MHz fS
70427A		
spec	350	49.2
typical	197	27.7
70428A		
Spec	279	39.8
typ.	157	22.4
8257D-540		
Spec	231	98.7
typ.	159	35.7

Table 4

It should be noted that the values for 1 Hz to 1 MHz are very much affected by the value used at 1 Hz from the data sheets but which is not given for the 8257D-540 and has to be extrapolated from the value at 10 Hz.

It should also be noted that the measurement noise floor will be given by the RSS of the sources used for the LO chain and of the source for the signal chain.

Therefore Table 5 gives the phase jitter for various combinations.

Model #	1 Hz to 1 MHz fS	10 Hz to 1 MHz fS
70427A/70427A		
spec	495	69.6
typical	279	39.2
70428A/70428A		
Spec	394.5	56.2
typ.	222	31.6
8257D-540/8257D-540		
Spec	326	139.6

typ.	224.8	50.5
70427A/8257D-540 Spec typ.	 419 253.8	 110.3 45.2
70428A/8257D-540 Spec typ.	 362 223	 106.4 42.1

Table 5

As can be seen, none of the combinations allows us to measure the 63 fS specified for the receiver from 1 Hz – 1 MHz, but the 70427A or 70428A ‘s would measure the spec. from 10 Hz - 1 MHz. Even the 8257D-540 would be sufficient if the typical values are used (not the spec).

3.7. First LO interface

The photonic LO source to FETMS software interface is TBD

3.8. Tilt mechanism

Specifications for the tilt mechanism are given in [RD4].

3.9. Thermal control

As given in [RD5] the operating temperature over which the Front End has to operate is from 16 ^{o} C to 22 ^{o} C with temperature changes of less than 1 ^{o} C per hour. The Front End being tested will have to be inside a thermal enclosure to ensure that the measurements are made within these requirements.

4 SOFTWARE

A large amount of software programming to interface between and to drive all the components will be necessary. (TBD)

- IF processor
- Phase measurement system (separate computer)
- Beam measurement system (separate computer)
- Photonic LO driver (separate computer).

For the software requirements and design descriptions see [RD6] and [RD7].