SCANTER 5102/5202 Radar Systems

Technical & Maintenance Manual

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615102-HT Rev. C2

Record of changes

Description	Rev	Date
Released.	A	2013-01-18
Installation documents are no longer part of this manual.	B	2011-04-15
General update. Removed "ASPECT" chapter.	C	2013-06-06
Added FCC and ISED/ISDE warning statements. Updated front page. Updated chapter 1. Minor editorial updates.	C1	2019-09-06
Updated section "Microwave Radiation Safety Margins / Marges de sécurité du rayonnement micro-ondes".	C2	2019-10-09

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1 INTRODUCTION

1.1 Purpose

The purpose of this manual is to describe the SCANTER 5102/5202 Radar System. The document includes a functional description of the radar system as well as information on main transceiver hardware components.

In addition, the document serves as a guidance for technical staff in connection with fault isolation and maintenance of the SCANTER 5102/5202 transceiver. The manual provides the necessary tasks for the preventive and corrective maintenance of the transceiver, including the tools, equipment and re-alignment procedures for the maintenance tasks.

1.2 Long-term Storage of Power Supply Units

SCANTER radar electronics must generally be stored and transported under the following conditions:

Packed for transportation and storage - environmental requirements		
Temperature	-40°C to 70°C	IEC 60068-2-1 / 60068-2-2
Humidity	93±3%RH @ 40°	IEC 60068-2-30
IP protection class	Keep dry	-

Two spare part units contain individual power supplies, that require reconditioning during long term(>3 years). These units are:

Terma part no.	Name
386250-002	SSPA, Long Range
386290-xxx	PSU

Due to the use of electrolytic capacitors, the units must be powered for some hours every 3 years in order not to degrade performance and risk damaging the unit when put into use after long-term storage.

It is recommended to mount a power supply spare part to the unit in the appropriate radar system and run it for some hours at least every 3 years. That way you ensure that you have a working and healthy spare part.

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1.3 Warnings and safety instructions

The following outlines basic warnings and safety instructions when working on the radar system. Further warnings and safety instructions can be found in doc. no. 970637-HT: "Warnings and Safety Instructions for Terma Radar Antenna Systems".

Fig. 1.1 Warnings and safety instructions

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1.3.1   Microwave Radiation Safety Margins / Marges de sécurité du rayonnement micro-ondes

ENGLISH:

The guidelines[1] for exposure to electromagnetic fields recommend an average permissible power density exposure limit of 10 W/m2 at the calculated safety distances summarized below.

Two limits are defined; one for occupational exposure and one for exposure to the general public:

Exposure characteristics	Power density [W/m^2]	Power density [dBm/cm^2]
Occupational (controlled exposure)	50	7
General population (uncontrolled exposure)	10	0

Compliance with the power density exposure limits is documented per Terma document 924000-RC: "Power Density in Proximity to SCANTER Antennas with SCANTER 4000/5000/6000 Series Transceivers".

The safety distances are summarized as follows:

- For all combinations of SCANTER 5000/6000 Series transceivers and SCANTER antennas, the safety limits are met at all distances from the radar antenna rotation center of 5 meters in the horizontal plane and/or more than 1 meter above or below the antenna center in the vertical plane.

- For vertical distances of more than 5 meters below the antenna and/or more than 65 meters range, the power density is at least 10 times below the limit for exposure to the general public.

- For vertical distances of more than 30 meters below the antenna, the power density is at least 100 times below the limit for exposure to the general public for all combinations of transceivers and antennas.

Note: Microwave power is not emitted from any parts of the SCANTER radar systems, but from the antenna.

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1. As defined by the following regulatory standards:

   a. ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields, Health Physics, 74 (4), pp. 494-522, 1998.
   b. FCC CFR: Title 47, Part 1.1310.
   c. ISED RSS-102, Sec 4.

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FRANCAIS:

Les lignes directrices[1] pour l'exposition aux champs électromagnétiques recommandent une limite d'exposition moyenne admissible de la densité de puissance de 10 W/m² aux distances de sécurité calculées résumées ci-dessous.

Deux limites sont définies; une pour l'exposition professionnelle et l'autre pour l'exposition au grand public:

Caractéristiques d'exposition	Densité de puissance [W/m²]	Densité de puissance [dBm/cm²]
Professionnelle (exposition contrôlée)	50	7
Grand public (exposition non-contrôlée)	10	0

Conformité aux limites d'exposition à la densité de puissance est documentée dans le document Terma 924000-RC: "Power Density in Proximity to SCANTER Antennas with SCANTER 4000/5000/6000 Series Transceivers".

Les distances de sécurité se résument comme suit:

• Pour toutes les combinaisons d'émetteurs-récepteurs SCANTER Séries 5000/6000 et d'antennes radar SCANTER, les limites de sécurité se conforment à toutes les distances du centre de rotation de l'antenne de 5 mètres dans le plan horizontal et/ou de plus de 1 mètre au-dessus ou au-dessous du centre de l'antenne dans le plan vertical.

• Pour les distances verticales de plus de 5 mètres au-dessous de l'antenne et/ou de plus de à 65 mètres de distance horizontale, la densité de puissance est au moins 10 fois inférieure à la limite d'exposition au grand public.

• Pour les distances verticales de plus de 30 mètres au-dessous de l'antenne, la densité de puissance est au moins 100 fois inférieure à la limite d'exposition du grand public pour toutes les combinaisons d'émetteurs-récepteurs et d'antennes.

Note: Le rayonnement micro-ondes n'est émise par aucune partie des systèmes radar SCANTER que par l'antenne.

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1. Comme définies par les normes législatives suivantes:

a. ICNIRP Guidelines for limiting exposure to time-varying electric, magnetic and electro-magnetic fields, Health Physics, 74 (4), pp. 494-522, 1998.
b. FCC CFR: Title 47, Part 1.1310.
c. ISED RSS-102, Sec 4.

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1.3.2 FCC Warning Statements

IMPORTANT:

The content of this section applies to installations in the United States only.

1.3.2.1 FCC CFR, Part 15.19(3)

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

1.3.2.2 FCC CFR, Part 15.21

CAUTION: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

1.3.2.3 FCC CFR, Part 15.105(b)

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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1.3.3　ISED Warning Statements / Déclarations d'avertissement ISDE

IMPORTANT:

The content of this section applies to installations in Canada only.

Le contenu de cette section s'applique uniquement aux installations au Canada.

1.3.3.1　ISED RSS-Gen, Sec 6.8/ CNR-Gen ISDE, Sec 6.8

ENGLISH:

This radio transmitter - IC: 2628A-SC5000 - has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Antenna type	Compact (CO)	High Gain (HG)	
Length	12'	18'	21'
Max. gain @ antenna flange	≥ 34 dBi	≥ 37 dBi	≥ 38 dBi
Polarization	Horizontal, vertical or circular	Horizontal or circular	

FRANCAIS:

Le présent émetteur radio - IC: 2628A-SC5000 - a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous, avec le gain maximal admissible indiqué. Les types d'antenne non inclus dans cette liste et dont le gain est supérieur au gain maximal indiqué pour l'un des types énumérés sont strictement interdits pour l'exploitation de l'émetteur.

Type d'antenne	Compact (CO)	High Gain (HG)	
Longueur	12'	18'	21'
Gain maximal à la bride d'antenne	≥ 34 dBi	≥ 37 dBi	≥ 38 dBi
Polarisation	Horizontale, verticale ou circulaire	Horizontale ou circulaire	

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1.3.3.2　ISED RSS-Gen, Sec 8.4 / CNR-Gen ISDE, Sec 8.4

ENGLISH:

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1.　This device may not cause interference.

2.　This device must accept any interference, including interference that may cause undesired operation of the device.

FRANCAIS:

Le présent appareil contient un ou plusieurs émitteurs-recepteurs conformes aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1.　L'appareil ne doit pas produire de brouillage.

2.　L'utilisateur de l'appareil doit accepter tout brouillage subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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1.4 Restrictions on use of Radio Transmitter

The following should be noted:

Restrictions on putting into service and/or requirements for authorization exist for all member states of the European Union.

The radar shall be configured in accordance with local frequency allocation, and authorization for transmission shall be obtained from relevant national authority.

1.4.1 Hazardous Material Information

1.4.1.1 RoHS Compliance

The SCANTER 5102/5202 Transceiver is RoHS compliant, but contains a few components, which are exempt from RoHS compliance. These components will be replaced by RoHS-compliant parts before the end of the exemption period.

1.4.1.2 Dangerous Goods Category Or Hazchem Coded Materials

The SCANTER 5102/5202 Transceiver does not contain materials regulated as dangerous goods or HAZCHEM.

1.4.1.3 Specific Substance(s) Information

The SCANTER 5102/5202 transceiver subsystem does not contain any specific substances, i.e. substances requiring by law disclosure of content within the product to authorities, customers and users.

1.4.1.4 Other Substance(s) Information

None of the prohibited substances in Annex XIV of EU Regulation (EC) 1907/2006 REACH are present in the SCANTER 5102/5202 Transceiver subsystem in concentrations above the minimum contained in the legislation.

1.5 Referenced documentation

615102-DP	SCANTER 5102 VTS & CS Radar - Product Specification
615202-DP	SCANTER 5202 VTS & CS Radar - Product Specification
357641-HO	SCANTER Radar Service Tool - Operator's Manual
695522-TI	SCANTER 5000/6000 Series Setup And Adjustment
386303-DI	SCANTER 5000 Series Transceiver Control Protocol Data Definition - Service Access Mode

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2   SCANTER 5102/5202 Radar Systems

The Terma SCANTER 5102/5202 radar systems are tailored specifically to meet the requirements for Vessel Traffic Services (VTS) and Coastal Surveillance (CS), for which the need for performance, versatile interface capabilities, quality and durability is significant. Surface coverage is provided and capabilities include the detection of very small targets in adverse and harsh weather conditions.

The SCANTER 5102/5202 radar systems (Fig. 2.1 (p. 19)) are X-band, 2D, fully coherent pulse compression radars, based on Solid State Power Amplifier (SSPA) transmitter technology with digital software defined functionality.

Terma's solidly proven Frequency Diversity, Time Diversity and best-in-class advanced video processing gives a truly high-end radar system, which is IALA V.128 compliant.

Novel low temperature SSPA transmitter technology optimizes the investment, and the long-life transmitter ensures high reliability and availability. The availability is further enhanced with provision of graceful degradation.

A receiver with superior dynamic range provides high resolution in the full range with clear and crisp radar pictures, in all weather conditions.

High-speed sampling is made on IF level, and all subsequent handling of signals, filtering, pulse compression, optional MTI processing based on Doppler shift is performed digitally. Advanced CFAR techniques and video processing with intelligent noise reduction provide high definition radar images with no need for further processing.

An optional embedded tracker with parallel tracking lines gives the opportunity to detect and track agile and small targets in severe weather conditions, and at the same time to use the tracker to detect large vessels. Information to track surface targets is obtained from a combination of normal and MTI processed signals.
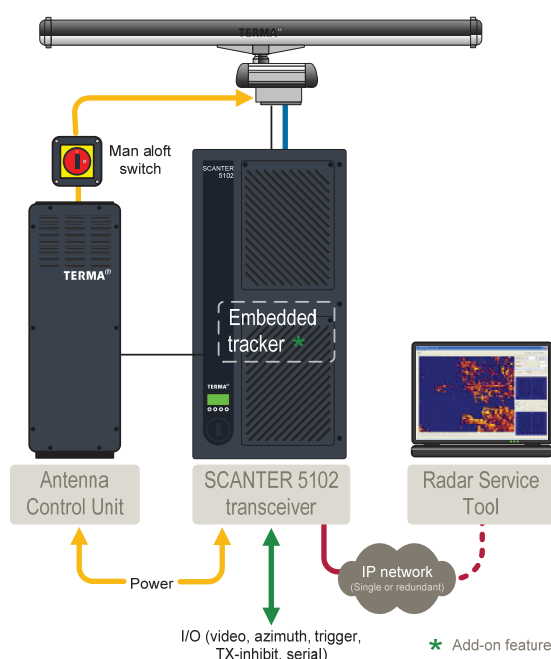
Fig. 2.1   Simplified system components schematics

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An optional air channel with tracker is available for SCANTER 5202.

Communication interface to the transceiver is established via a standard IP network (LAN or WAN), which provides network radar video, plots, tracks, control, etc. Conventional digital video is also available.

A temperature-conditioned environmental housing for the transceiver may be supplied for outdoor installation or for use in other harsh environments as add-on feature.

Service information is obtained via the front panel display and/or the IP network.

The SCANTER Service Display (Radar Service Tool) provides access to powerful radar imaging, control, easy wizard set-up, BITE measurements, error handling, fault finding and LRU replacement of the complete radar sensor package.

2.1 Single transceiver system configuration

A complete radar sensor () system consists of a transceiver, an - Antenna Control Unit (ACU) and an antenna unit. Service Display software handling radar video imaging, control, set-up, BITE, etc. is also included. A PC for running the software may be added, either as a rack-mounted PC or as a portable solution.

An embedded tracker with multiple tracking lines can be integrated as add-on in the transceiver.

Fig. 2.2   Single transceiver system configuration

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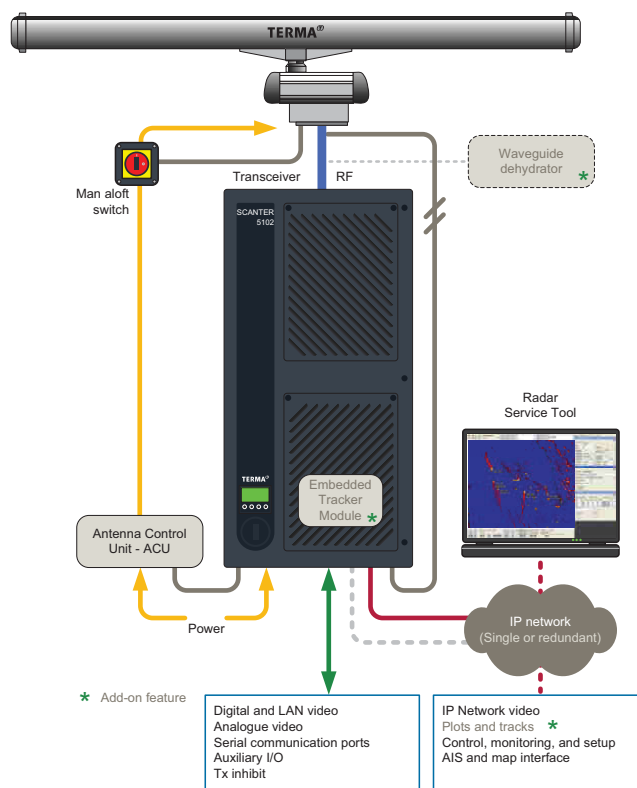
The transceiver is a one-box wall-mounted unit and all connections except the waveguide are connected at the bottom of the housing. A temperature-conditioned environmental housing for the transceiver can be supplied as add-on feature for outdoor installations or in harsh environments.

IP network video is available as well as IP network transceiver control, monitoring and set-up.

Auxiliary I/O, serial communication ports for mounting external equipment such as GPS, gyro, log, etc. as well as conventional digital video output are available.

Mains power supply to the antenna unit is via an ACU (Antenna Control Unit) controlled by the transceiver. Antenna unit status, encoder signals, and man aloft switch are connected directly to the transceiver.

2.2 Redundant transceiver system configuration

The SCANTER 5102/5202 redundant system configurations (Fig. 2.3 (p. 21)) are fully redundant in respect of all transceiver functions. Features include automatic switch-over (only once) in case of failure, and furthermore, "graceful degradation" is implemented in each transceiver.
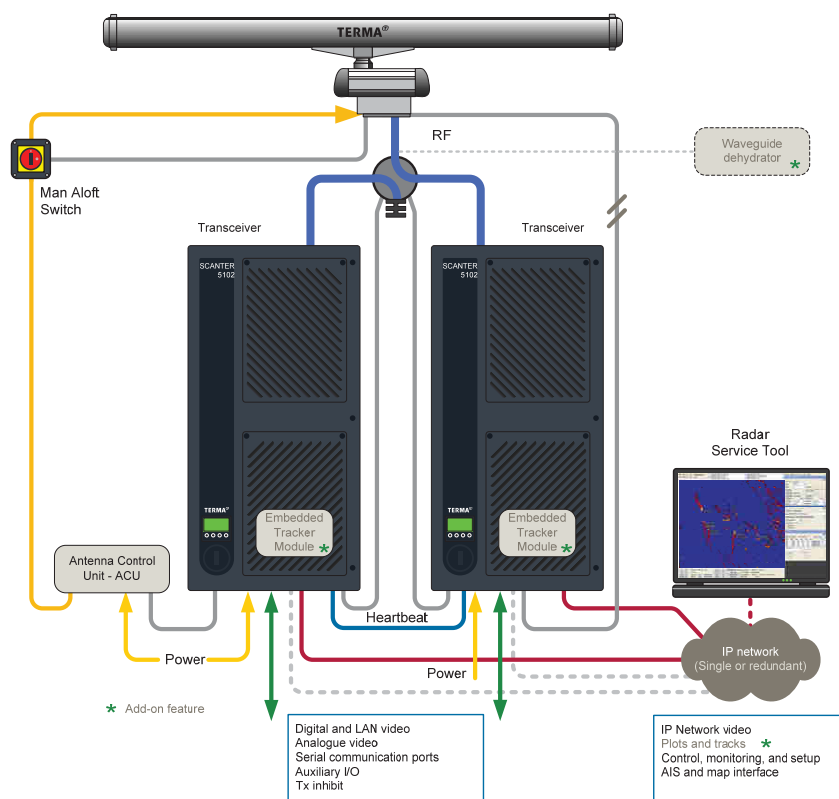
Fig. 2.3   Redundant transceiver system configuration

Waveguide switch and dummy load are installed externally to the transceivers on a metal frame.

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2.2.1 Redundant transceiver operation

In a redundant transceiver configuration, most of the parameters are identical in the two transceivers, except for a few site-specific parameters, e.g. IP address. Consequently, any changes to the parameters in one transceiver must also be made in the other transceiver.

Redundancy ensures continuous operation of the radar in case of critical transceiver failure. In a redundant transceiver system the transceivers communicate a heartbeat signal via a LAN network connection.

Each transceiver has a unique IP address. Thus, setting up redundant system mode must be done for each individual transceiver by connecting the Radar Service Tool (RST) to the transceivers. An instance of the RST client can be run for each transceiver when setting the parameters.

The mains and antenna parameters must be set to "On" and the Tx parameter must be set to "On" for both transceivers. In addition, the same profile must be selected for both transceivers. Any transceiver can be made active by selecting "Force" in the Redundant System Failover parameter.

To prevent a radar transmission stop in case of a critical failure, both the active and passive transceiver in a redundant system must allow for automatic switch-over. This is done by setting the parameter Redundant System Failover to "Enable". In case of failure, transmission then automatically changes to the passive transceiver and the failover enabled in both transceivers is disabled. When the error in the failing transceiver is corrected, failover in both transceivers must be re-enabled manually to allow for automatic switch-over in case of future failure.

Redundant system errors must be critical in order to disable a transceiver. An example of such error is "Noise Figure High Error". For an overview of "Redundant System Critical Errors", see "BITE errors and warnings" on page 151.

2.2.2 SCANTER 5102/5202 product features

The flexible design from earlier SCANTER non-coherent radars are combined with fully digital, fully coherent, pulse compression technology.

Signal processing and 32-bit floating-point representation of data is combined into a modular concept with microwave SSPA (Solid State Power Amplifiers). Performance and functionality is further enhanced by digital receiver technology, sampling on IF and scalable processing power. Technology and features are listed below:

- Software-defined functionality
- Frequency Diversity and Time Diversity
- Full coherency and pulse compression

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- Utilization of the Doppler shift, sub-clutter visibility. (add-on feature)

- Transmitter power level control in sectors

- Video processing

- Environment adaptation

- Control / Profiles / BITE

The necessary processing power is added in the form of plug-in CP4 - Common Platform 4 processing boards. The CP4 boards are electrically identical, but are programmed differently, according to desired functions.

	5102	5202
Featuring		
Surface coverage, normal radar	●	●
Supplemented by coherent processing (MTI)		○
Air channel with air tracker		○
Techniques		
2-D, fully coherent, software-defined functionality, Solid State, pulse compression radar	●	●
Frequency diversity and time diversity with automatic adaptation to the environment	●	●
Transmitter with programmable power, also in sectors	●	●
Video processing	●	●
Frequency		
Programmable frequencies within 9.0–9.5 GHz	●	●
Up to 16 sub-bands	●	●
Transmitter		
50 kW SSPA: Equivalent pulse power, programmable up to 75 kW	●	
200 kW SSPA: Equivalent pulse power, programmable up to 300 kW		●
Receiver		
Digital Sampling on IF, ≥ 140 dB amplitude span of signals handled	●	●
Embedded tracker		
Surface, 500 tracks	○	○
Short range, low-level air, 100 tracks		○
External Interfaces		
Digital and IP network radar signals	●	●
Control and monitoring via IP network	●	●
Fibre optic IP network	○	○
Design		
Open architecture, wall mounted, ruggedized housing	●	●
Antennas		
12´or 18´ Compact - HP	○	○
21´Large Aperture - HP, CP		○
18´ or 21´ High Gain - HP, CP or switchable, Fan or Cosec^2	○	○

● Standard feature

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2.2.2.1 Doppler-based processing (SCANTER 5202 only)

The Doppler-based processing option allows the transceiver to separate moving targets from background clutter and provides an additional video channel with moving objects. The Doppler processing option includes an additional processing board (CP 4 board) in the transceiver.

2.2.3 Technology, functions and features

Built on the flexible, versatile design and superior price/performance heritage from the previous non-coherent radars, the new generation introduces fully digital signal processing and solid-state technology.

SCANTER 5102/5202 uses fully coherent, pulse compression technology to get superior resolution and radar image quality. The radar transmits chirps with frequency sweeps in different intervals generated by a digital synthesizer. The chirps are upconverted to X-band frequencies, and the output power is generated by a microwave SSPA (Solid State Power Amplifier).

In order to support full frequency diversity, the receiver has two channels receiving the different frequencies. The signals from the two receiver channels are sampled in 14 bits at 400 MHz, yielding a stream of 11.2 Gbit/s of raw data. This data stream is input to the processing chain, which uses multiple FPGAs (Field Programmable Gate Arrays) in a modular configuration to perform the calculations and data reduction needed to provide crisp and noise free radar images. The radar provides:

- Software-defined functionality.
- Frequency diversity and time diversity.
- Full coherency and pulse compression.
- Sub-clutter visibility and Doppler shift processing.
- SSPA - Solid State Power Amplifier.
- Video processing.
- Environment adaptation.
- Control / Profiles / BITE (Built-in Test Equipment).

All but the transmitter amplifier and receiver front-end are purely digital. The necessary processing power is added in the form of plug-in CPs - Common Platform processing boards - in order to minimize the number of different LRUs. The CP boards are identical, but are programmed differently, according to desired functions.

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2.2.3.1 Physical appearance of SCANTER 5102/5202
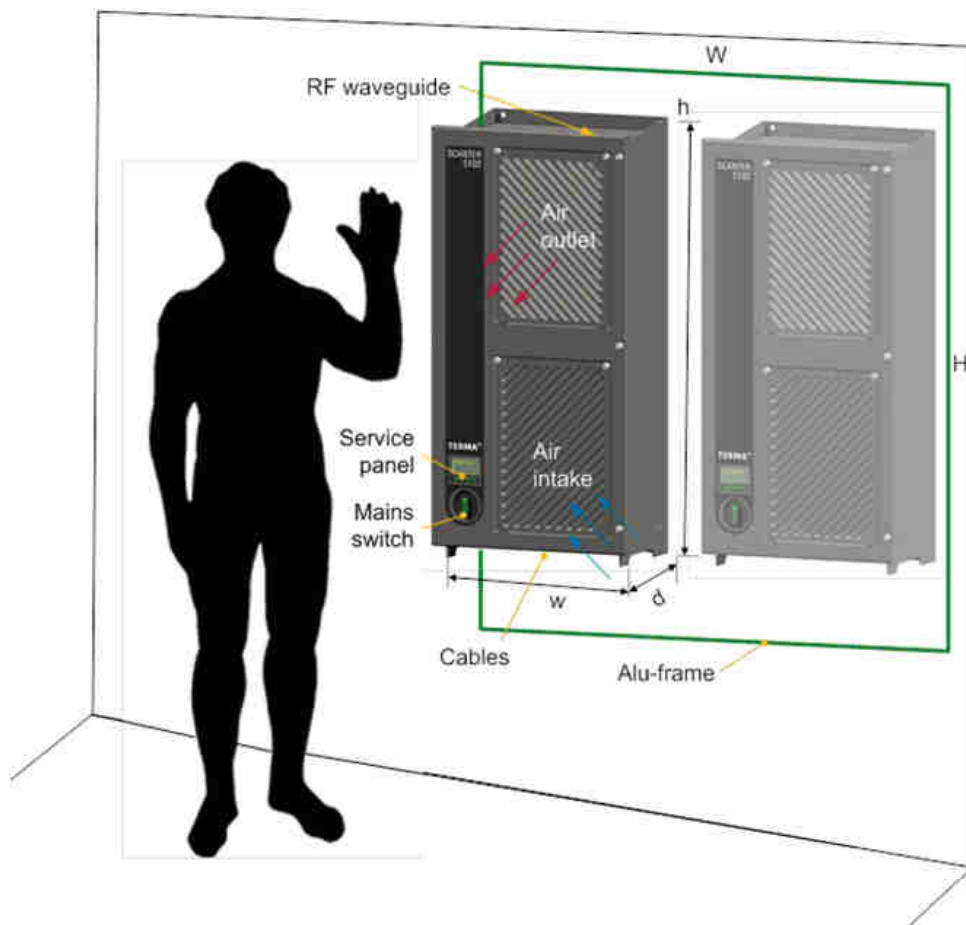
Fig. 2.4   Wall-mounted transceiver dimensions

Weight:	75 kg installed
	115 kg packed for transportation
H x W x D	990 x 497 x 305 mm installed
	˜ 610 x 1050 x 660 mm packed for transportation

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2.2.3.2 Interior of SCANTER 5102/5202

The transceiver contains a number of RLUs - Line Replaceable Units - as illustrated below.
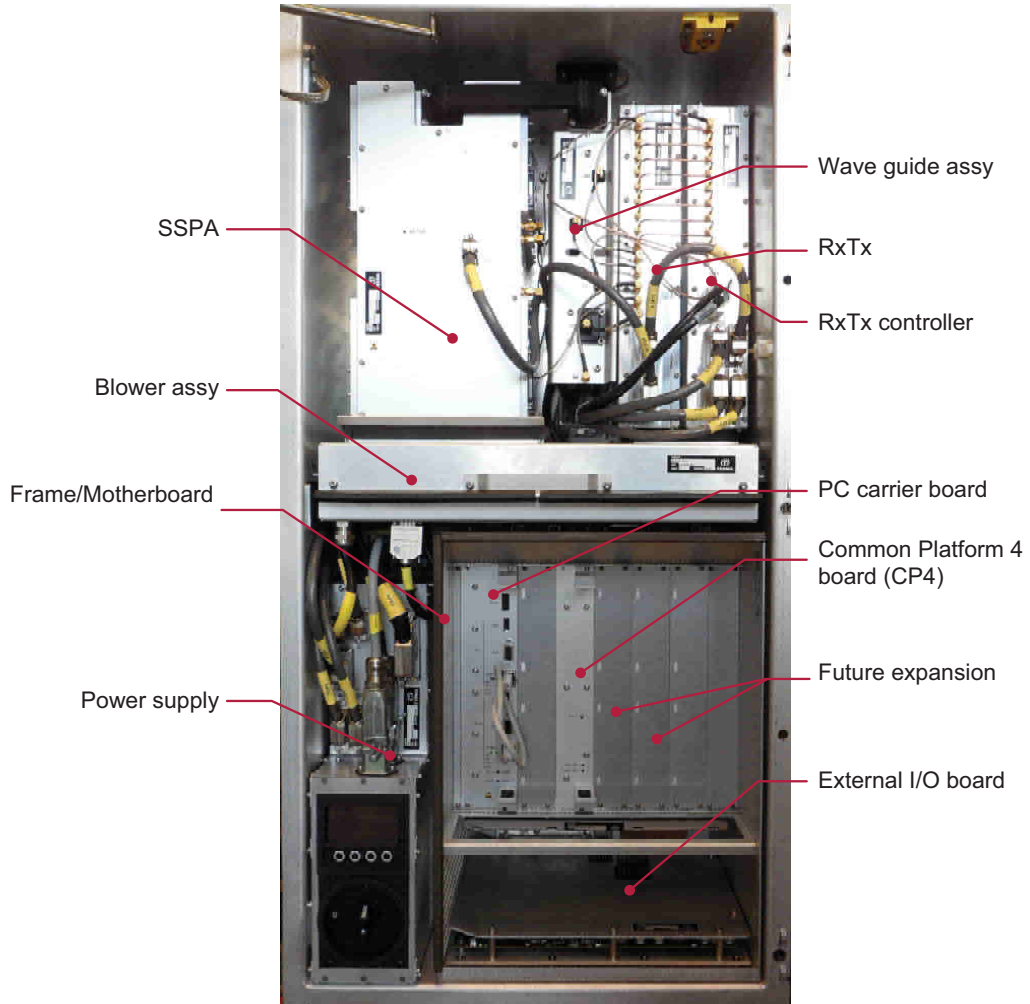
Fig. 2.5   The interior of the SCANTER 5102/5202 transceiver

2.2.4 Add-on features

2.2.4.1 Embedded Tracking, SCANTER 5102

The purpose of the add-on embedded tracker is to automatically identify target echoes in the extractor as plots, and to initiate and maintain tracks in the tracker.

The embedded tracker is aimed at detecting and tracking multiple kinds of targets on the sea surface. It assists the operator to create an overview even when multiple targets are present.

Several parallel trackers (tracking lines) are introduced to be able to optimize against each individual target type. This gives the opportunity for emphasis on the detection and tracking of agile and small surface and air targets in severe weather conditions, and at the same time to use the system to track large vessels, helicopters, etc.

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Fig. 2.6   Interfaces, plot extraction, tracking lines, correlator and combiner

Each extractor analyses the incoming video, creates plots, and calculates plot properties such as area, intensity, center of gravity, etc. Based on a number of filters, plots are selected for track initiation or track maintenance. The plot filters include selection criteria on video level, plot area, plot intensity, and a comparison with the actual clutter environment.

The tracker calculates match between incoming plots and existing tracks. Non-matched plots are used as candidates for initiation of new tentative tracks. The track propagation uses advanced algorithms to estimate the next (future) scan position and velocity of the target as well as to compare the predicted position with the available plots.

Track initiation and association of plots to existing tracks are based on multiple criteria. These include radar accuracy, expected manoeuvrability of the targets, plot characteristics such as size and strength, and a concept for measuring track quality expressed in a track quality factor. Aids to navigation e.g. buoys are tracked using specially adapted algorithms.

Fig. 2.7   From real life through advanced processing to confirmed track

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Functions

The interface to the embedded tracker allows the operator to initiate a track manually and to delete an existing track.

Tracks are terminated based on the number of "lacks" i.e. missing consecutive updates of the track. The actual number of "lacks" which will lead to termination of a track is given as set-up parameters depending on the status of the track and which tracking line it belongs to.

Plot Records	
Timestamp	Line
Azimuth	Widths
Range	

Track Records		
	ID	
Timestamp	Status	Kind
Name	Line	Size
Range	Azimuth	Lat./Long.
Speed	Course	Quality
Lacks	Window	Error

Status	
No. of plots	No. of tracks
Overflow	Notifications
Video alarms	
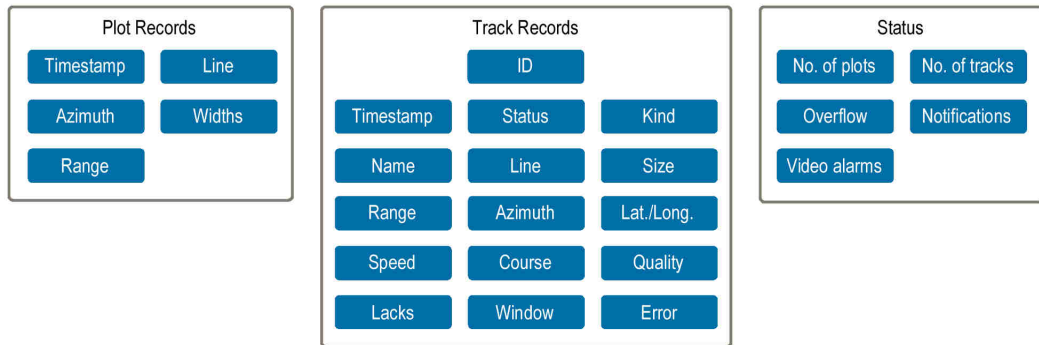
Fig. 2.8   Selected examples of output data from the embedded tracker

Data from all tracking lines are correlated and combined, and the plots and tracks are pub-lished on the network using an ASCII TCP/IP protocol, together with the accompanying status information.

The embedded tracker is based on years of intensive product development and frequent tests with different kinds of small targets in a number of countries and in all kinds of weather conditions.

2.2.4.2   Embedded Tracking, SCANTER 5202

The purpose of the add-on embedded tracker is to automatically identify target echoes in the extractor as plots, and to initiate and maintain tracks in the tracker.

The embedded tracker is aimed at detecting and tracking multiple kinds of targets on the sea surface and short range, low-level air targets, helicopters etc. It assists the operator to create an overview even when multiple surface and air targets are present.

Several parallel trackers (tracking lines) are introduced to be able to optimize against each individual target type. This gives the opportunity for emphasis on the detection and tracking of agile and small surface and air targets in severe weather conditions, and at the same time to use the system to track large vessels, helicopters etc.

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Fig. 2.9   Interfaces, plot extraction, tracking lines, correlator and combiner

Each extractor analyses the incoming video, creates plots, and calculates plot properties such as area, intensity, center of gravity, etc. Based on a number of filters, plots are selected for track initiation or track maintenance. The plot filters include selection criteria on video level, plot area, plot intensity, and a comparison with the actual clutter environment.

The tracker calculates match between incoming plots and existing tracks. Non-matched plots are used as candidates for initiation of new tentative tracks. The track propagation uses advanced algorithms to estimate the next (future) scan position and velocity of the target as well as to compare the predicted position with the available plots.

Track initiation and association of plots to existing tracks are based on multiple criteria. These include radar accuracy, expected manoeuvrability of the targets, plot characteristics such as size and strength, and a concept for measuring track quality expressed in a track quality factor. Air targets and aids to navigation e.g. buoys are tracked using specially adapted algorithms.
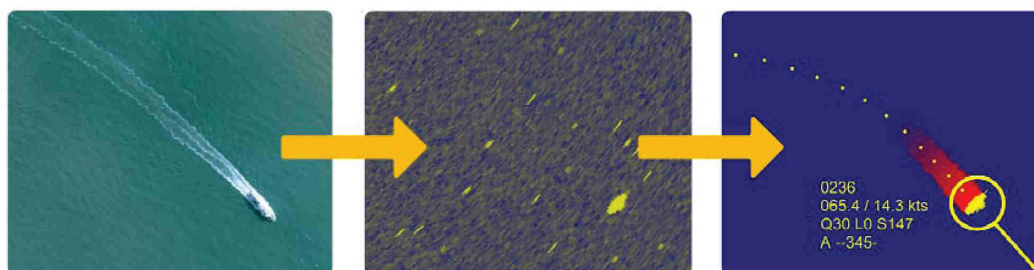
Fig. 2.10 From real life through advanced processing to confirmed track

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Functions

The interface to the embedded tracker allows the operator to initiate a track manually and to delete an existing track.

Tracks are terminated based on the number of "lacks" i.e. missing consecutive updates of the track. The actual number of "lacks" which will lead to termination of a track is given as set-up parameters depending on the status of the track and which tracking line it belongs to.

Plot Records		Track Records			Status	
Timestamp	Line		ID		No. of plots	No. of tracks
Azimuth	Widths	Timestamp	Status	Kind	Overflow	Notifications
Range		Name	Line	Size	Video alarms	
		Range	Azimuth	Lat./Long.		
		Speed	Course	Quality		
		Lacks	Window	Error		
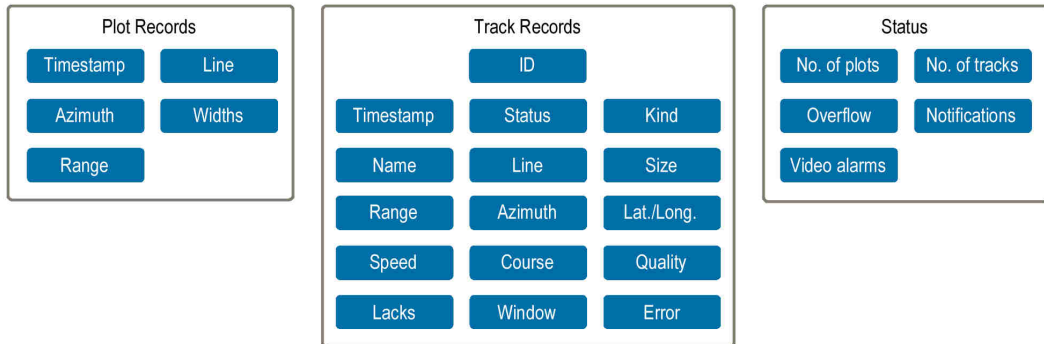
Fig. 2.11 Selected examples of output data from the embedded tracker

Data from all tracking lines are correlated and combined, and the plots and tracks are published on the network using an ASCII TCP/IP protocol, together with the accompanying status information.

The embedded tracker is based on years of intensive product development and frequent tests with different kinds of small targets in a number of countries and in all kinds of weather conditions.

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3 Functional Description

The transceiver is the central component in the radar system. See Fig. 3.1 (p. 31). The transceiver is connected to signal distribution through single or redundant IP network(s). Serial communication lines are available, handling easy integration into other sub-systems. The recommended video outputs are digital and IP network formats.

The transceiver utilizes frequency modulation (chirping or frequency sweeping) and pulse compression to increase the range resolution as well as the signal-to-noise ratio. This allows for transmission of long frequency modulated pulses (chirps) with relative low peak power, but still gets a high range resolution and probability of detection.

By the digital frequency synthesis, any frequency within the frequency bands 9000-9200 and 9225-9500 is selectable as required by the application. The signal is generated in the radio controller and upconverted in the transmitter. The receiver will automatically tune to the transmitted frequency bands and pass the received signal to the radio controller which will sample the signals and combine the data stream from the two receiver channels.
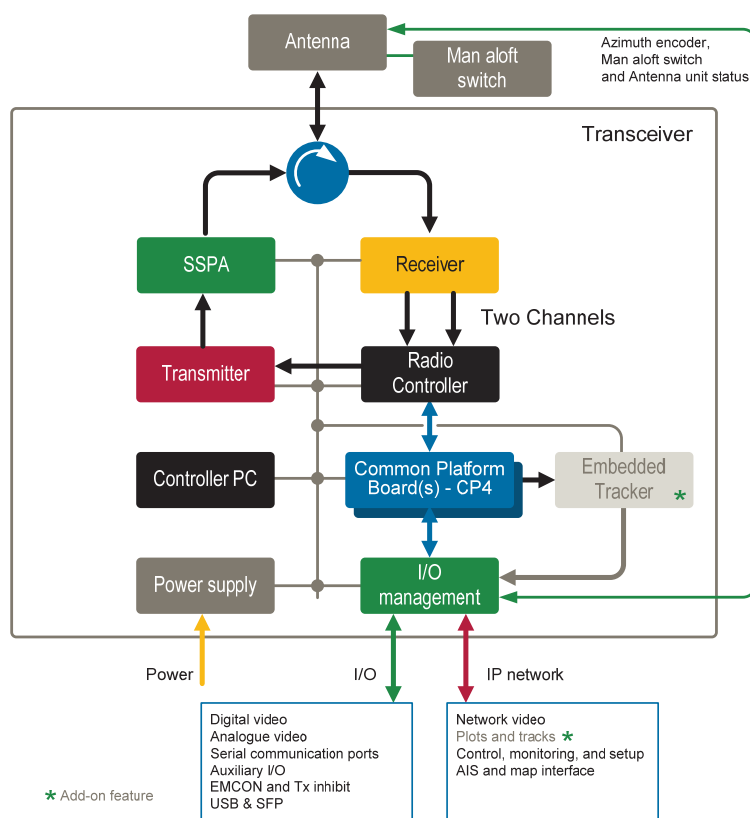
Fig. 3.1   Transceiver block diagram

The receiver has two channels in order to support simultaneous reception of two frequency bands. The receiver sensitivity is dynamically and automatically controlled in range, in azimuth and over time. Optimum signal-to-noise performance is ensured by low noise amplifiers.

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In the SCANTER 5102/5202 the processing is done in the digital domain. The chirps are fed directly from the Digital to Analogue Converter into the RF mixer feeding the Solid State amplifier.

The signal returns are as early as possible converted from the analogue domain back to the digital domain, where all processing takes place.

Highly advanced proprietary processing techniques follow, providing normal radar video as well as Doppler processed radar video. Video is converted from linear to logarithmic before making it available for tracking and image presentation.

Embedded tracking is available as a plug-in module, making plots and tracks available on the IP network.

Integrated BITE functions perform continuous monitoring of the radar during start-up and operation. This includes temperatures, voltages, signal activity, key performance parameters etc. The receiver noise figure, forward and reverse power are used for performance monitoring.

3.1 Software-defined functionality

Multiple types of SCANTER radars utilize identical core software, which enables a high level of testability, ensures deployment flexibility and makes it easy to add new functionality.

A variety of radar signal processing techniques are available. Multiple functions, such as automatic adaptation to weather scenarios etc., are performed simultaneously. This, in combination with the use of multiple, identical and powerful, common platform processing modules, leads to the concept "software-defined functionality".

The entire processing structure is defined by software and functions relevant for the individual application and are invoked as appropriate. It is also possible to switch between different modes of operation by modifying both the synthesized transmit waveforms and receive signal processing tasks, even on the fly. Additional parallel coherent transmit and receive channels enables the video processing.

In summary, the radar transceiver is configured to the application scenario, and adaptation to the environment is highly automated.

3.2 SSPA - Solid State Power Amplifier

The SSPA - Solid State Power Amplifier - modules for the SCANTER 5102/5202 are designed using state-of-the-art MMIC (Monolithic Microwave Integrated Circuit) power transistor amplifiers.

3.2.1 200 watt/50 watt

Each Power Amplifier (PA module) consists of 8 power transistors. The PA amplifies the signal to be transmitted and produces 50 watt of microwave power. The output power from four PA modules is combined in one SSPA to produce the final output power of 200 watt. A short-range SSPA with a PA module producing an output power of 50 watt is also available.

The power sector mode feature allows the SSPA output power to be adjustable in azimuth sectors.

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Fig. 3.2   200 watt SSPA with 4 x 50 watt PA modules. Note that a 50 watt SSPA is also available.

3.2.2   SSPA graceful degradation

Careful integration of several power transistor modules ensures limited SSPA failure in the event of a loss of one or more individual power transistors.

This means that loss of a single or few power transistors will only result in marginal drop of performance. However, the power transistors loss will be reported by the BITE system. It is therefore possible to design a system with a margin allowing for one or more failed power transistor and postpone replacements until it becomes convenient.

The figure illustrates the relation between loss of modules, peak power and free space range performance of the radar.

The free space range performance assumes line of sight from radar to target and excludes any influence from propagation, clutter or precipitation.

shows that at 50% of power transistors in failure, 25% output power remains, however, 70% of the free space range is achievable.

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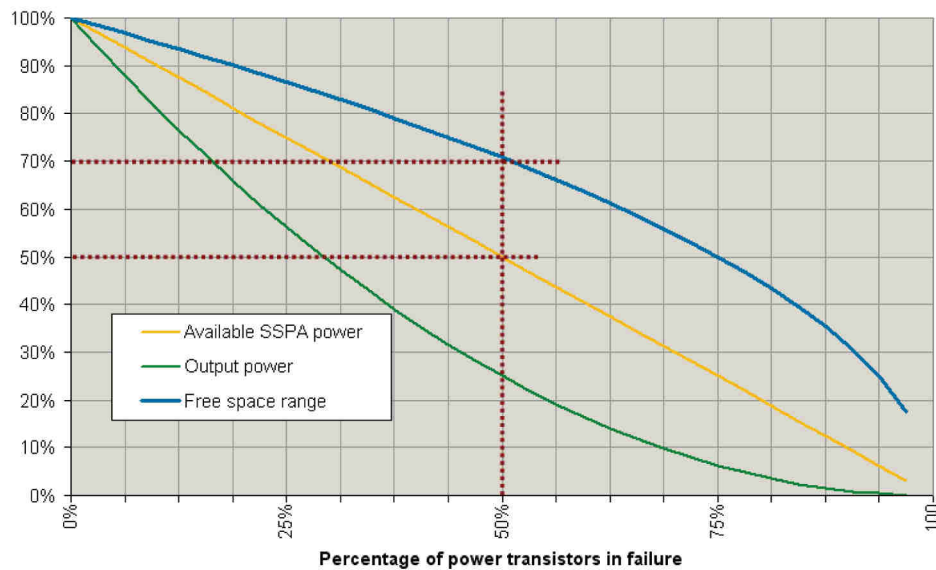
Fig. 3.3   Free space range and power vs. power transistor failure

3.3   Frequency diversity and time diversity

The effect of the Terma SCANTER frequency and time diversity capabilities is to improve the probability of detection of desirable targets by separating targets from clutter. This is achieved by illuminating the target with radar pulses in different frequency bands and integrating the received radar echoes. In combination with full coherence and pulse compression the radar images become crisp and clear.

The transceiver is capable of transmitting pulses in 16 frequency bands with instant frequency change from pulse to pulse. The receiver has two complete receiving channels, capable of simultaneous reception of two different frequency bands. Compared to single frequency transmission, the benefits from correlation, integration and time differences entail additional performance.

Targets can be simultaneously illuminated by more than one chirp in each pulse repetition interval, instead of simple frequency alternation (which is called FD by some manufactures). This is combined with proprietary processing techniques considering multiple chirp trains. Swerling case 1 targets is then seen as Swerling case 3 targets.

The return signals, corresponding to identical antenna directions, are combined using proprietary operations. The difference in squint and timing between the frequencies applied is corrected by alignment in azimuth.

Full benefit from the frequency diversity is obtainable only if dynamic characteristics are adapted to actual weather and complex clutter situations.

The sensitivity is therefore matched to the actual clutter levels, providing optimum detection at all ranges and in all directions.

On a SCANTER linear array antenna two different frequencies are transmitted in different angles (the angle difference is the squint, see Fig. 3.4 (p. 35)). Together with a rotating antenna this gives the time diversity.

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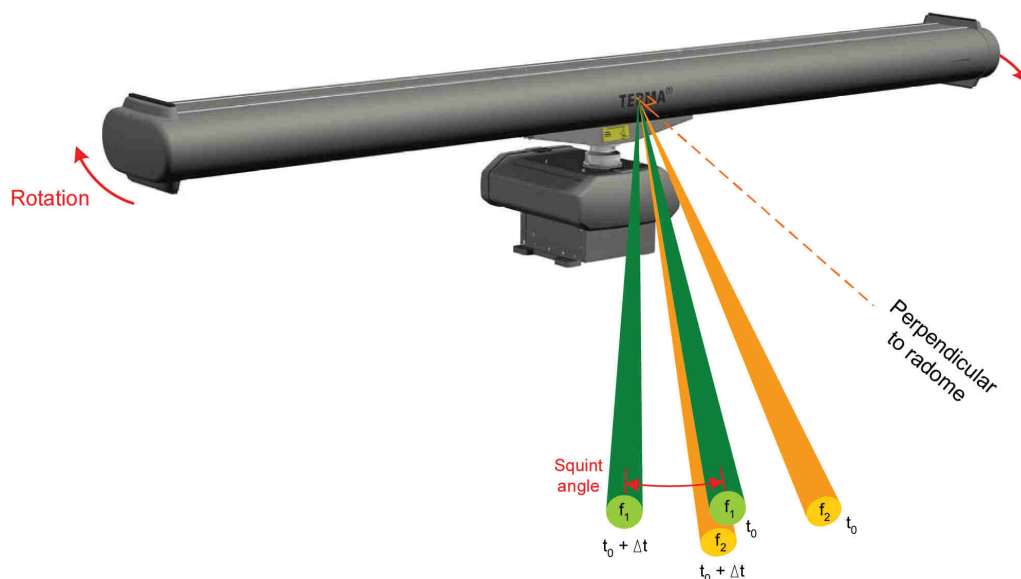
Fig. 3.4   Squint angle

The two returned signals are combined using proprietary operations and the clutter reduction for small targets in rough sea conditions is typically 6 – 10 dB. Due to the FD, improvement on target detection in other conditions or with antennas without squint (reflector types) is in the order of 6 dB.

Furthermore, receivers and the processing chain have sufficient dynamic range and all components provide sufficient resolution to handle the variety of signals coming from small and large targets at all ranges. This contributes substantially to provision of crisp and clear radar images in all weather situations. Furthermore, high resolution improves discrimination of clutter from wanted targets and thereby allowing the processing to separate targets from clutter.

3.4   Full coherency

The SCANTER 5102/5202 is fully coherent utilizing amplitude and phase information during transmission and reception. A common, phase-stable reference oscillator is used for transmission and reception. Coherency enables pulse compression and allows the receiver to compare the phases of the received echoes from chirp to chirp and thereby detect if targets are moving or not, utilizing the Doppler shift. Sub-clutter visibility is achieved for targets moving radial (moving in range) and with a speed different from clutter.

MTI is available as add-on feature. This improves detection of targets moving radial (moving in range) and with a speed different from clutter.

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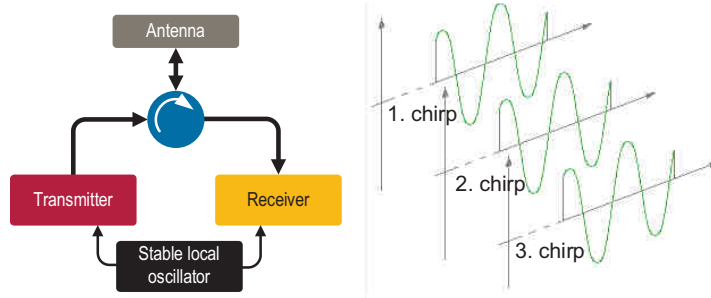
Fig. 3.5   Coherency principle

3.5   Pulse compression

While a magnetron-based radar is capable of transmitting many kilowatts of power, a solid state radar has a much lower peak power. In order to illuminate a target with sufficient energy for detection, it has to transmit much longer pulses. Unless some clever processing is used, this would lead to a significant loss of range resolution. The SCANTER 5102/5202 transceiver utilizes frequency modulation (chirping or frequency sweeping) and pulse compression to increase the range resolution as well as the signal-to-noise ratio. This allows for transmission of long frequency modulated pulses (chirps) with relative low peak power, and at the same time have sufficient average power and bandwidth.

When closely separated targets reflect these chirps, the frequency content of the echoes from different targets at a given time will be different as illustrated in .
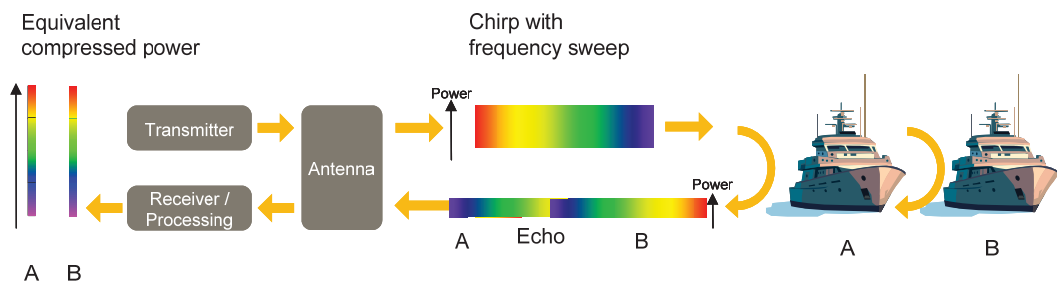
Fig. 3.6   Frequency sweep

By pulse compression, the signal-to-noise ratio is improved by the pulse compression gain or a factor, equivalent to the chirp length times the effective bandwidth of the transmitted chirps.

A special feature of the pulse compression technique is that the resulting radar sensitivity to noise is independent of the resolution bandwidth. The resulting signal-to-noise ratio is therefore proportional to the transmitted power divided by the overall receiver noise figure. In consequence, the bandwidth can be selected freely e.g. to minimize the clutter power, bearing in mind that too fine a resolution will introduce a range-straddling loss. In other words, the radar sensitivity is determined by the transmitted power (chirp or pulse length), as in normal pulse radar, but the resolution can be selected freely.

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A drawback from the transmission of long chirps is an extended minimum range – the radar is blind during transmission. This is compensated by the radar being capable of producing a mixture of short, medium and long chirps to cover both short and long range. See .
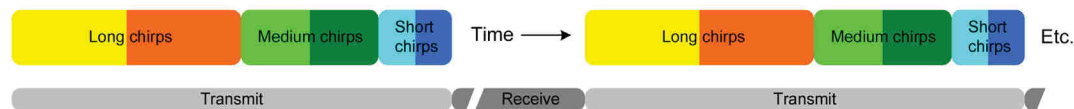
Fig. 3.7   Principle of transmission sequence

Up to 16 sub-frequency bands can be used and the sequence of pulse patterns is fully software defined and can be adapted to the actual situation and the chirp combination (transmission sequence) is defined as part of individual profile set-ups.

By nature, pulse compression will create time side lobes in a radar image. These are imperfections in range, where a target will appear with "artificial" targets before and/or after the actual target. Similar effects, called antenna side lobes, can appear in azimuth.

Side lobes are unwanted, as they will limit the size of a small RCS target that can be detected next to a large RCS target. The ratio between the peak level of the target and the highest time side lobe is called the Peak Side Lobe Ratio (PSLR).

Traditionally this may be a severe limitation in pulse compression radars. However, a new proprietary approach that overcomes this has been developed for the SCANTER 5102/5202 radar. The result is that time side lobes are strongly reduced, in the order of 60 dB.
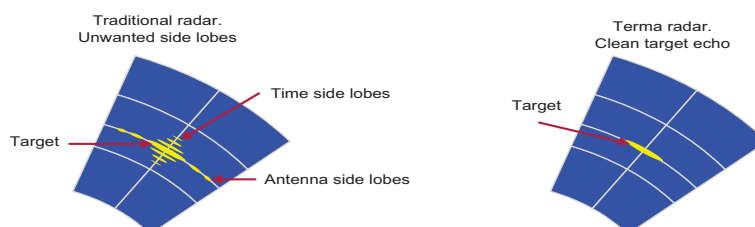
Fig. 3.8   Before and after side lobe processing

3.6   Power sector transmission

In order to avoid interference from strong echoes from large stationary targets like buildings, mountains or ship superstructure and to reduce the risk of interfering with other X-band systems, a power sector mode is available. This feature allows definition of up to 16 individual user defined sectors where the transmitted power can be controlled. Each sector is defined as either:

- Prohibit sector

- Transmit sector

- Reduced power sector

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The sectors are aligned relative to either ships heading or north.

Prohibit sectors take precedence over transmit sectors.

For the transmit sectors the power may be attenuated by up to 16 dB in each sector, thus providing a mode with low RF emission.

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3.7 Sub-clutter visibility and Doppler-based processing

Sub-clutter visibility in the transceiver is obtained by discrimination of speed based on the Doppler shift in the received coherent signal.

The transceiver supplies two channels at the same time: Normal radar and MTI radar.

Stationary targets such as earth ground clutter (land, buildings, etc) will be dominant at zero or low Doppler frequencies, while targets with faster radial speed will produce higher Doppler shifts.

Stationary targets and clutter are suppressed by the use of a series of proprietary adaptive MTI filters and correlators. In addition special proprietary algorithms adopts the filters to the speed of sea and rain clutter, suppressing clutter even if it is moving, all resulting in the clean crisp display of moving targets only. See Fig. 3.9 (p. 39).

Land clutter   Shoreline   Moving target   Trails
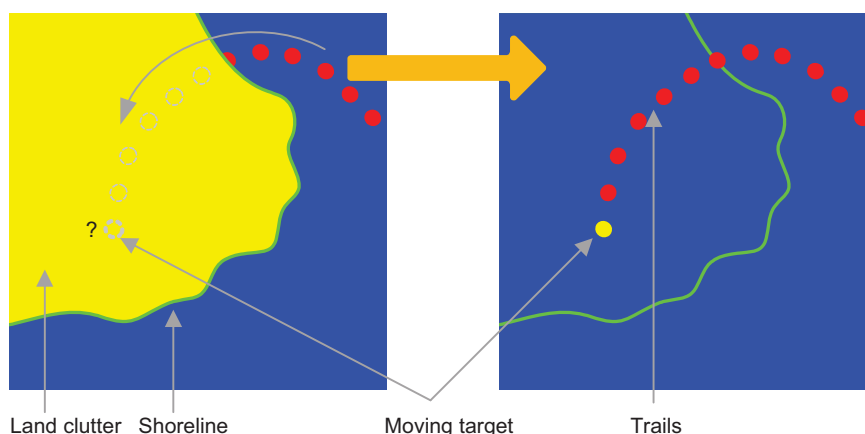
Fig. 3.9   Before and after utilization of the Doppler shift

3.7.1 Enhanced surface target detection

For surface radar applications, the utilization of Doppler information is substantially different from the techniques used for air surveillance:

- Speed differences between targets and surroundings are much smaller and discrimination is therefore less efficient.

- Targets of interest on the surface will often move tangentially or with low radial speed for prolonged periods and in such cases they will be completely suppressed.

- Most small surface targets have radar cross section virtually independent of their aspect angle. Therefore large echoes can not be expected for small tangentially moving surface targets.

Surface surveillance radars relying too much on Doppler information may therefore appear as unstable in operation and detection. In consequence, the SCANTER radar series utilize both:

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- Basic detection of surface targets based on non-Doppler processed (Normal Radar) signals. E.g. with proprietary scan-to-scan correlation techniques.

- Supplementary utilization of Doppler processed signals for detection of surface targets is added in applications where additional performance can be obtained.

The best of that detected in the two channels is automatically selected. An intelligent combination of the two channels are forwarded for presentation and tracking.

3.8 Video processing

After down conversion in the receiver, the signal is sampled with 14 bit at high speed, demodulated, pulse compressed and MTI processed. Normal radar video as well as MTI processed video are forwarded for display and tracking through the video processing as shown in Fig. 3.10 (p. 40).
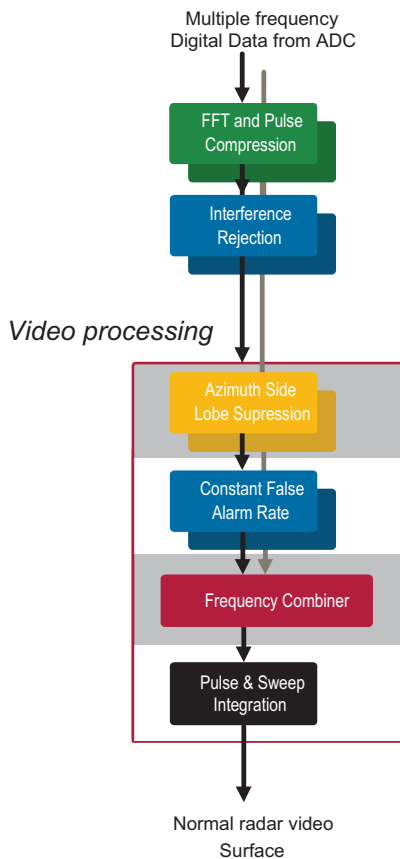
Fig. 3.10 Signal processing, simplified

The processes include automatic adaptation to the environment. Smart channel combiner and interference filtering suppresses asynchronous interferences and second/multiple time around returns, as staggered transmission sequences are used.

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The Doppler processing will simultaneously suppress stationary targets as well as moving clutter. The MTI is compensated for own unit movements and the speed and propagation movement direction of clutter is automatically determined using Terma proprietary algorithms.

Auto adaptive parameter settings are used in the filters, in the frequency diversity combiners and in the integration processes to omit beam shape losses and other losses as well as to optimize sensibility.

Signals are converted from linear to logarithmic as part of the processing.

Several techniques have been combined into the video processing, which facilitates discrimination of targets of interest from noise based on statistical properties in the signal.

3.9 Environment adaptation

A false alarm is an erroneous radar target detection caused by clutter, noise or other interfering signals exceeding the detection threshold. In general, it is an indication of the presence of a radar target when there is no valid target.

The CFAR – Constant False Alarm Rate – and other adaptation techniques provide automatic adjustments such as false alarm rate, i.e. it provides a flat noise floor - also based on proprietary algorithms.

Antenna side lobe suppression is an integral part of the CFAR functions. The SCD - Sea Clutter Discriminator - is an example of other adaptation processing.

3.10 Controlling and using the radar

3.10.1 Local and remote control

The radar can be controlled and monitored in several different and parallel ways.

- On the transceiver itself, a display and buttons are mounted, from where IP settings, errors etc. can be accessed locally.

- On the Service Display, a software package connects to the transceiver via an IP network connection. From the software package all parameters, settings, BITE measurements and errors can be accessed. Furthermore, an advanced Radar Image Viewer (RIV) is included.

- Via an open IP network protocol, all parameters, settings, BITE measurements and errors can be accessed.

Radar video is available as analogue video, digital 8 bit LVDS video and TCP/IP network video.

3.10.2 Profiles

Profiles are predefined parameter sets used to set optimal transceiver performance according to varying weather conditions or specific operational demands.

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Thus, the 16 available profiles allow the operator to adjust the radar system transmission mode and/or receiver processing in a fast and reliable way.

The profiles eliminate the risk of maladjustment of the radar and reduce the operator need to acquire detailed knowledge about radar characteristics and meaning as such.

At any time, the operator may set a specific radar parameter, e.g. pulse width, to override the definition of the profile.

The profiles are selectable via the Service Display or per remote IP network.

3.10.3 Built-in Test Equipment (BITE)

Continuous status monitoring of a significant number of parameters/signals on each module is performed in real time by the housekeeping system. The status of the parameters/signals is internally assessed to initiate appropriate actions automatically to maintain operation to the extent possible if an error is detected.

The BITE reporting, see , clearly describes the actual event or error and relates it to a specific module, i.e. no need for translation of code numbers. The details of these reports will allow identification to the level of the Line Replaceable Unit at fault.
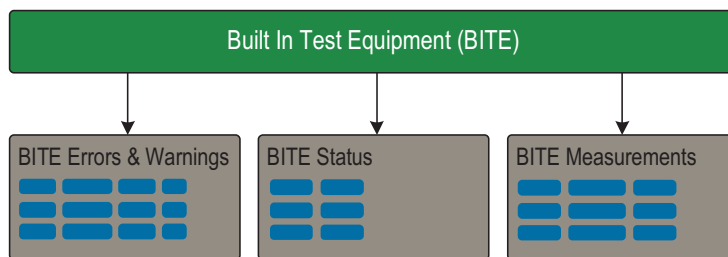
Fig. 3.11 Built-In Test Equipment (BITE)

At power up, the following diagnostic tests are performed:

- Module presence test.
- Data Link test.
- Memory test of all RAM circuits.

The BITE monitors the system during standby and operation and reports the following:

BITE errors/warnings:	Signal activity and processes.
	Internal supply voltages.
	Noise figure, internal voltages and temperatures.
	Forward power.

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	Status from motor, gear and optional inputs providing antenna status.
BITE status:	Displays transceiver components status
BITE measurements:	Temperatures.
	Internal power supplies.

If parameters exceed specifications, warnings or error messages are automatically issued to the various human user interfaces available i.e. both on the control panel on the front of the transceiver and across the LAN interfaces.

3.10.3.1 BITE - errors/warnings

Errors and warnings are used to report the presence of abnormal conditions detected by the transceiver software and include the following information:

Title:	The title of a BITE error/warning is a short text indicating the abnormal condition and/or the transceiver component to which it applies, e.g. "Main fan", "High temperature", etc..
Description:	The description of a BITE error/warning is a text that can be used to provide the system operator with an understanding of the context of the abnormal condition, e.g. "FPGA High Temperature Fatal Error # SP1" indicates that the core temperature of the first FPGA (SP1) on the processing board in slot 1 has exceeded the allowed maximum rating.
Severity:	The severity of a BITE error/warning is used to indicate the impact of the abnormal condition on transceiver operation. There are three categories of severity and beside that warnings: **Fatal error, critical error and error.** A "fatal error" shuts down the system and a "critical error" stops transmission.
Priority:	The priority of a BITE error is used to indicate the relative importance of an error compared to other errors of the same severity.

3.10.3.2 BITE status

These messages indicate the state of transceiver components or entities of importance to the operational state of the transceiver, e.g. TX Status "On" / "Off".

3.10.3.3 BITE measurements

BITE measurements are used to periodically report a numerical measurement in the transceiver and includes the following information: Title, description and value.

Measured parameters include noise figure, forward and reverse power, temperatures, voltages etc. For each measured parameter, configuration of lower limit, upper limit, maximum update interval and precision are defined.

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3.10.3.4 BITE logging

Logging of BITE errors and warnings, BITE status and BITE measurements is performed and data is stored in an allocated area of the hard disc on the PC controller board. See .
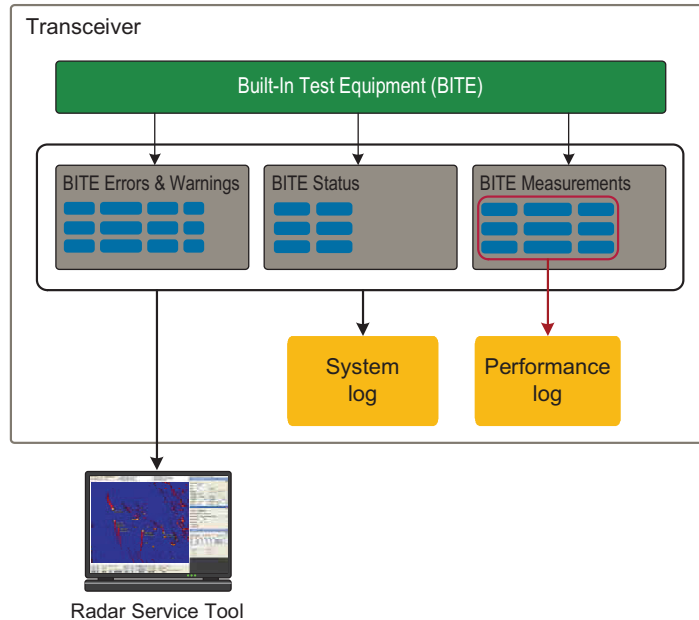
Fig. 3.12 System and performance logs

A change log approach is used meaning that BITE errors, warnings, status and measurements are logged in case of a changed value or a changed state.

Furthermore, there is a performance log, where performance parameters such as noise figure, forward power, etc. are measured periodically and not just in case of a value change.

Overheating at one or more of the temperature test points will issue a warning or error message and critical overheating will result in automatic shut down.

Automatic shutdown is either based on autonomous HW circuitry or a SW controlled shutdown based on the BITE system.

The power supply unit includes a mains check functionality (HW), that shuts off the system if the mains input exceeds the specified limits in terms of voltage level and frequency. Furthermore, the unit includes a thermal switch that shuts down in case of a hazardous temperature.

The BITE errors and warnings have a severity property which is used to take action on the BITE errors. One of these actions is to shut down in case of a "Fatal error" e.g. an over-temperature in a unit.

All the BITE and measurements data are remotely available on the proposed maintainer's laptop facility.

True graceful degradation will only be obtained with a redundant system. Some units are based on a design that yields a kind of graceful degradation e.g. the Solid State Power Amplifier with parallel coupled power groups.

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The system will however be able to run with degraded performance as long as the severity of BITE errors are not "fatal error" or "critical error" as these shut down the system or stops transmission.

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4   Hardware modules

4.1   Transceiver building blocks

The transceiver consists of the building blocks shown below, parted up in a radio section and a processing section.

The building blocks are as shown in the following illustration.

SSPA
Amplifies the signal before transmission. The SSPA is available in a short (50 W) and long range (200 W) version.

WG Assy
The interface between the transmitter, receiver and antenna. It includes an antenna, circulator and a static STC/ Limiter function.
Furthermore a coupler for reverse power monitoring and isolators for matching.

Blower Assy
Includes two fans for ventilation inside the cabinet

PC Controller Board
PC board that hosts an PC and an optional tracker.

Common Platform 4
Processing board consisting of four FPGA's and dedicated memory. Connects to the motherboard through two VXS connectors. A CP4 board also contains a PCIe switching for data switching between the internal four FPGA's.
The frame can hold up to 4 CP4 boards.

PSU
1400W power supply with mains switch and display

External I/O
Includes all external interfaces. Includes a FPGA to handle the control and video/ redundancy support etc.

Interconnection PCB

WG, SSPA

RxTx
Performs up- and down conversion of the signals in transmitter and receiver chains. Includes the synthesizer part, which generates LO signals and clock signals. The adaptive calibration signals are looped internally in RxTx block.
The RxTx is implemented on one PCB board with signals from x-band to low IF.

RxTx Control
Provides the interface to the processing section. It generates the baseband transmission signal which is upconverted in the RxTx, gained in the SSPA, transmitted through the antenna, received and downconverted in the RxTx before sampling is done in the RxTx controller. Control of the timing and signal processing are also carried out in the RxTx controller.

Frame Assy
The Frame Assy consists of the structure holding all processor boards - the motherboard is included as well and hosts the connections to PC boards and the CP4 boards. Furthermore, it interfaces to the radio section, the power supply and the external I/O board. The high speed data transmission between the radio section and the processing section is implemented as PCIe through copper. Hence, the motherboard includes PCIe switch circuitry.

Fig. 4.1   Transceiver building blocks

To the system also the Antenna Control Unit (ACU) should be mentioned as this is always a part of the application.

The ACU takes care of controlling the antenna rotation speed based on the parameter settings in the transceiver.

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4.1.1 Transceiver block schematic
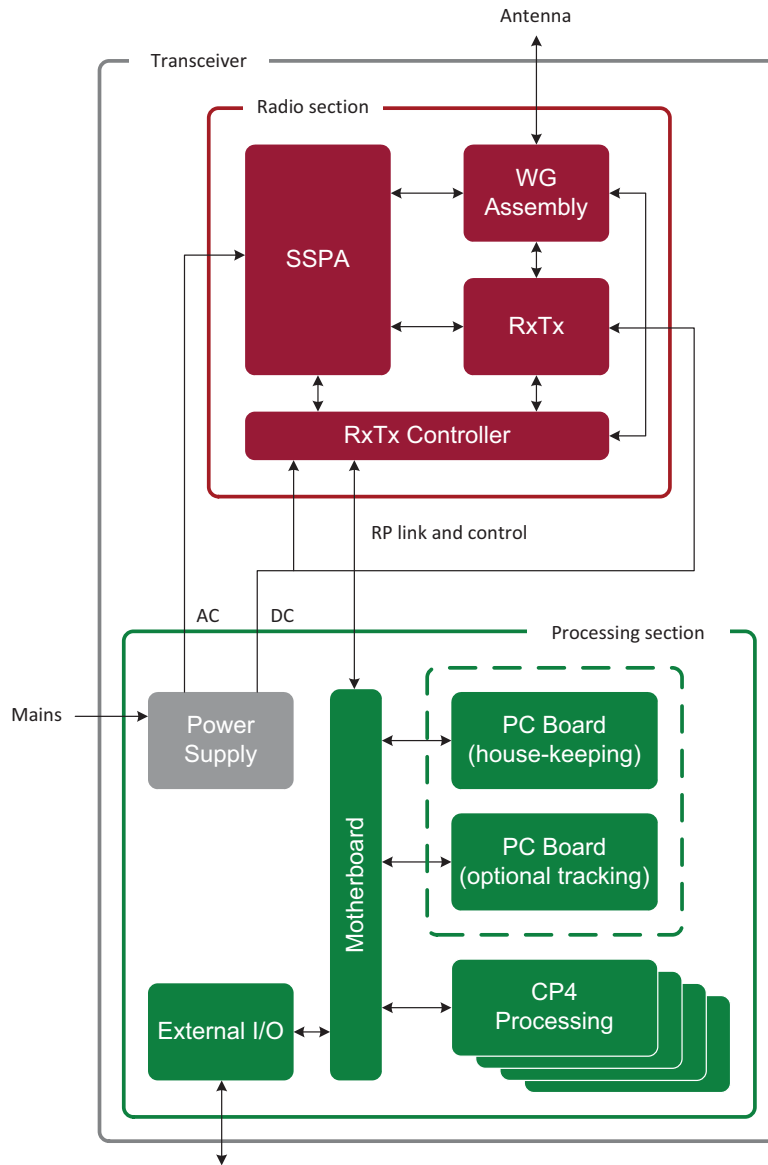
Fig. 4.2   Block schematic

4.1.2 Part numbers, modules

Part numbers for all transceiver modules as well as for the radar system and consumables, are listed in section 7.2 (p. 112).

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4.2 Hardware structure

4.2.1 Internal cabling

Fig. 4.3 Internal cabling

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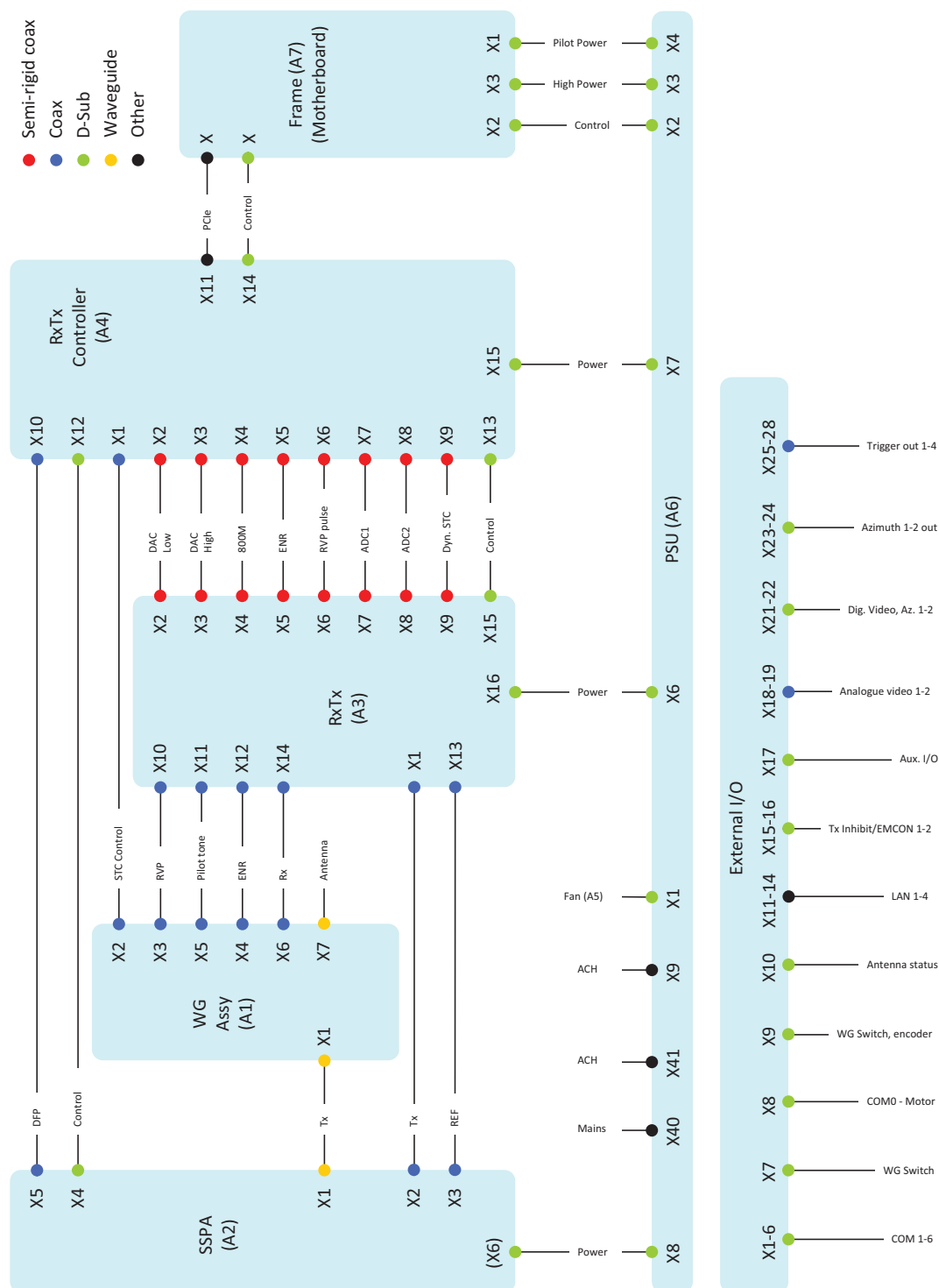
4.3 Modules

4.3.1 SSPA - Solid State Power Amplifier

The SSPA (Solid State Power Amplifier) modules for the SCANTER radars are designed on the basis of state-of-the-art power transistors. See Fig. 4.4 (p. 50).
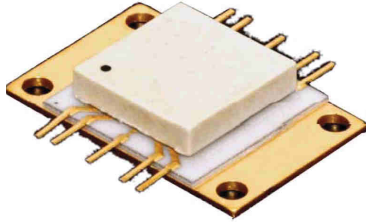
Fig. 4.4   Power transistor

Each power amplifier (PA module) consists of 8 power transistors. The PA amplifies the signal to be transmitted and produces 50 W of microwave power.

The SSPA output power is adjustable in azimuth sectors.The peak output power may be reduced by up to 16 dB.
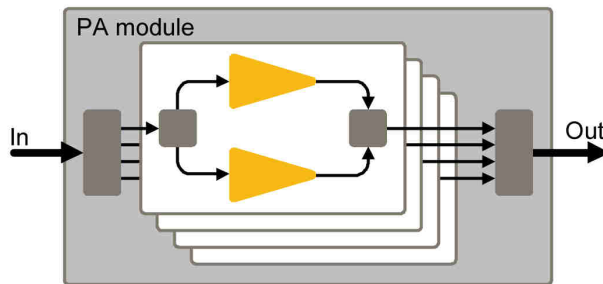
Fig. 4.5   50 W SSPA module

4.3.1.1 SSPA description

The SSPA basically amplifies the pulsed X-band transmission signal from the RxTx to an appropriate power level. The output power level is measured with a logarithmic detector circuit.

The SCANTER 5102 SSPA is a short-range version producing 50 W output power, and the SCANTER 5202 SSPA is a long-range version producing 200 W output power. The latter combines four 50 W PA modules.

Both SSPA versions consist of boards mounted on a common profile. The integrated waveguide power combiner is also mounted on the profile.

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Fig. 4.6   SCANTER 5102/5202 SSPA module - 4 x 50 W PA modules

Block schematics of the two versions are shown below:
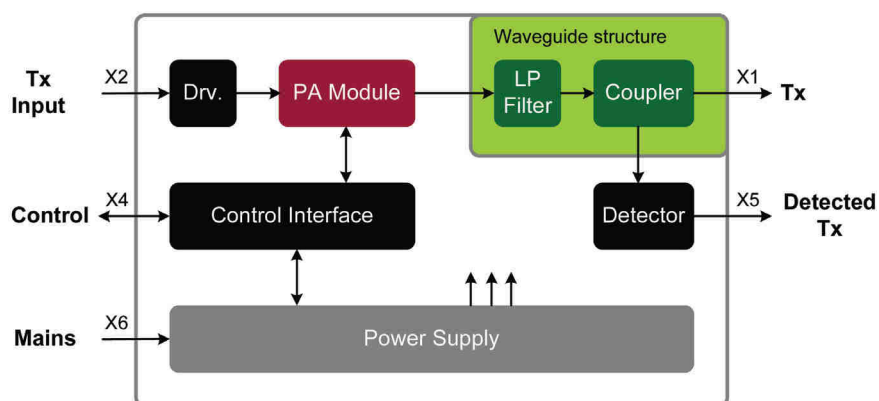
Fig. 4.7   SSPA 50 W
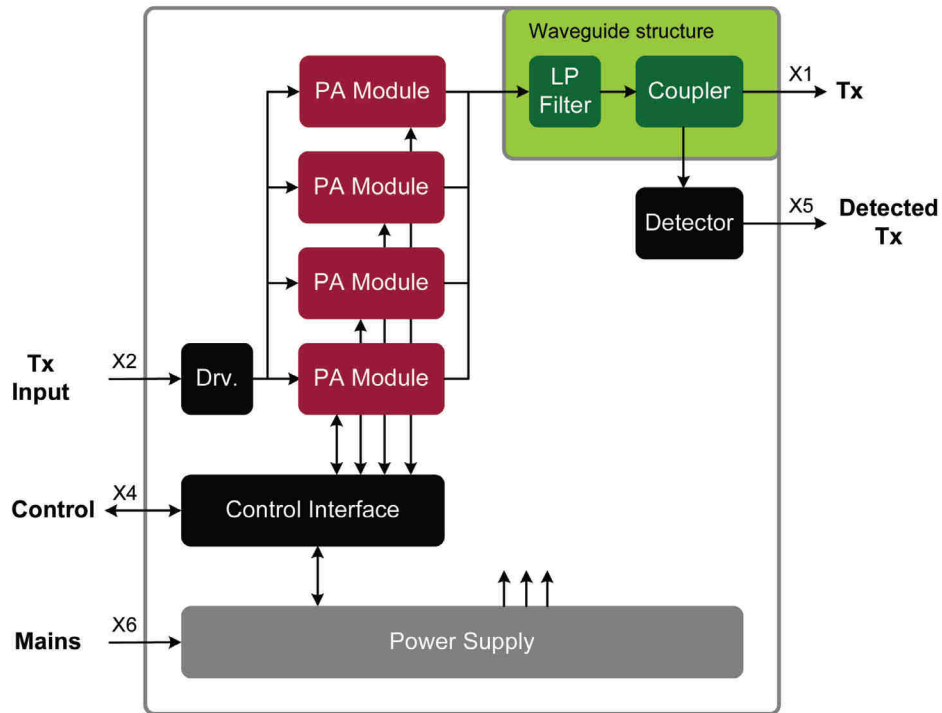
Fig. 4.8   SSPA module - 200 W

Mains is connected directly to the SSPA, and a power supply is creating all necessary supplies for the module. The local power supply is shown below. When the safety relay is energized, mains is applied a filter, rectified and passing a power factor correction before it is applied three DC/DC converters to generate the final power supplies.
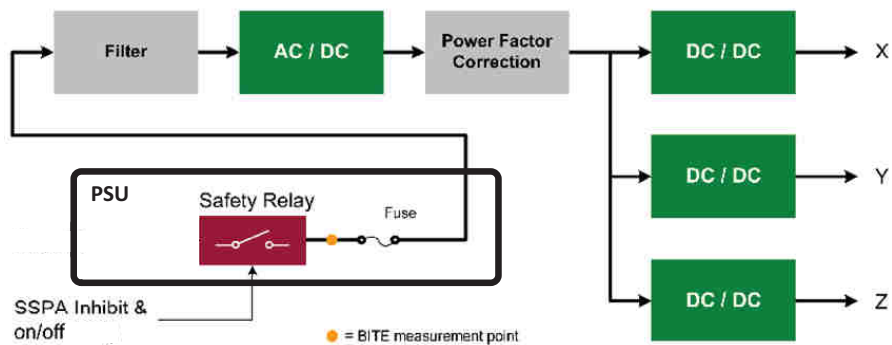
Fig. 4.9   Power supply, SSPA

A control interface is controlling the output transistors so these are turned on during transmission and turned off during reception. At the same time, the control interface is controlling how many transistors are turned on (and also the phase shift between the transistors); for example, if it is necessary to decrease the power in one or more sectors.

Via an I²C connection to the SSPA module, the following information is available:

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- Temperature on all PCBs.

- Current consumption on each regulated voltage.

- Voltage level of the most important regulated voltages.

- Status of the negative power supplies on the PA module(s).

- Fault status.

Physical data for the SSPA as follows:

	Short-range SSPA
Part number	386255-002
Output peak power	50 W
Power consumption (@ 20% duty cycle)	120 W
Weight	11 kg
Dimensions h x w x d (foot print)	352 x 217 x 189 mm

	Long-range SSPA
Part number	386250-002
Output peak power	200 W
Power consumption (@ 20% duty cycle)	410 W
Weight	11 kg
Dimensions h x w x d (foot print)	352 x 217 x 227 mm

4.3.1.2   Reliability

There is no need for periodic replacement of Solid State amplifiers as required if using magnetrons or other tube transmitters. In addition, low-voltage power supplies replace the high-voltage supplies needed for magnetron technology. It is therefore commonly assumed that Solid State transmitters are virtually maintenance free and that logistic support is like computer electronics. However, this is not necessarily the case.

Failure mechanisms for high power microwave components are different to those in the computer industry and continuous reliable operation requires dedicated methods during design and operation.

4.3.2   **Waveguide Assy**

The waveguide assembly is mounted between the SSPA power amplifier and the output flange to the antenna which is located on top of the cabinet. The waveguide assembly includes various test and calibration ports.

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Waveguide Assy	Conn.	Function
	X1	Waveguide (SSPA)
	X2	STC Control
	X3	Measurement port
	X4	Test port
	X6	Rx port
	X7	Waveguide (antenna)
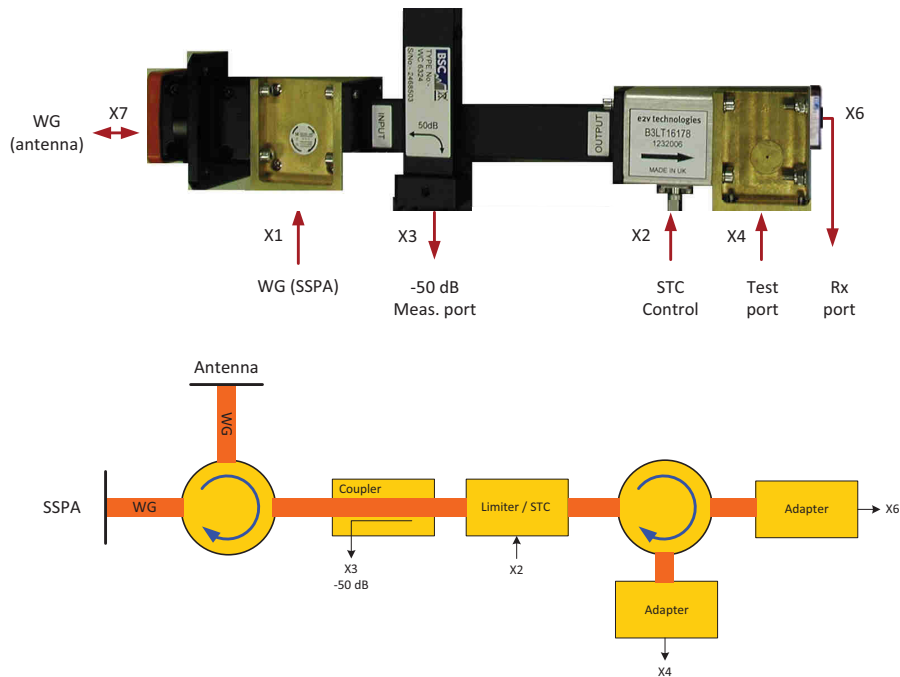
Fig. 4.10 Waveguide assy - block schematic

In the block schematic in Fig. 4.10 (p. 54), the RF signal from the SSPA is applied to a circulator and guided to the antenna.

The received signal from the antenna is applied to the same circulator and guided through a cross coupler where a -50 dB signal is available.

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After the coupler, the received signal is applied to the Limiter/STC, where attenuation of the signal takes place - the Limiter/STC is able to attenuate the signal with up to 40 dB.

The signal passes a second circulator before it is available for the receiver. Two adapters are mounted on this circulator to change the connections from waveguide flanges to SMA connectors.

4.3.3   RxTx

The RxTx is part of the Radio Section in the transceiver. The RxTx is connected to the RxTx controller and the SSPA. The functionality of the RxTx includes:

- Tx up converter.

- Rx down converter.

- Frequency synthesis circuitry.

- A VCO which provides the local oscillator signals in the Rx and Tx chains.

- A Tx chain attenuator supports TX reduced transmit power in sectors.

- The RxTx provides system clock to the RxTx Controller.

- Measurement system for monitoring noise figure, forward and reverse power.

The position of the RxTx in the system is shown in .

Fig. 4.11 RxTx

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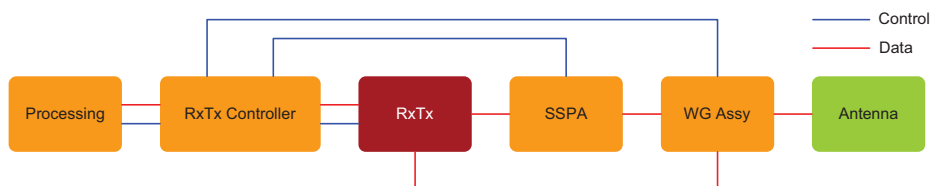
RxTx Module	Conn.	Function
	X1	TX out
	X2	DAC Low
	X3	DAC High
	X4	800 MHz CTRL
	X5	Noise DAC
	X6	Rev. Power Env.
	X7	RX ADC1
	X8	RX ADC2
	X9	STC2
	X10	Rev. power in
	X11	Pilot WG
	X12	Noise out
	X13	TX Ref.
	X14	RX in
	X15	Control
	X16	Power

The I/O categories to and from the RxTx are shown in .
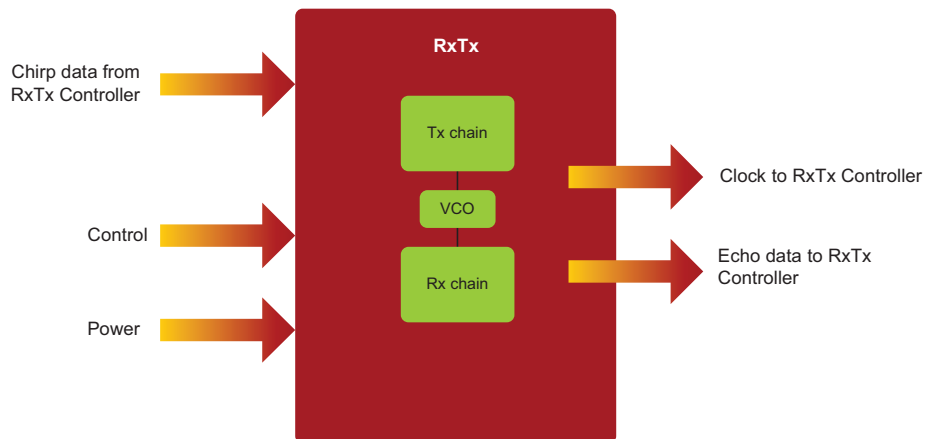
Fig. 4.12 Signal categories to and from RxTx

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4.3.4 RxTx Controller

The main tasks of the RxTx controller are:

- Communicate with the processing section via a PCIe interface.
- Generate two channels of chirp signals modulated to a carrier frequency.
- Generate dynamic and static STC.
- Generate a signal for the RxTx noise diode.
- Sample the received radar signal in two channels.
- Sample reverse power.
- Control the RxTx.
- Handle the radar timing sequence and to control the SSPA.

The position of the RxTx controller in the system is shown in .
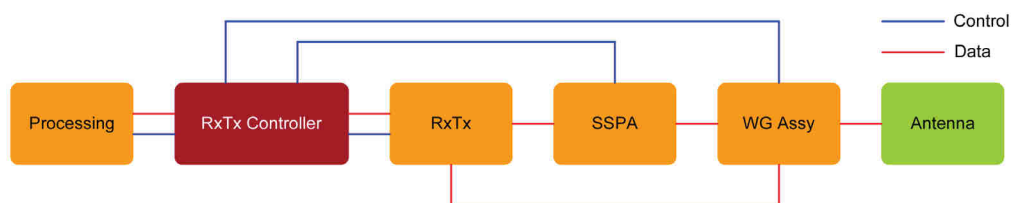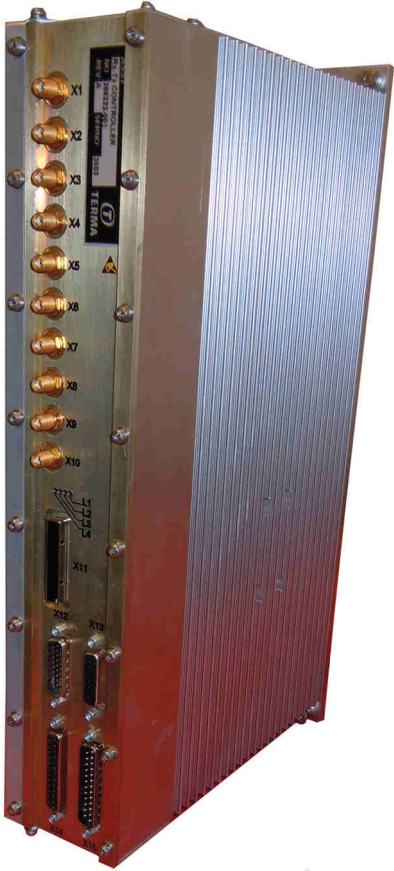
Fig. 4.13 RxTx Controller in the system

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RxTx Controller	Conn.	Function
	X1	Static STC output
	X2	Low band
	X3	High band
	X4	Reference Clock
	X5	Noise diode output
	X6	Reverse power input
	X7	Rx echo data input
	X8	Rx echo data input
	X9	Dynamic STC output
	X10	Forward power
	X11	PCIe
	X12	RxTx control
	X13	SSPA control
	X14	Control signals
	X15	Power input

The I/O categories to and from the RxTx controller are PCIe, control, power, chirp data to RxTx, echo data from RxTx, transceiver control and transceiver clock as shown in .
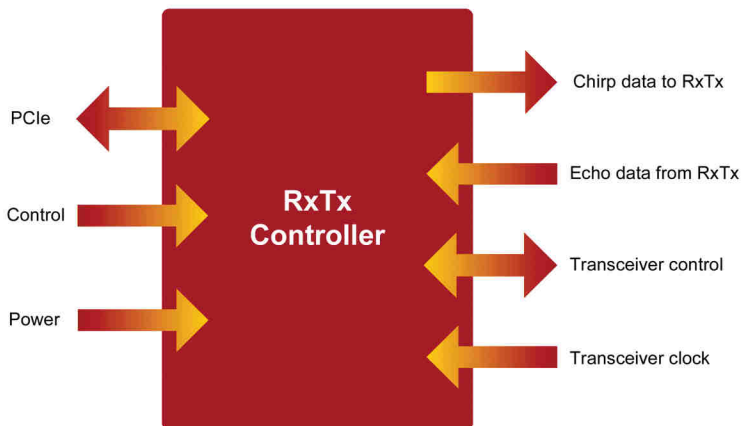
Fig. 4.14 Signal categories to and from RxTx Controller

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4.3.5 Blower Assy

Fig. 4.15 Blower assy

4.3.6 Frame Assy/Motherboard

The motherboard is a part of the Frame Assy and is one unit - the spare part "Frame Assy" also includes the motherboard.

The motherboard is part of the SCANTER 5102/5202 transceiver processing section. The processing section consists of - besides the motherboard - up to five CP4 processing boards, the External I/O Board, and the PC Controller Board (with up to two PCs on-board).

The motherboard is mounted vertically at the back of the frame. The PC Carrier Board and the CP4 Boards are plug-in modules, mounted in slots in a crate. See .

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Fig. 4.16 Frame assy, shown with Ext. I/O and a CP4 board
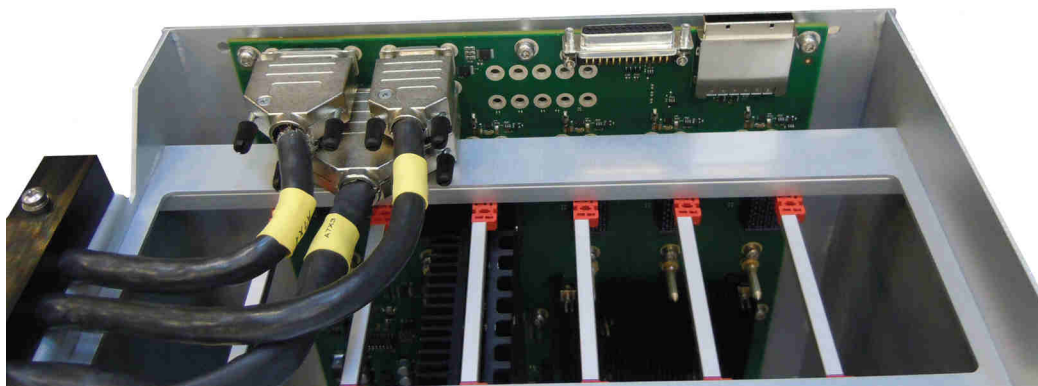
Fig. 4.17 Motherboard and connections shown in frame assy

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The block schematic for the motherboard and its peripherals is shown in Fig. 4.18 (p. 61) - the external interfaces are:

- PC Controller board interface (VITA 46.4, PCIe x4 + x4).

- 4 x CP4 interfaces (VITA 46.4, PCIe x8).

- PSU board power (12 V pilot and 12 V).

- PSU board control signals.

- External I/O board power (through Interconnection PCB).

- External I/O board control signals (through Interconnection PCB).

- External I/O board PCIe x8 (through Interconnection PCB).

- RxTx Controller control signals.

- RxTx Controller PCIe x8.

- 1 x USB interface (through Interconnection PCB).

- JTAG.
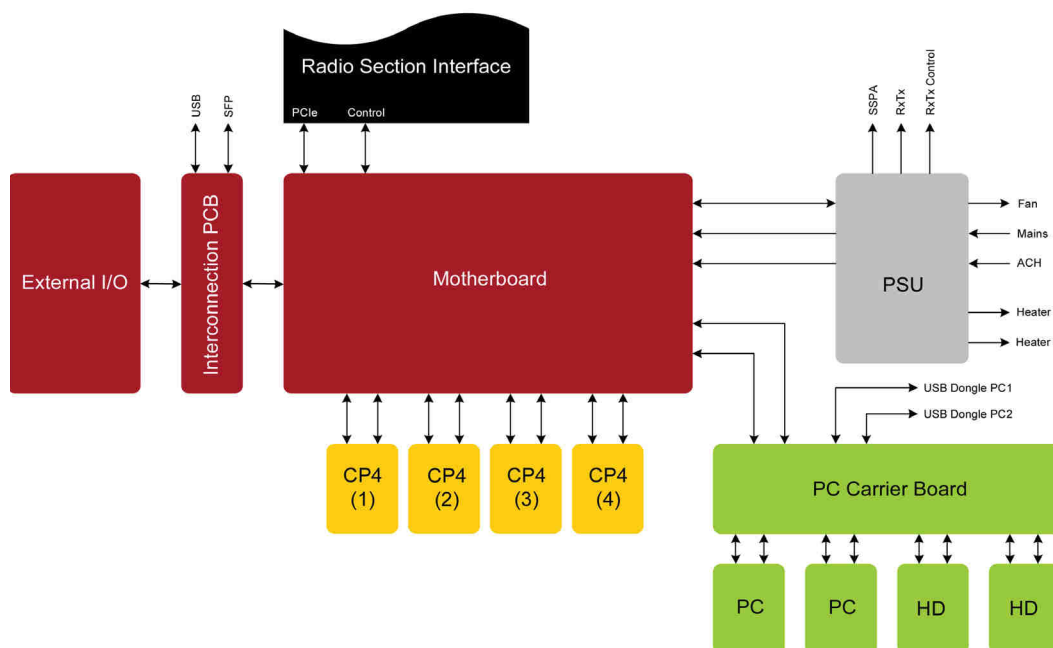
Fig. 4.18 Motherboard and surrounding units

The motherboard uses the VITA 46 keying system. This prevents a plug-in module from being inserted into a wrong slot. The keying system consists of three alignment keys in each slot position. Each key has five different angular positions.

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There are six different keying devices for the plug-in modules: five that match each of the allowed angles of the backplane keying pin plus one type which allows for the plug-in module keying device to be mated with the backplane pin, no matter the angle (an un-keyed module).
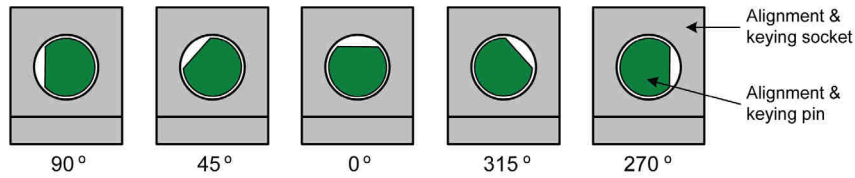
Fig. 4.19 Keying of modules

The PC Controller board has a 315º keying and the CP4 boards have a 0º keying.

4.3.7 PC Controller Board

The PC Controller Board contains two PC Boards, two SSD, two RJ45 connectors for LAN interface, EEPROM, battery holders, JTAG connector, two USB connectors for onboard memory sticks, two USB connectors for keyboard and mouse interface, and two VGA connectors.

Fig. 4.20 PC Controller Board
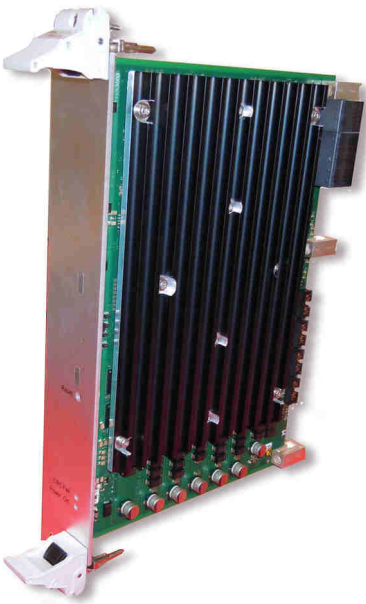
The PC Controller Board is based on a medium performance processor. It comprises the PCIe root complex, handles the PCIe initialization and uses the PCIe bus to upload new firmware to CP4 boards, External I/O Board, and the RxTx Controller. Furthermore, it also controls the display, the push buttons, the BITE system and initializes the processing in the CP4 boards and RxTx controller.

On the PC Controller Board, a battery takes care of supply to the real time clock on the two PC boards. Battery type is Varta Lithium, size CR ½AA. The battery capacity is 950 mAh.

The battery needs to be replaced after 7 years.

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4.3.8 Common Platform 4 (CP4) Board

The crate in the transceiver can hold four Common Platform 4 (CP4) boards - the task of the CP4 board is to process the video coming from the RxTx controller and depending on the required processing 1 to 4 boards can be mounted. The boards are connected to the RxTx Control module with a PCIe bus.

Common Platform 4 Board	Front	Function
	Reset	The cut-out in the middle of the front plate gives access to a reset button.
	Power OK	A green LED on the front tells that power to the board is OK.
	Fail	A red LED indicates that an error has occurred.

The CP4 board consists mainly of four FPGA's (Field Programmable Gate Array) which take care of all signal processing - each FPGA has its own memories, SDRAM, SRAM and Flash.
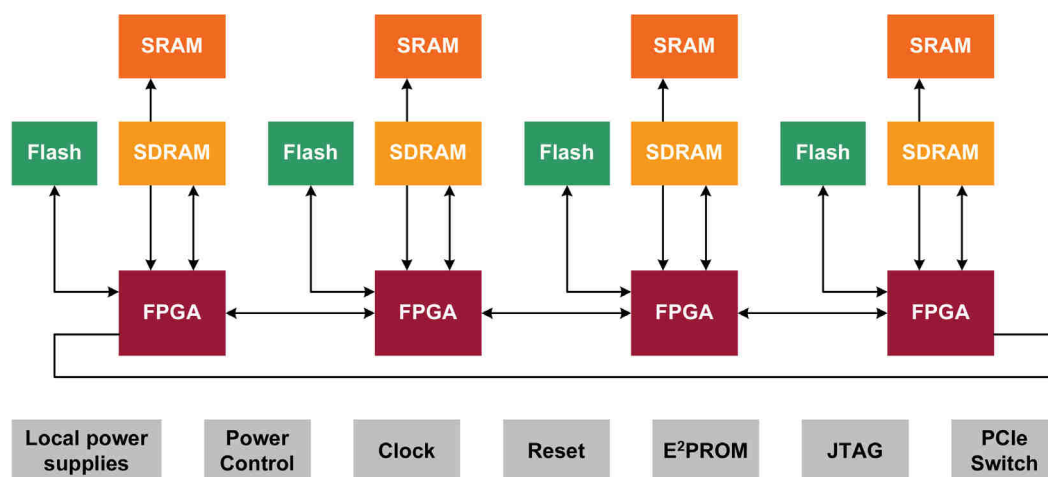
Fig. 4.21 CP4 board, block schematic

The board produces its own local power supplies, based on +12 VDC.

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4.3.9 Power Supply Unit (PSU)

The power supply unit, located in lower left corner of the cabinet, supplies all modules in the transceiver - the SSPA is applied and is generating its own local supplies.

Beside the power supplies, the PSU has a local BITE circuit to measure voltages and temperatures and it also holds - on the front - a display, a mains switch, and four push buttons for human interface to the transceiver and for status indication.

4.3.9.1 Connections

Power Supply Unit	Conn.	Function
	X1	Fan and pressure sensor
	X2	Motherboard, control signals
	X3	Motherboard, high power
	X4	Motherboard, pilot power
	X6	RxTx, power
	X7	RxTx Controller, power
	X8	SSPA, AC power
	X9	ACH, AC power (optional) Heater, power (optional)
	X40	Mains, AC power
	X41	ACH, AC power (optional)

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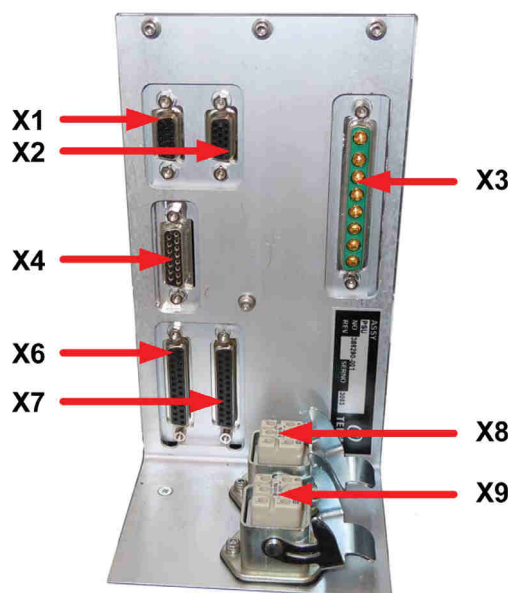
Fig. 4.22 PSU connections, top
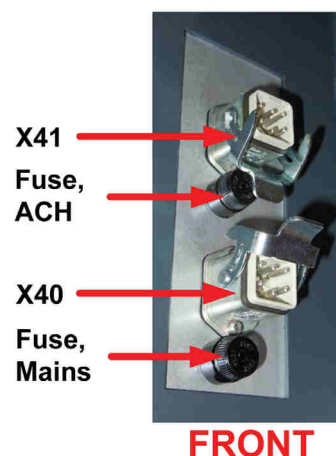
Fig. 4.23 PSU connections, bottom

4.3.9.2 Block Schematic, Supplies

Referring to mains is applied - when turning the mains switch on and presuming the fuse is not blown - to a relay controlled by a circuit which is checking the mains supply and the temperature in the PSU. This means, if some limits are exceeded, it will not be possible to turn on the transceiver (if the temperature is below 0º C, the heater will be turned on and in that way ensure temperatures above 0º C).

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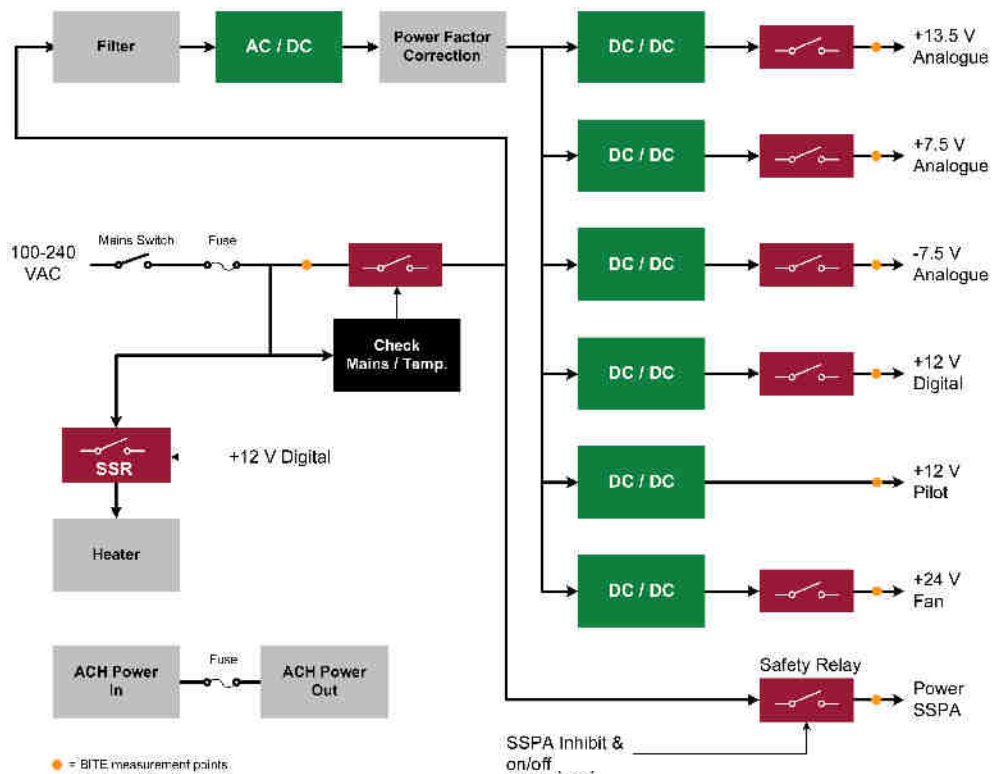
Fig. 4.24 Block schematic, supplies, PSU

The limits are:

Parameter	Minimum	Maximum
Temperature in PSU	0º C/ 32º F	85º C/ 185º F
Mains voltage	90 VAC	264 VAC
Mains frequency [Hz]	47 Hz	63

Not exceeding the above mentioned limits, mains is applied to the SSPA module (which produces its own supplies) and to the mains filter. The filter ensures that no noise is radiated back to mains and at the same time it reduces spikes that may be in the mains supply voltage.

After having passed an AC/DC converter and a Power Factor Correction circuit, a DC voltage is applied six DC/DC converters, which are producing all necessary DC voltages. The voltages will not be present at the connected modules before the relay is energized. Only the +12 V Pilot is available all the time as this supply voltage is used to wake up the display, giving the possibility to start up the transceiver.

The power consumption for each supply voltage (for a fully equipped transceiver, (i.e. two PCs and 5 CP4 modules) is shown in the following table.

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Supply voltage	Approx. power [W]
Mains, AC (SSPA module)	450
+13.5 V (RxTx)	47
+12 V (RxTx Control, 5 x CP4, 2 x PC)	420
+7.5 V (RxTx, RxTx Control)	31
-7.5 V (RxTx, RxTx Control)	6
+12 V Pilot (Motherboard, I/O, 2 x PC)	126
+24 V (Fan)	41

4.3.9.3   Block Schematic, SPI and I2C buses
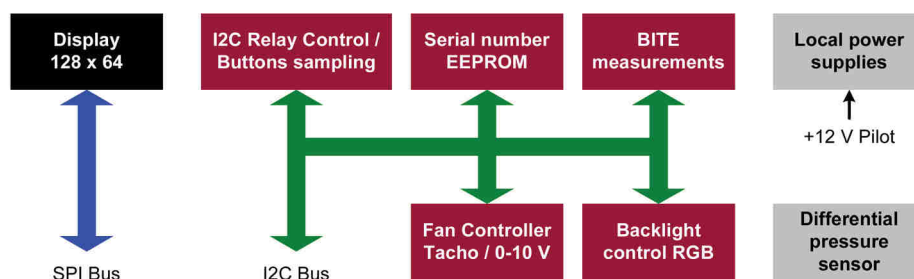
Fig. 4.25 Block schematic, SPI and I2C buses, PSU

Apart from the generation of power supplies, the PSU also includes a processor-based part to take care of the human interface, BITE logic and fan control.

This part produces local supplies based on the +12 V Pilot. As a future option, there is a circuit to monitor the pressure out of the fan (a differential measurement to monitor the air flow).

A SPI bus is controlling the 128 x 64 display, while an I2C bus is connecting functions as BITE measurement, control of the backlight color in the display, detection of activated buttons, fan speed monitoring and control of relays in the PSU.

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4.3.9.4 Operator's Panel

The display has several functions:

Read-out of errors and warnings.

The bottom line of the display dedicates functions to the four software definable keys just below the display.

The backlight of the display tells about transceiver status:

Cold white backlight indicates that the transceiver is booting.
Red backlight indicates errors or warnings.
Yellow backlight indicates warnings.
Green backlight indicates that everything is running OK.
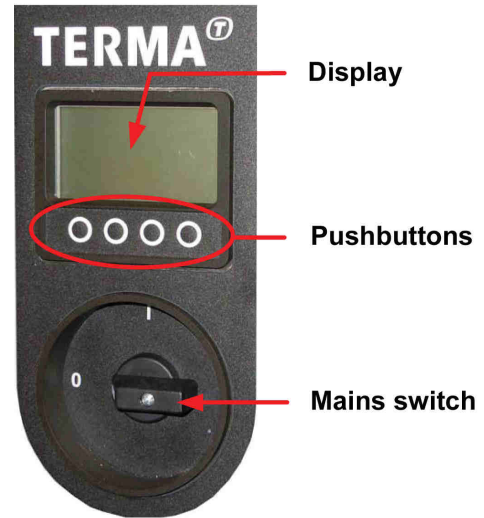
Fig. 4.26 Display and buttons

Each push button is located inside a white ring. The ring has a light green backlight to indicate physical position in darkness.

The functions of the buttons are determined by the text in the display (software defined). Typical functions are "Left" and "Right" to navigate between the menus, and "Select" and "Exit" to navigate up and down in the menu hierarchy.

The mains switch is placed below the four push buttons and is used to switch ON or OFF.

4.3.10 External I/O Board

The External I/O Board handles all communication going to and from the radar. It provides radar video on LAN, digital video, and control and timing signals to external Terma equipment or external third party equipment.

The External I/O Board hosts the connections for all external access to the SCANTER 5102/5202 radar sensor. This includes LAN video, digital video, analog video, antenna rotation data, man aloft switch, ACU, GPS, meteorological system and miscellaneous communication interfaces such as RS-485, RS-232, RS422, and LAN.

All connections are accessible at the bottom of the cabinet. The I/O Board is supplied from the motherboard with +12 V Digital and produces itself necessary local supplies.

All inputs and outputs of the I/O Board are controlled by a FPGA with an included UART.

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4.3.10.1   Connections

External I/O Board	Conn.	Function
	X1-X4	COM 1-4 (COM 1 not connected)
	X7	Waveguide switch
	X8	Motor Communication, COM 0
	X9	Waveguide switch and Encoder
	X10	Antenna status
	X11 - X12	LAN 1-3 (LAN 1 not connected)
	X15 - X16	Tx Inhibit / EMCON
	X17	Aux I/O
	X18 - X19	Analogue Video Output
	X21 - X22	Digital Video and Azimuth Output
	X23 - X24	Azimuth Output
	X25 - X28	Trigger Output
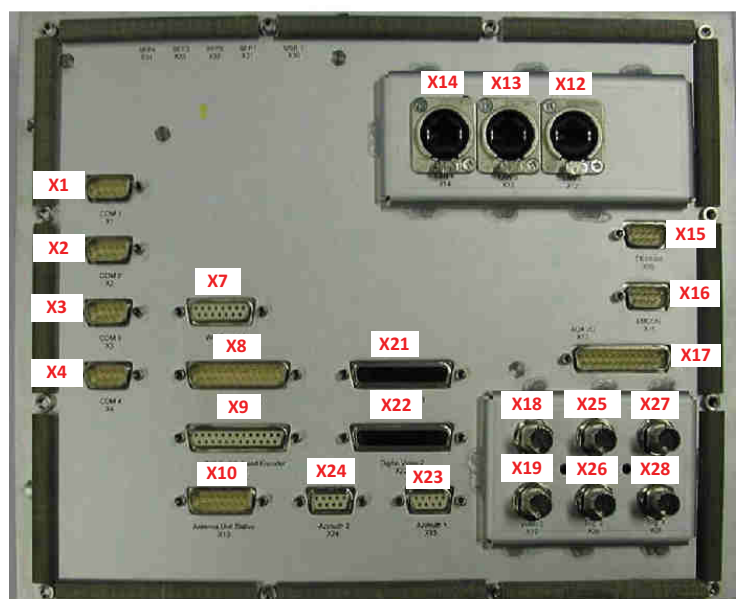
Fig. 4.27 External I/O, connections

4.3.10.2   X1 - X4, COM 1 - 4

The serial communication is galvanic isolated. The protocol can be selected as RS422 or RS232. The default protocol is RS422.

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Description	Data or Settings
Communication speed	1200 - 115200 bps
Interface standard	RS422 or RS232, galvanic isolated
Bit Rate	1200, 2400, 4800, 9600, 19200, 38400, 57600 or 115200 baud
Data bits	8
Parity	No, Even or Odd
Stop bits	1 or 2
Connector	D-Sub 9, male

Terminal	Function RS232	Function RS422
1	NC	Transmit data Tx+
2	Transmit data TxD	Transmit data Tx-
3	Receive data RxD	Receive data Rx+
4	NC	Receive data Rx-
5	Return 0 V	Return 0 V
6	NC	NC
7	NC	NC
8	NC	NC
9	NC	NC

4.3.10.3   X7, WG Switch

X7, Waveguide Switch, can be used to control a switch in the antenna or in a redundant configuration. The outputs are short circuit protected (3 Amps.).

Description	Data or Settings
Number of outputs	1
Waveguide switch signal	+28 V ± 1 V
Tell back signal	+24 V +1/-2 V
Output	Relay output 28 VDC. Pulse 2 sec. Diode protected. Max. 3 A.
Connector	D-Sub 15, female

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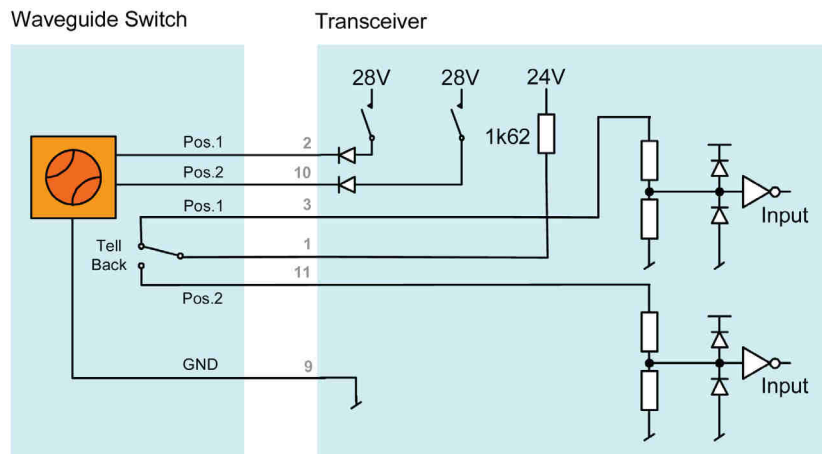
Fig. 4.28 Waveguide switch X7

Terminal	Function	Terminal	Function
1	24 VDC output	9	GND
2	Position 1	10	Position 2
3	Tell back position 1	11	Tell back position 2
4	NC	12	NC
5	NC	13	NC
6	NC	14	NC
7	NC	15	NC
8	NC		

4.3.10.4   X8, Motor Communication, COM 0

X8 includes serial communication to the motor controller, antenna ON signal and the safety loop.

Description	Data or Settings
Communication speed	1200 - 115200 bps
Interface standard	RS485, galvanic isolated
Format	RS485, balanced line, baud 9600, 8 bits, no parity, 2 stop bits½
Safety loop	External switch
Connector	D-Sub 25, male

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Terminal	Function	Terminal	Function
1	+24 VDC	14	ACU fault p. 2 (safety loop)
2	ACU fault p.1 (safety loop)	15	RS485-
3	RS485+	16	NC
4	RS485 common	17	Motor start pin 2
5	Motor start pin 1	18	Motor start pin 4
6	Motor start pin 3	19	NC
7	NC	20	NC
8	NC	21	NC
9	NC	22	NC
10	NC	23	NC
11	NC	24	NC
12	NC	25	NC
13	NC		

4.3.10.5 X9, Waveguide Switch and Encoder

X9 includes more than one function as it interfaces to a waveguide switch and the encoder.

The output for waveguide switch can be used to control the polarization switch in the antenna. The connector includes supply for the encoder (one per transceiver) and the encoder data.

Description	Data or Settings
Waveguide Switch:	
Number of outputs	1
Waveguide switch signal	+28 V ± 1 V
Tell back signal	+24 V +1/-2 V
Output	Relay output 28 VDC. Pulse 2 sec. Diode protected. Max. 3 A.
Connector	D-Sub 25, female (shared with encoder data)
Encoder:	
Antenna rotation rate	Up to 60 RPM
Pulses per revolution	ACPs: 4096 or 8192, ARP: 1

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Description	Data or Settings
Pulse width, ACPs and ARP	> 10 µs
Format	RS422A, balanced line
Encoder supply	+5 V adjustable. 5-7 VDC, max. 1 A.
Connector	D-Sub 25, female (shared with WG Switch)
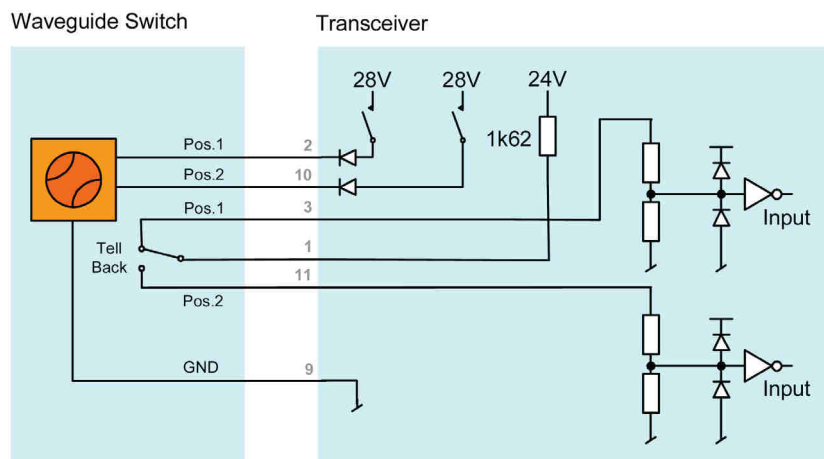
Fig. 4.29 Waveguide switch X9
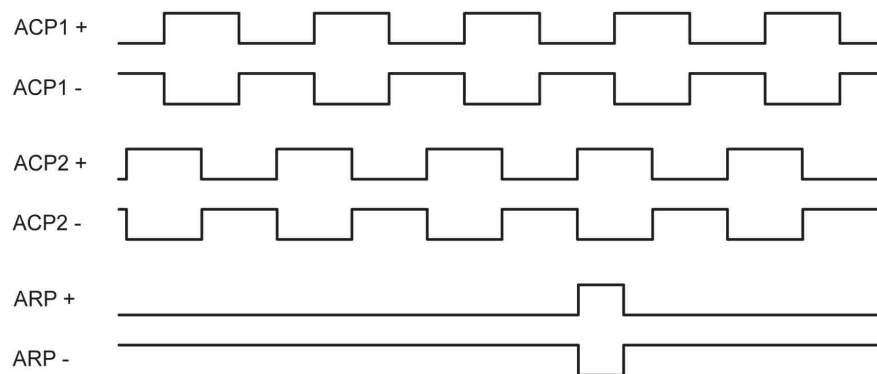
Fig. 4.30 Wave forms measured relative to GND. Antenna rotation CW

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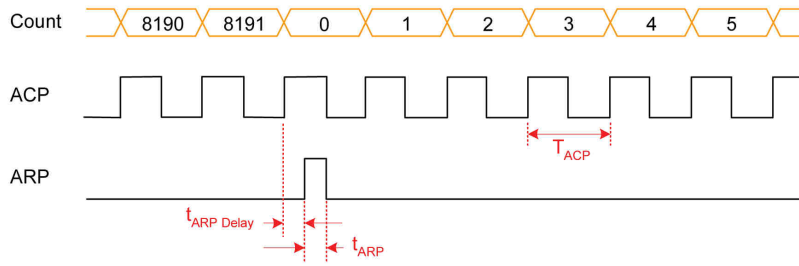
$$T_{ACP} = \frac{60}{Antenna\ RPM\ x\ Encoder\ pulses}$$

$$t_{ARP\ Delay} = 0.25\ x\ T_{ACP}$$

$$t_{ARP} = 0.25\ x\ T_{ACP}$$

Fig. 4.31 Azimuth timing

Terminal	Function	Terminal	Function
1	Encoder ACP2+ input	14	Encoder ACP2- input
2	Encoder ARP+ input	15	Encoder ARP- input
3	Power supply for encoder	16	Encoder power return. 0 V
4	Encoder ACP1+ input	17	Encoder ACP1- input
5	NC	18	NC
6	NC	19	NC
7	NC	20	NC
8	NC	21	NC
9	NC	22	Tell back, position 1
10	24 VDC output	23	Tell back, position 2
11	24 VDC output	24	GND
12	Position 1, WG switch	25	GND
13	Position 2, WG switch		

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4.3.10.6 X10, Antenna Unit Status

Signals from X10 include motor status, antenna gearbox status and safety loop status. The man aloft switch, which is a part of the safety loop, is included as well.

Description	Data or Settings
Interface	15 mA current loop
Loop resistance	Max. 100 Ohms
Motor temperature warning	External switch - normally closed
Oil level warning	External switch - normally closed
Oil temperature warning	External switch - normally closed
Motor protection (safety loop)	External switch - normally closed
Man aloft switch (safety loop)	External switch - normally closed
Connector	D-Sub 15, male

Terminal	Function	Terminal	Function
1	24 VDC	9	GND
2	Oil temperature warning	10	Motor temperature warning
3	Oil level warning	11	Reserved
4	Motor protection pin 1 (safety loop)	12	Motor protection pin 2 (safety loop)
5	Man aloft switch pin 1 (safety loop)	13	Man aloft switch pin 2 (safety loop)
6	NC	14	NC
7	NC	15	NC
8	NC		

4.3.10.7 X12-X14, LAN 1-3

For video and control interfaces, refer to SCANTER LAN video protocol.

Description	Data or Settings
Interface standard	Ethernet standard IEEE 802.3 10 / 100 / 1000 Base-T
Connector	RJ-45 Jack 8, with or without NEUTRIK NE8MC enclosure

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Terminal	Function	Terminal	Function
1	BI_DA+	6	BI_DB-
2	BI_DA-	7	BI_DD+
3	BI_DB+	8	BI_DD-
4	BI_DC+	SHELL	Shield
5	BI_DC-		

4.3.10.8   X15-X16, Tx Inhibit / EMCON

The two Tx Inhibit/EMCON inputs are hardware-controlled inhibit functions of the RF transmitter. Both inputs have a software tell back function.

Description	Data or Settings
Number of inputs	2
Tx Inhibit / EMCON input	External contact to GND. Max. 25 VDC when open. Max. 15 mA when closed.
Connector	D-Sub 9, male
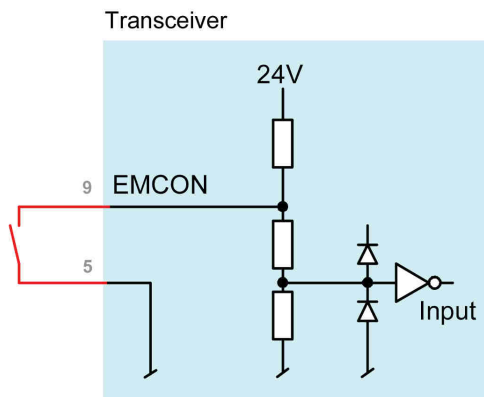
Fig. 4.32 Input circuit for Tx Inhibit

Terminal	Function	Terminal	Function
1	NC	6	NC
2	NC	7	NC
3	NC	8	NC
4	NC	9	Inhibit input
5	GND		

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4.3.10.9   X17, Aux. I/O

To control or monitor external equipment, 4 inputs and 1 output are available.The outputs are floating relay contacts.

The inputs sense a short circuit to AUX 0 V.

Description	Data or Settings
AUX input	External contact between AUX IN and AUX 0 V. Max. 25 VDC when open. Max. 15 mA when closed.
AUX output	Neutral contact. Max. 100 V, 1 A, 50 VA.
Connector	D-Sub 25, male
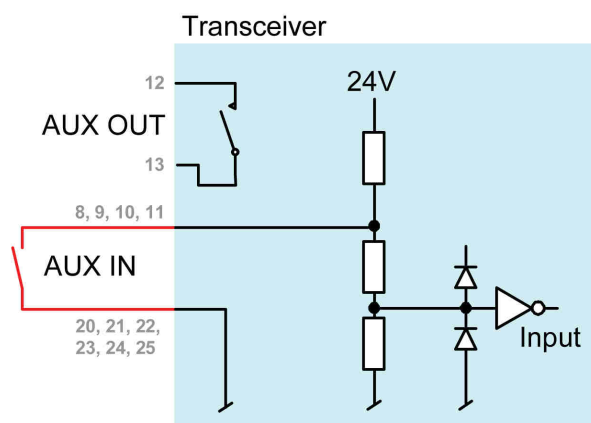
Fig. 4.33 Input circuit, AUX inputs/output

Terminal	Function	Terminal	Function
1	NC	14	NC
2	NC	15	NC
3	NC	16	NC
4	NC	17	NC
5	NC	18	NC
6	NC	19	NC
7	NC	20	AUX 0 V
8	AUX1 IN	21	AUX 0 V
9	AUX2 IN	22	AUX 0 V
10	AUX3 IN	23	AUX 0 V
11	AUX4 IN	24	AUX 0 V

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Terminal	Function	Terminal	Function
12	AUX1 OUT	25	AUX 0 V
13	AUX1 OUT		

4.3.10.10   X18-X19, Analogue Video Output 1-2

Description	Data or Settings
Number of outputs	2
Level	0-1 V_{peak} @ 50 Ohm nominal load, DC-level less than 0.05 VDC, or 0-5 V_{peak} @ 75 Ohm nominal load, DC-level less than 0.5 VDC. Levels are individually selectable for each output.
Connector	50 Ohm BNC

4.3.10.11   X21-X22, Digital Video and Azimuth Output 1-2

Description	Data or Settings
Number of outputs	2
Video resolution	8 bits
Format	12 x differential lines: 8 bit data, 1 D_En, 1 clock and 2 status bits EIA-644 (LVDS), max. 50 MHz output data rate
Video type	NR Ch. A, NR Ch. B, MTI selectable
Data rates available	12.5 MHz, 25 MHz and 50 MHz, selectable
Connector	D-Sub 44 HD, female

1	GND	16	GND	31	GND
2	ARP-	17	ARP+	32	GND
3	ACP-	18	ACP+	33	GND
4	Status1-	19	Status1+	34	GND
5	Status0-	20	Status0+	35	GND
6	Data_En-	21	Data_En+	36	GND
7	Clock-	22	Clock+	37	GND
8	Data7-	23	Data7+	38	GND

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9	Data6-	24	Data6+	39	GND
10	Data5-	25	Data5+	40	GND
11	Data4-	26	Data4+	41	GND
12	Data3-	27	Data3+	42	GND
13	Data2-	28	Data2+	43	GND
14	Data1-	29	Data1+	44	GND
15	Data0-	30	Data0+		

Digital video timing is shown on the following drawing.
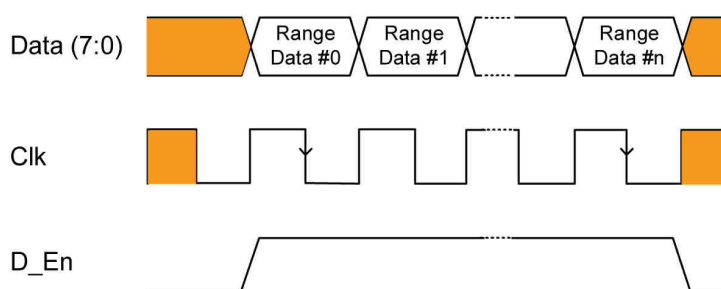
Fig. 4.34 Digital video timing

The leading edge of the D_En (data enable) is adjustable based on the T_0 trigger. The trailing edge coincides with the end of each radar sweep.

Retiming factor, status signals definition:

	Status1	Status0
Retiming factor 1	0	1
Retiming factor 2	1	0
Retiming factor 4	1	1
Retiming factor 8	0	0

4.3.10.12   X23-X24, Azimuth Output 1-2

The output follows the input of the antenna encoder corrected for installation offset and processing delay. The azimuth ACP output delivers 4096 or 8192 pulses per antenna rotation (depending on encoder type used) as well as one ARP pulse for each antenna rotation.

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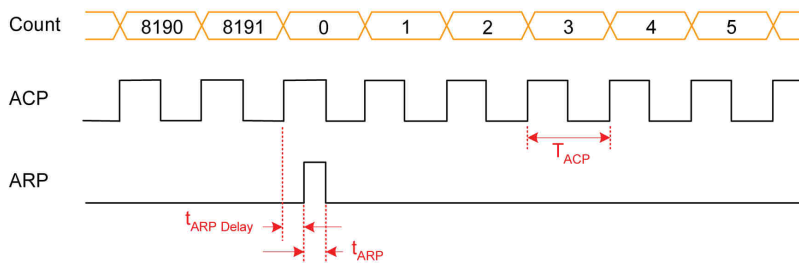| Description	Data or Settings
Number of outputs	2
Antenna rotation rate	As input
Pulses per revolution	4096 or 8192 ACPs and 1 ARP
Azimuth type	Antenna A, Antenna B, selectable
Pulse width, ACP and ARP	>10 µs
Format	2 x balanced lines, RS422
Connector	D-Sub 9, female

Terminal	Function	Terminal	Function
1	ACP+	6	GND
2	ACP-	7	GND
3	ARP+	8	NC
4	ARP-	9	NC
5	NC	SHELL	Shield

$$T_{ACP} = \frac{60}{Antenna\ RPM\ x\ Encoder\ pulses}$$

$$t_{ARP\ Delay} = 0.25\ x\ T_{ACP}$$

$$t_{ARP} = 0.25\ x\ T_{ACP}$$

Fig. 4.35 Azimuth timing specification

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4.3.10.13   X25-X28, Trigger Output 1-4

Description	Data or Settings
Number of outputs	4, each is individually programmable. The output can also be used for RF transmitting status and is programmable with pre-time of 100 µs in steps of 1 µs and a post-time of 100 µs in steps of 1 µs.
Amplitude	8 V ± 1 V
Drive capacity	75 Ohms nominal load, max trigger duty cycle is 15%
Trigger point definition	At low-to-high transition
Rise time	< 30 ns (10-90%)
Connector	50 Ohms BNC
Cover Pulse Functionality	The output X25 can further be used as a "Cover Pulse" when configured as such by software set-up. In this case, the pulse can be programmed with a maximum blanking lead time = 1µs and a maximum blanking lag time = 500ns. This means the pulse is active during the complete transmit cycle of the radar with a duty cycle of up to 20% (plus lead/lag times). Otherwise, the output specification is unchanged from the above.

4.3.11   Antenna Control Unit (ACU)

The antenna control unit (ACU) is a separate cabinet for mounting directly on a wall - this could be the cabinet alone - or for mounting on an optional aluminum frame. Inside the cabinet is the frequency converter, a fan, a mains switch, terminals to connect incoming cables (through stuffing tubes at bottom), and space for an

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optional brake kit. The closed and open cabinet is shown in Fig. 4.36 (p. 82) and Fig. 4.37 (p. 82), respectively.
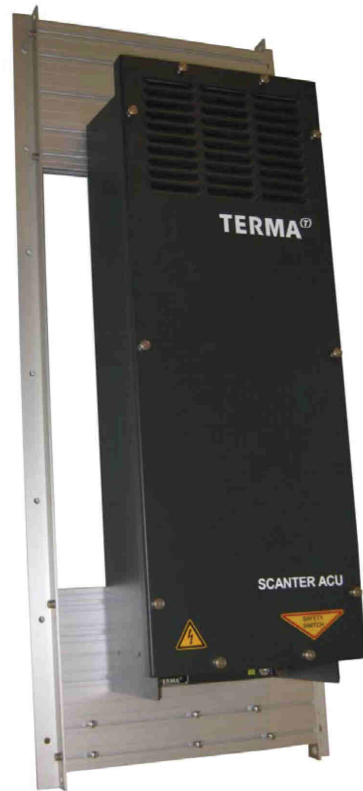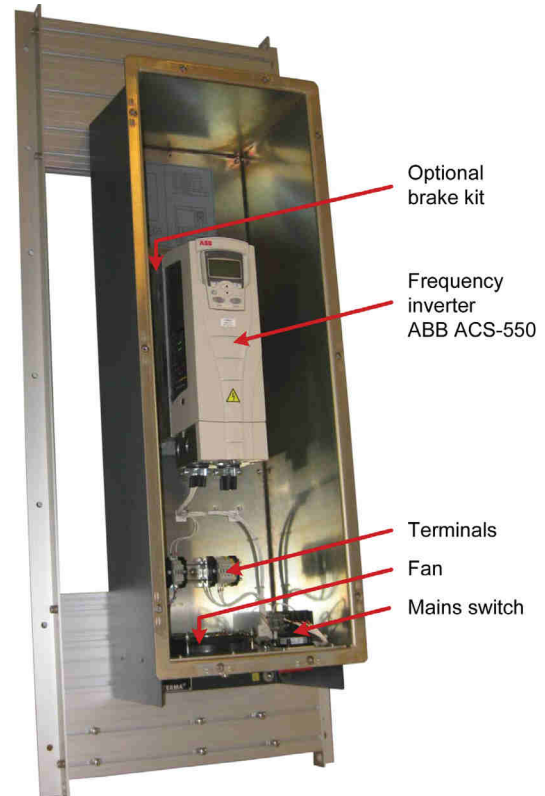

Fig. 4.36 Antenna Control Unit

Fig. 4.37 Antenna Control Unit, open

4.3.11.1   ACU variants

The cabinet is available with a standard ABB frequency converter and depending on power supply and motor size, four variants are available.

SCANTER antenna type	ACU supply [VAC]	Drive power [kW]	Motor power [kW]	Motor conn.	Motor current [A]	Max. current [A]
Compact 50 Hz	3 x 400	1.1	1.1	Y	2.7	6.0
Compact 50 / 60 Hz	1 x 230	1.1 / 1.1	1.1 / 0.9	Δ / Y	4.6 / 3.9	16.1
Compact 60 Hz	3 x 230	1.1	0.9	Y	3.9	11.8
High gain	3 x 400	4.0	2.2	Y	6.0	13.6
High gain	3 x 230	4.0	2.2	D	10.4	24.8
High gain/ Large aperture	1 x 230 / 3 x 230	7.5	2.2 / 4.0	Δ / Δ	10.4 / 15.7	30.8
High gain	3 x 400	7.5/11.0	4.0/7.5	Y/Y	9.0/15.7	23.0

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4.3.11.2   ACU in installation (simplified)
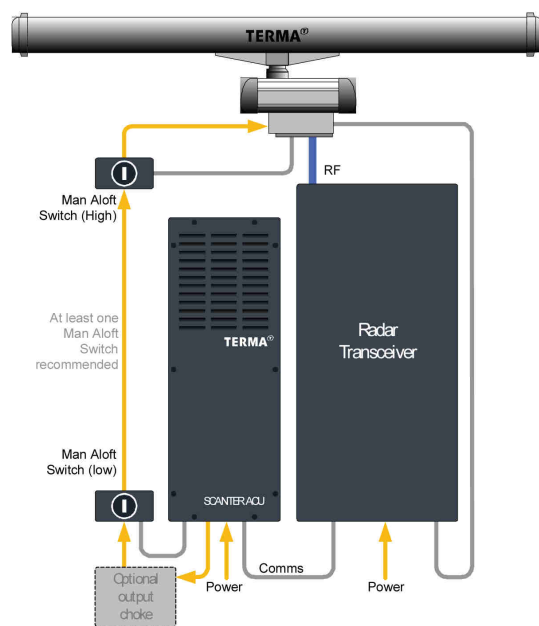

Fig. 4.38 ACU in installation

4.3.11.3   ABB ACS-550

The most commonly used motor controller for the 2.2 kW motor is the ABB ACS-550.

The connections to the unit are shown on the following picture. The star and triangle connections for the motor are shown as well.

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Fig. 4.40 Motor connection

Oil level sensor (or bypass)

Motor start, +24VDC, GND

Safety Loop

RS485

3 phases, Motor

3 phases, Mains
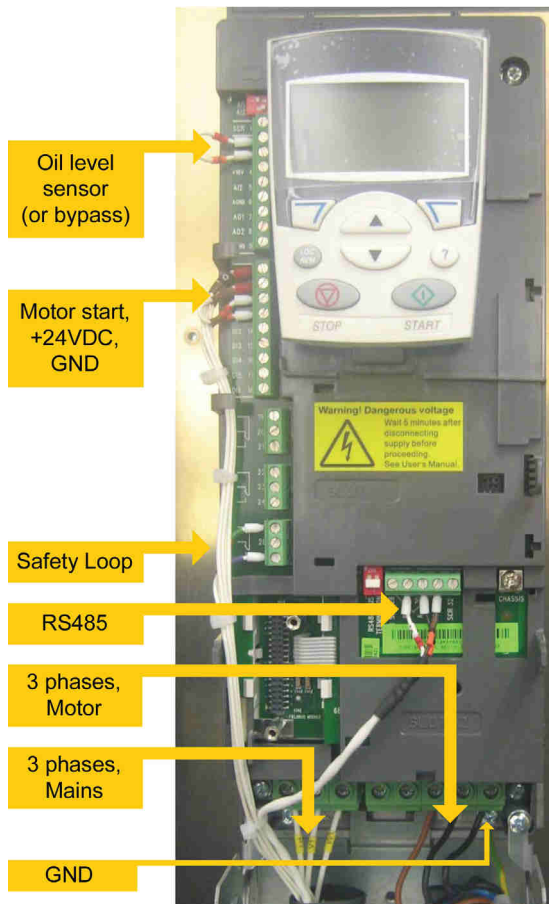
GND

Fig. 4.39 ACS-550 motor controller

The motor controller parameters - actually eight of them - are entered with the operator's panel mounted on the front of the controller. The layout of the panel is shown below in .

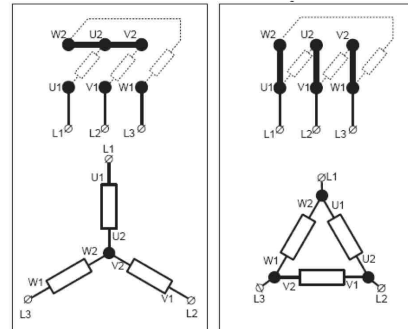Remaining parameters are entered afterwards in the transceiver.

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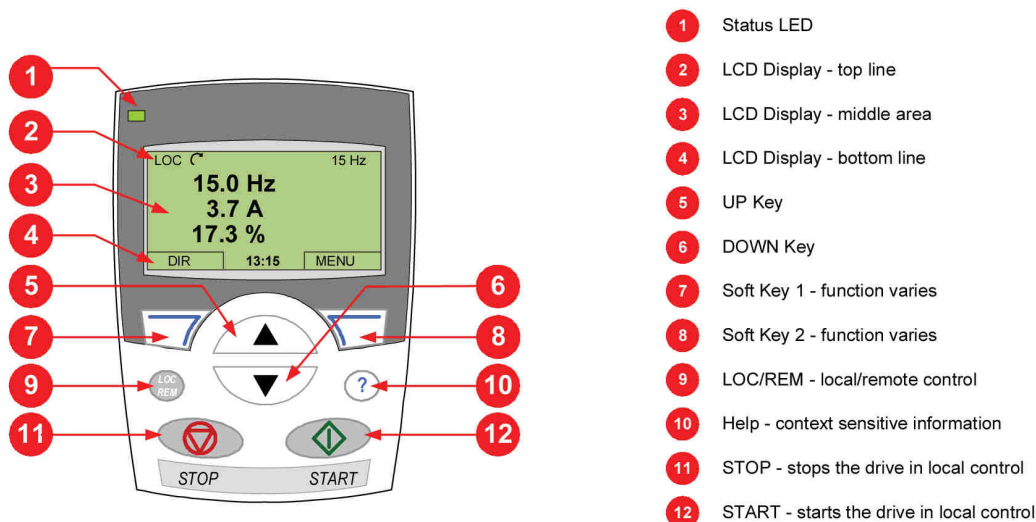|	
1	Status LED
2	LCD Display - top line
3	LCD Display - middle area
4	LCD Display - bottom line
5	UP Key
6	DOWN Key
7	Soft Key 1 - function varies
8	Soft Key 2 - function varies
9	LOC/REM - local/remote control
10	Help - context sensitive information
11	STOP - stops the drive in local control
12	START - starts the drive in local control

Fig. 4.41 Operator's panel

4.3.11.4   Function

Depending on the variant, the frequency converter is supplied with one or three phases which are rectified. A control circuit and three output stages produce a 3-phase signal with 120 degrees between the phases. This signal is a pulse width modulated signal (PWM) and is applied in the antenna motor.
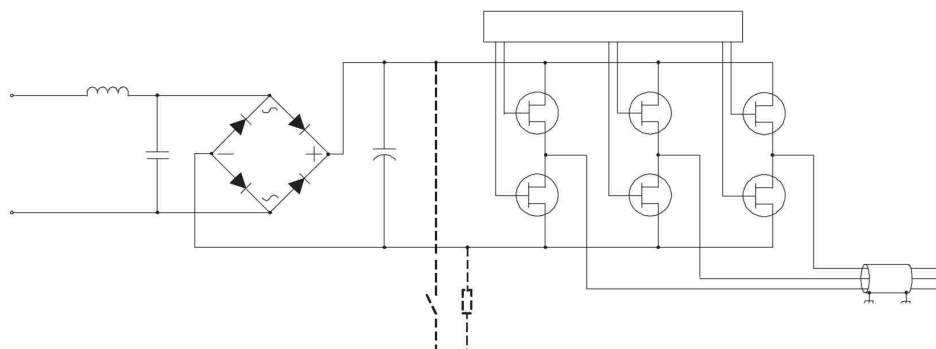

Fig. 4.42 Simplified block schematic, motor controller

The output of the frequency converter is based on a 4 kHz clock and consists of squares. The width of the squares corresponds the amplitude so converting the area of the squares a sine is formed - small width of the squares close to zero and getting wider when the amplitude is increasing.

The frequency of the sine determines the motor speed - the higher frequency, the higher rotation speed.

So, as shown in , the cycle of a certain frequency contains a certain number of squares (with 4000 pulses per second as base) - the double frequency contains half the number of squares in a cycle.

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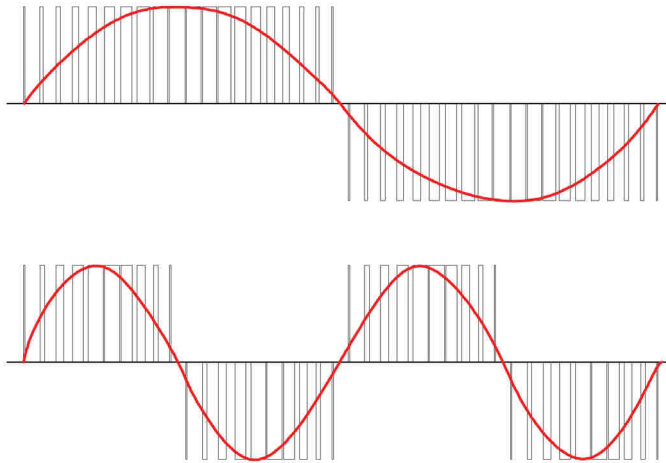615102-HT

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Fig. 4.43 PWM output from frequency converter

4.3.11.5   Set-up

Press the button LOC/REM to activate local mode (LOC is shown in upper left corner of the display).

Activate STOP if the motor is running (normally it will not be running before set-up).

By choosing PARAMETERS in the menu (Soft key 2) it is possible to get access to each parameter. Set up the below-mentioned parameters to the value indicated.

Parameter	Name	Set to value
9902	Applic Macro	ABB STANDARD
9909	Motor nom. power	*(according to motor size)*
1001	EXT1 Commands	10 (COMM)
5302	Station ID	1
5303	Baud rate	9600 bits/s
5304	Parity	1 (8N2)
5305	Ctrl. Profile	0 (ABB Drives)
9802	Comm. Prot. Sel.	1 (STD MODBUS)

Activate LOC/REM button to return to remote mode (REM shown in upper left corner).

After set-up of the motor controller, the parameters in the transceiver have to be entered.

Set up the below mentioned parameters in the SCANTER 5102/5202 transceiver. "Motor Nominal Current" and "Motor Nominal Speed" depend on the motor size and the number of poles in the motor.

The required antenna rotation speed is selected in the first menu, but is as such not a part of the initial set-up (often changed with changing profiles when operative).

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The second menu, "Perform calibration", is used to calibrate the antenna after set-up.

The remaining 18 parameters must be set up now.

TC3: Service/Motor Controller	4 poles			6 poles	Unit	Comments
	1.1 kW	2.2 kW	4 kW	2.2 kW		
Antenna RPM	0 - 60 (application dependent)				RPM	
Antenna calibration	Perform calibration (Read-out: Calibrated / Not calibrated)					
Applic macro	1					
Motor nom. voltage	400 / 230				VAC	Y /△
Motor nom. current	2.7 / 4.7	5.1 / 8.8	9.1 / 15.7	6.0 / 10.4	A	Y /△
Motor nom. frequency	50				Hz	
Motor nominal speed	1390	1390	1390	930	RPM	
Direction	2					Reverse (Fwd. = 1)
Maximum frequency	50				Hz	
Start function	2					Flying start
Stop function	1					Coasting
Acceleration time	15				s	
Deceleration time	15				s	
Slip compensation	0				%	
No of trials	2					
Motor thermal prot.	0					Off (On = 1)
Start block	0					Off (On = 1)
Trial time	30				s	
Delay time	3				s	
Overvoltage control	Enabled					

Fig. 4.44 Parameter settings

Check that the right motor controller is selected (otherwise select it).Select the motor controller type ACS-550 in the transceiver parameters.

Check that the right encoder type is selected.

Start antenna calibration by means of the RST Parameters view. Search for "Antenna Speed Calibration" and set value to "on".

4.3.11.6   Dimensions, internal wiring, etc.

For dimensions of the ACU, internal cabling, etc., refer to chapter

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