SCANTER 6002 Radar System

Technical & Maintenance Manual

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606002-HT Rev. E2

Record of changes

Description	Rev	Date
Released.	A	2013-01-18
Added ACS-800 set-up procedure. Added new I/O module and WG Assy module.	B	2013-07-20
Included system configurations. Updated functional description. Added ET2 tracker description and zones feature. Corrected safety distances. Updated PSAT calibration procedure. Updated transceiver setup and adjustments. Added ACU ACS-880 variant. Added hazardous material information. Added software license information. Updated Radar Service Tool chapter. Added safety loop for LSAS. Updated SCANTER tool kit.	C	2016-09-13
Updated references. Removed ACU maintenance (inserted reference to ACU manual). Added scheduled preventive maintenance and replacement procedure for Blower Assy, CP4. Updated figures and terminology (fig. 9.13, 11.7). Updated Backup/Restore section. Other minor updates and additions.	D	2017-08-30
Minor updates and additions Revised chapters 3 and 4, Functional Description and ET2 Tracker to reflect latest updates to product specifications.	E	2018-08-23
Added FCC and ISED/ISDE warning statements. Updated tasks 4 + 5 (replacing External I/O and Interconnection Board).	E1	2019-09-06
Updated section “Microwave Radiation Safety Margins / Marges de sécurité du rayonnement micro-ondes” to comply with FCC and ISED regulatory standards. Updated section “ISED RSS-Gen, Sec 6.8 / CNR-Gen ISDE, Sec 6.8” to comply with ISED RSS-238, sec 4.2.	E2	2019-10-09

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1 INTRODUCTION

1.1 Purpose and Scope

The purpose of this manual is to describe the SCANTER 6002 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 6002 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.

Note:

Antenna systems are only briefly described to provide an overview of the available configurations for the SCANTER 6002 system. In-depth descriptions, specifications and maintenance information on the antenna systems can be found in separate manuals - see section 1.7 (p. 29).

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.

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

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/m²]	Power density [dBm/cm²]
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.

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.

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/m^2 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/m^2]**	**Densité de puissance [dBm/cm^2]**
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.

1. Comme définies par les normes législatives suivantes:

   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.

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 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 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 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.

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)**		
Length	7'	9'	12'
Max. gain @ antenna flange	≥ 31 dBi	≥ 32 dBi	≥ 34 dBi
Polarization	Horizontal		

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)**		
Longueur	7'	9'	12'
Gain maximal à la bride d'antenne	≥ 31 dBi	≥ 32 dBi	≥ 34 dBi
Polarisation	Horizontale		

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.

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 6002 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 6002 Transceiver does not contain materials regulated as dangerous goods or HAZCHEM.

1.4.1.3 Specific Substance(s) Information

The SCANTER 6002 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 6002 Transceiver subsystem in concentrations above the minimum contained in the legislation.

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1.5 Technical Terms and Definitions

Accuracy	The difference between the average of repeated measurements of the same quantity under identical conditions and the known "true" value i.e. the difference between the average of the measurements of the range to a fixed reference target and the range value calculated from the geographical coordinates of the reference target and radar sensor.
Antenna	The upper rotating part of the antenna system. The antenna is radiating the RF power and receiving the echoes from the targets. Depending on the antenna type the radiating component can be a slotted waveguide or a horn with belonging reflector.
Antenna Polarization	Antenna polarization is determined by the direction of the electrical field. It can either be horizontal, vertical or circular.
Antenna System	System consisting of antenna, motor and gear for antenna rotation and, if present, stabilized platform (motors and gears to compensate for roll and pitch on a ship).
Azimuth	The angle between a horizontal reference direction (north or heading) and the horizontal projection of the direction of interest, measured clockwise.
Blind Speed	Blind speed is one limitation occurring in pulse MTI radars. The blind speed occurs in pulse radar because the Doppler frequency is measured by discrete samples at the pulse repetition frequency. Blind speeds occur if the moving target Doppler frequency happens to be equal to the PRF or a multiple thereof. Increasing the wavelength or the PRF, results in a higher first blind speed value. Blind speed occurrence is due to the use of delay-line cancellers. Can be avoided by using stagger.
Coherent MTI	In coherent MTI radar, the phase information of the transmitted signal is preserved as a reference signal. The reference signal is needed to detect the Doppler frequency shift.
Diplexer	A 3-port device with 1 input and 2 outputs, or 2 inputs and 1 output, all ports with waveguide flanges. The diplexer includes two band pass filters enabling the diplexer to split a two-frequency input signal into two separate signals. The diplexer is often used in frequency diversity systems.

Doppler Effect	In radar technology the Doppler Effect is used for speed measurement and Moving Target Indication (MTI). The Doppler Effect is the apparent change in frequency or pitch when a moving target is hit by a radar beam. When a target is approaching the radar, the target is "compressing" the beam in front of it resulting in a higher frequency in the echo.
Double Cancellation	A circuit consisting of two cascaded Single Delay Line Cancellers. The frequency response of the Double cancellation circuit improves the filters ability to eliminate DC components of fixed targets and clutter.
Encoder	Unit which provides information about the azimuth i.e. the direction in which the antenna is pointing. For each rotation the encoder sends a number of azimuth count pulses (ACPs), typically 8192 pulses and one azimuth reference pulse (ARP). The encoder is included in a encoder assembly which normally holds one or two encoders.
Extractor	The extractor analyses the incoming video for plot creating plots. Furthermore, it calculates plot properties such as area, intensity, centre of gravity etc.
Frequency diversity	Frequency diversity (FD) is a sequential transmission on two different frequencies which after processing increases the signal quality by an increase of the signal-to-noise ratio. The target is hit twice and behaves differently depending upon the frequency of the electromagnetic wave hitting it. Furthermore, if slotted waveguide antennas are used, an additional advantage is achieved, namely the time diversity.
Lack	Lack is a number counting unsuccessful consecutive updates of a track.
Log Compression	In this process, the signal is converted from a 26 bit floating point signal into an 8-bit logarithmic signal.

Mixer	A function of the mixer is to convert frequencies, either up or down. The ideal mixer performs the mathematical multiplication of two input signals. It creates signal components positioned at frequencies equal to the sum and difference of the input signals. For ideal performance, the mixing device must be perfectly linear and there must be no leakage of the input signals to the output port. Typically, either the sum, or the difference frequency is removed with a filter. The term Double Balanced Mixer is used to imply neither of the input terms will appear at the mixer output. In practice, suppression of these input components is never perfect. Odd harmonics of the carrier frequency are present but can be easily filtered out. In a Single Balanced Mixer, both even and odd harmonics are present at the output.
MTI Radar	Moving Target Indicator radar utilizes the Doppler frequency shift as a means for discriminating moving and fixed targets. Usually, it operates with ambiguous Doppler measurement, so-called blind speeds, but with unambiguous range measurements.
Noise Figure	Noise Figure is defined as the signal-to-noise ratio at the input divided by the signal-to-noise ratio at the output. Noise Figure is expressed in dB.
Own Unit	A moveable platform, normally a ship, which is carrying the radar sensor.
Parameter	A parameter is a quantity which influences the radar video, the subsequent signal processing, the plot extraction, or the target tracking. Examples are: transmitted power, video sampling rate, video threshold for plot selection, and expected maximum speed of target.
Plot	A radar plot is a group of connected radar cells in which the measured video signal exceeds a defined threshold value and/or fulfils some other discrimination criterion.
Precision	The standard deviation of repeated measurements of the same quantity under identical conditions i.e. the standard deviation of the measurements of the range to a fixed reference target.
Profile	A profile is a set of common operational parameters for the transceiver. Profiles are identified by a name. When a specific profile, i.e. Profile Name, is chosen by the operator, all transceiver parameters are set according to the profile content.

Pulse Compression	For a simple rectangular pulse, the pulse duration is equal to the reciprocal value of its bandwidth. Improving the radar sensitivity by increasing pulse duration and thereby the transmitted power, will have a negative impact on the range resolution. Pulse compression, also known as pulse coding, is a signal processing technique designed to maximise the sensitivity and resolution of a radar system. By manipulating the amplitude and phase of a pulse, it is possible to increase the pulse bandwidth, while keeping the pulse duration unchanged, or vice versa. By doing so, the increased average transmitted power improves sensitivity while having a high range resolution. The effectiveness of a particular pulse code is often judged by its time-bandwidth product. The time-bandwidth product for a simple rectangular pulse is equal to one. A compressed pulse might have a time-bandwidth product of ten. This means that each compressed radar pulse contains ten times the energy of the simple uncoded pulse of the same resolution. Equivalently, range resolution is ten times finer than an uncoded pulse of the same duration.
Radar Cell	The disc around the radar out to the maximum range is covered by a polar grid consisting of 4096 equal azimuth sectors. Each azimuth sector is divided into 4096 range cells of equal range depth. A specific range cell in a specific azimuth sector is called a radar cell.
Radar Cross Section	The Radar Cross Section (abbreviated RCS) is the size and ability of a target to reflect RF energy - this is summarized in a single term, which has the dimension [m^2]. The size of the RCS depends on frequency, antenna polarisation and a lot of characteristics of the target, ex. physical dimensions, aspect angle, coating and material, surface. The RCS can be quite difficult to estimate and is normally determined by measurements and in certain extend experience.
Radial Speed	The true velocity of an airplane is composed of three vectors. The vector, which points directly towards the radar or away from the radar, represents the radial speed of the airplane. Assuming, an airplane is flying around the radar in a circle path, the radial speed will be permanently zero. The produced Doppler frequency is zero and the airplane is not detected.
Resolution	The minimum distance in range or angle between two equally strong radar targets (same radar cross section) which allow the echoes from these targets to be perceived as separate echoes.

Scan	The collection of consecutive sweeps covering one full rotation.
Stabilized Platform	A stabilized platform is (or can be) used on ships. The antenna is mounted on the stabilized platform which, within a certain range, secures that the antenna always is kept in horizontal position, independent of the ships movements (roll and pitch).
Staggered PRF	Staggered PRF is mainly used to cope with multiple-time-around echoes. In fact, targets at ranges greater than maximum range appear as echoes of the following pulses at shorter range. It is possible to remove this range ambiguity by changing the PRI during time-on-target. With different PRIs, the target will appear at different ranges. Using a proper logic, it is possible to identify the echo as a second-time-around one, and assign to it the proper range.
Sweep	The radar return of one transmitted pulse as a function of range.
Track	The track of a target is a table holding position, speed, course, etc versus time.
Tracking	Tracking is the process of associating a time series of plots with the physical movement of one physical object (the target) and to derive speed, course etc from this time series.
Track update	A track is updated when a plot from the most recent scan is associated to a tentative or a confirmed track.
Trail	Historic radar echoes, usually presented in a color different from the actual radar echoes and fading away within a user defined time interval.
Waveguide	Hollow metal conductor within which RF energy can be efficiently transmitted.

1.6 Abbreviations and Acronyms

Term	Definition
2D	Two-dimensional
ACH	Anti Condensation Heater
ACP	Azimuth Count Pulse
ACU	Antenna Control Unit
ADC	Analog to Digital Converter
AIS	Automatic Identification System
ARP	Azimuth Reference Pulse
AAZ	Automatic Acquisition Zone
BITE	Built-In Test Equipment
CEU	Control Electronics Unit
CFAR	Constant False Alarm Rate
CNR	Cahier des charges sur les normes radioéléctriques
CNR-Gen	Exigences générales relatives à la conformité des appareils de radiocommunication
CO	Compact
$Cosec^2$	Cosecant squared
CP	Circular Polarization
CP4	Common Platform 4 (Board)
CS	Coastal Surveillance
CW	Continuous Wave
$DBHG^+$	Dual Beam High $Gain^+$
DC	Direct Current
EBL	Electronic Bearing Line
EC	European Commission
EEPROM	Electrially Erasable Programmable Read Only Memory
EIA	Electronics Industries Alliance
EMCON	EMission CONtrol
ESD	ElectroStatic Discharge
ET2	Embedded Tracker 2
EU	European Union

Term	Definition
FCC	Federal Communications Commission
FD	Frequency Diversity
FPGA	Field Programmable Gate Array
FTP	File Transfer Protocol
GPS	Global Positioning System
GUI	Graphical User Interface
HAZCHEM	Hazardous Chemicals
HP	Horizontal Polarization
HW	Hardware
I/O	Input/Output
ICNIRP	International Commission on Non-ionizing Radiation Protection
IEC	International Electrotechnical Commission
IF	Intermediate Frequency
IFF	Identification Friend or Foe
IP	International Protection / Internet Protocol
ISDE	Innovation, Sciences et Développement économique Canada
ISED	Innovation, Science and Economic Development Canada
LAN	Local Area Network
LED	Light Emitting Diode
LRU	Line Replaceable Unit
LSAP	Lightweight Stabilized Antenna Platform
LSAS	Lightweight Stabilized Antenna System
LVDS	Low Voltage Differential Signalling
MHz	Mega Hertz
MMIC	Monolithic Microwave Integrated Circuit
MTI	Moving Target Indicator
NTZ	Non-Tracking Zone
NAAZ	Non-Automatic Acquisition Zone
PA	Power Amplifier
PC	Personal Computer

Term	Definition
PCIe	Peripheral Component Interconnect Express
PRF	Pulse Repetition Frequency
PSLR	Peak Sidelobe Level Ratio
PSU	Power Supply Unit
RCS	Radar Cross Section
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RF	Radio Frequency
RH	Relative Humidity
RIB	Rubber Inflatable Boat
RoHS	Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment
RPM	Rotations Per Minute
RS	Recommended Standard
RSS	Radio Standards Specification
RSS-Gen	General Requirements for Compliance of Radio Apparatus
RST	Radar Service Tool
Rx	Receive / Receiver
RxTx	Transceiver
SCD	Sea Clutter Discriminator
SCM	Static Clutter Map
SDRAM	Synchronous Dynamic Random Access Memory
SFP	Small Form-Factor Pluggable
SMA	SubMiniature version A
SNR	Signal-to-Noise Ratio
SPI	Serial Peripheral Interface Bus
SRS	Ship Radar System
SSD	Solid State Drive
SSPA	Solid State Power Amplifier
STC	Sensitivity Time Control
STW	Setting-To-Work
SW	Software

Term	Definition
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TD	Time Diversity
TLS	Transport Layer Security
Tx	Transmit / Transmitter
UDP	User Datagram Protocol
USB	Universal Serial Bus
V	Volt
VAC	Voltage Alternating Current
VCO	Voltage-Controlled Oscillator
VCO	Voltage Controlled Oscillator
VDC	Voltage Direct Current
VGA	Video Graphics Array
VRM	Visual Range Markers
VTS	Vessel Traffic Services
W	Watt
WAN	Wide Area Network

1.7 Referenced Documentation

606002-DP	SCANTER 6002 Naval Surveillance Radar
606002-EB	SCANTER 6000 Series Configurations
606002-ZD	Installation drawing, transceiver
357641-HO	SCANTER Radar Service Tool - Operator's Manual
357641-HI	SCANTER Radar Service Tool - Installation Manual
386304-DI	SCANTER 6000 Series Transceiver Control Protocol Data Def. - Service Access Mode
386300-DI	SCANTER 5000/6000 Series Transceiver Interface Specification
303949-SI	SCANTER Track Management Protocol
1026364-DI	ET2 Track Data Protocol
794948-DI	SCANTER ASTERIX Protocol
941070-HT	SCANTER Compact Antenna Systems - Technical & Maintenance Manual
876100-HT	SCANTER Dual Beam High Gain+ Antennas with Fixed Turning Unit - Technical & Maintenance Manual
876111-HT	SCANTER Lightweight Stabilized Antenna System (LSAS) - Technical & Maintenance Manual
978100-HT	SCANTER Antenna Control Units - Technical & Maintenance Manual
924000-RC	Power Density in Proximity to SCANTER Antennas with SCANTER 4000/5000/6000 Series Transceivers
970637-HT	Warnings and Safety Instructions for Terma Radar Antenna Systems

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2 SCANTER 6002 Radar System

The SCANTER 6002 Radar System is optimized to ensure a high level of situational awareness on naval platforms. SCANTER 6002 may also serve as an advanced navigational radar to ensure safe conduct of a vessel.

The SCANTER 6002 Radar System includes an X-band, 2D, fully coherent pulse compression radar, based on Solid State transmitter technology with software defined functionality. The system is optimized to ensure a high level of situational awareness on naval platforms and offers superior performance through intelligent design and advanced processing.

SCANTER 6002 meets the requirements for professional ship-borne services, where quality and durability is significant. Surface and short range, low-level air coverage and helicopter control is provided in harsh weather conditions.

The SCANTER 6002 provides superior detecting performance as a versatile and flexible radar:

- Helicopter control
- Controlling helicopter launch and landing
- Surface surveillance
- Small target detection
- Monitoring low airspace
- Self-protection of the vessel
- Navigational assistance

Terma's solidly proven frequency diversity (FD), time diversity (TD), together referred to as waveform diversity, and advanced video processing gives a truly high-end surveillance radar system.

Novel low-temperature Solid State Power Amplifier (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 Intermediate Frequency (IF) level, and all subsequent handling of signals, filtering, pulse compression, Moving Target Indicator (MTI) processing based on Doppler shift is performed digitally. Advanced Constant False Alarm Rate (CFAR) techniques and intelligent noise reduction, provide high definition radar images with no need for further processing.

An embedded tracker (ET2), utilizing knowledge-based tracking and the Interactive Multiple Model extended Kalman tracking filter, 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 Doppler-processed signals.

Information to track airborne targets is primarily obtained from the Doppler processed signals, but supplemented by normal radar signals to follow targets with no or low radial velocities, e.g. helicopters.

IP network video and digital video is available as well as IP network (LAN/WAN) or serial control, monitoring and set-up. Serial communication ports, auxiliary I/O. USB is also available for connecting PC peripherals.

Service information is obtained via the front panel display and/or the IP network. The SCANTER Service Display runs the Radar Service Tool (RST) software providing access to radar imaging, control, Built-in Test Equipment (BITE) measurements, and error handling.

Antenna systems with fixed turning unit or Lightweight Stabilized Antenna Systems (LSAS) are available to match requirements for different classes of vessels.

2.1 System Overview

The radar sensor system consists of a transceiver and an antenna system. An Antenna Control Unit (ACU) is applicable for antennas with fixed turning unit, and a Control Electronics Unit (CEU) is applicable for antennas with Lightweight Stabilized Antenna Platform (LSAS). In addition, an optional installation rack is available for LSAS and/or systems with Indentification of Friend or Foe (IFF) antenna. See system drawings in section 2.1.2 (p. 33).

The transceiver is a one-box wall-mounted unit, and all connections except the waveguide connect at the bottom of the housing.

IP network video is available as well as IP network transceiver control, monitoring and setup.

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

Mains power supply to the antenna unit is via a motor controller (ACU or CEU) controlled by the transceiver. Antenna unit status, encoder signals, and man aloft switch are connected directly to the transceiver.

2.1.1 Configurations

According to configuration, the SCANTER 6002 Radar System consists of the standard components shown in the below table. Simplified system drawings are shown in section 2.1.2 (p. 33), and detailed drawings are available in doc. no. 606002-EB.

System configurations	
Antenna system with fixed turning unit	**LSAS (Lightweight Stabilized Antenna System)**
Compact antenna	
Dual Beam High Gain+ antenna	Dual Beam High Gain+ antenna
IFF antenna (optional with Dual Beam High+ antenna)	IFF antenna (optional)
Fixed turning unit	Lightweight Stabilized Platform (LSAP)
Transceiver	Transceiver

System configurations	
Antenna control unit (ACU)	LSAP control unit (CEU)
Installation rack (optional - for systems with IFF antenna)	Installation rack (optional)

2.1.2 System Drawings

2.1.2.1 System With Fixed Turning Unit

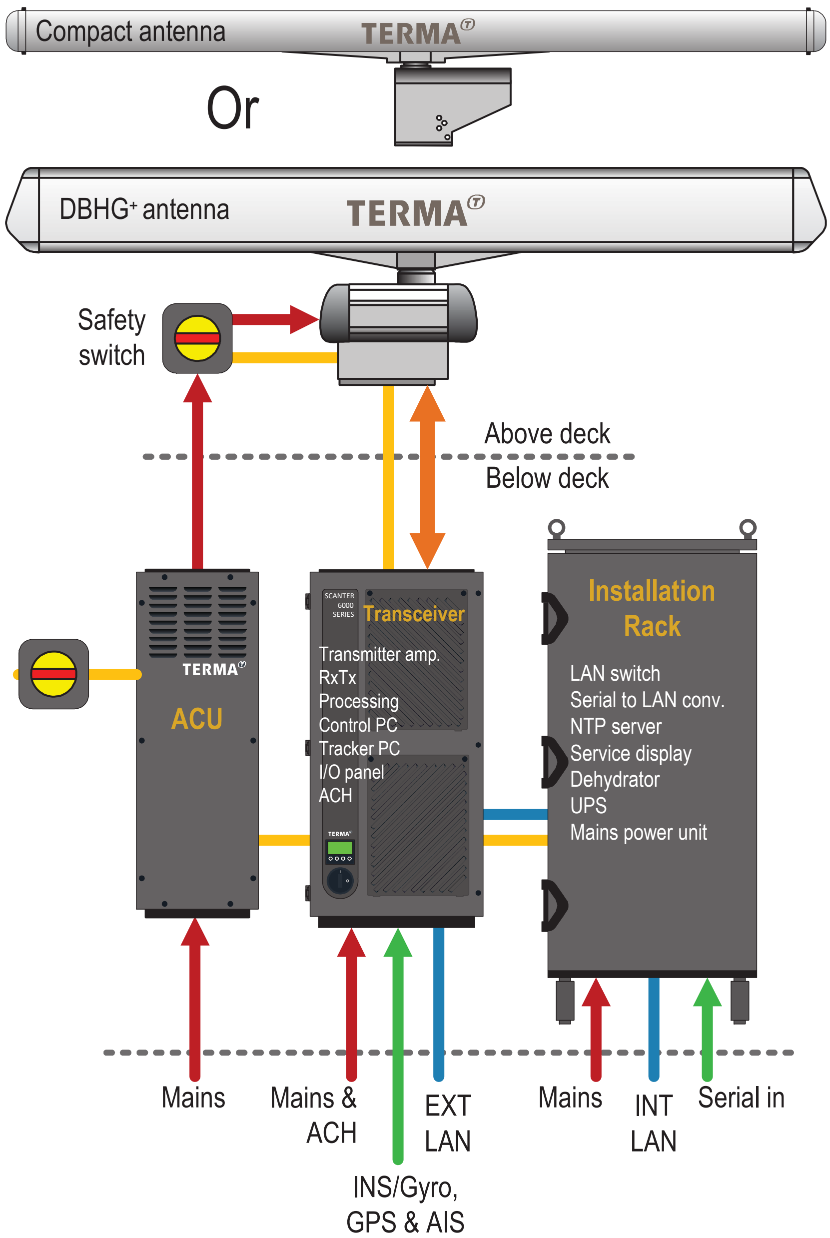


Fig. 2.1 Simplified system drawing (fixed turning unit)

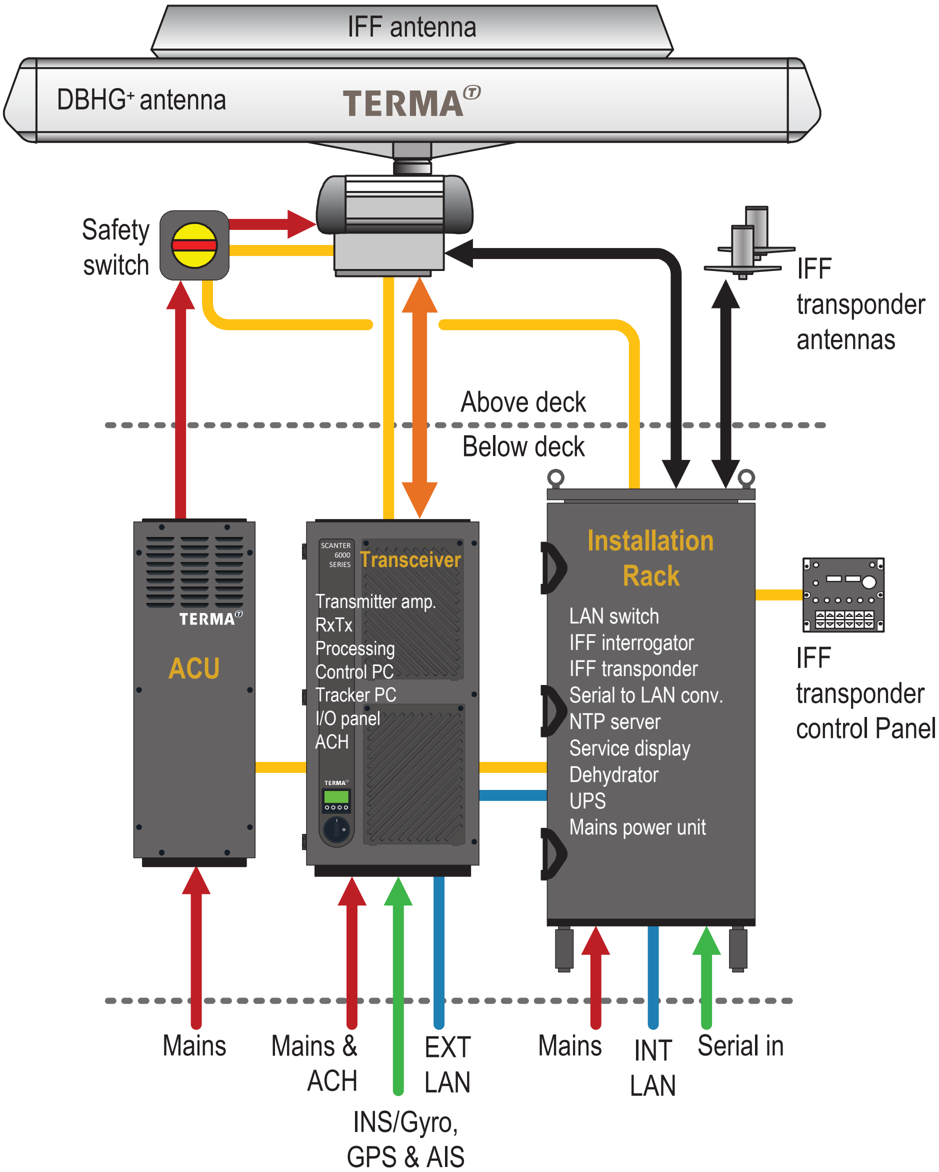


Fig. 2.2 Simplified system drawing (fixed turning unit), with IFF antenna

2.1.2.2 System with Stabilized Platform

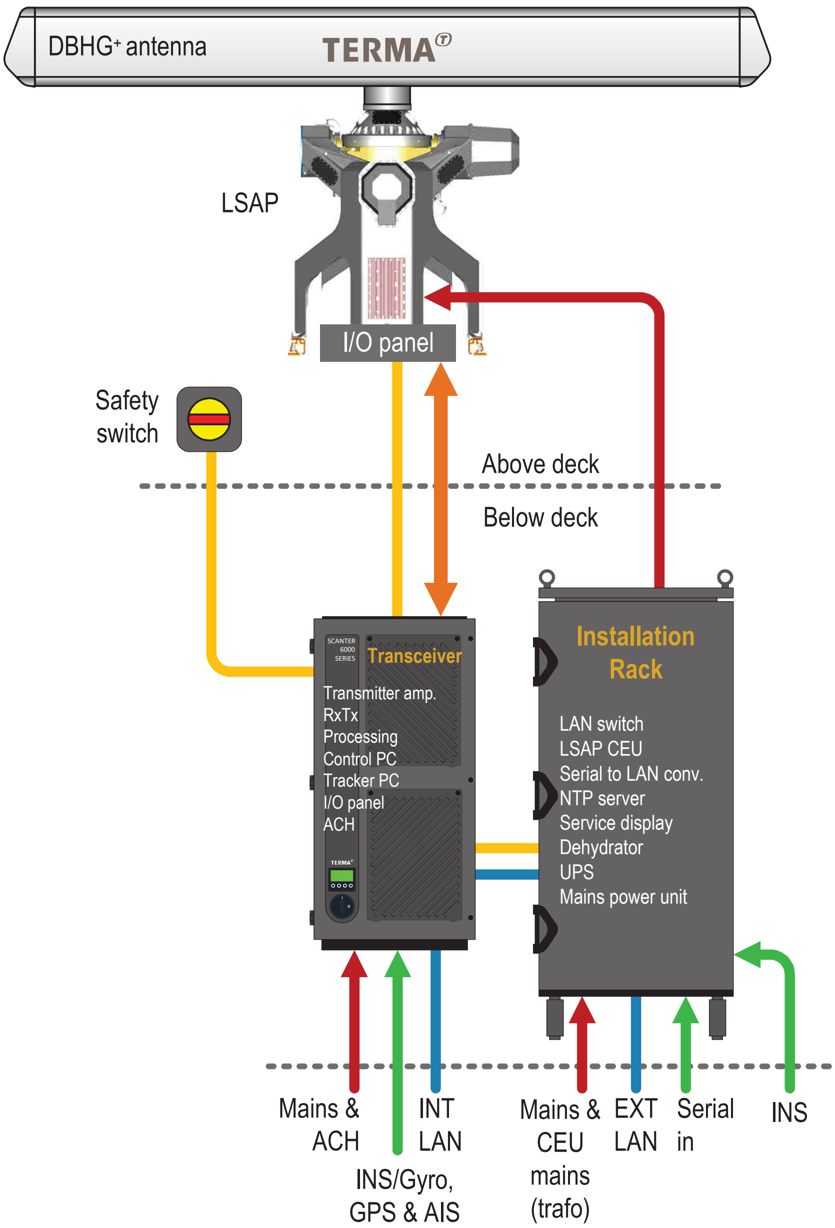


Fig. 2.3 Simplified system drawing (stabilized platform)

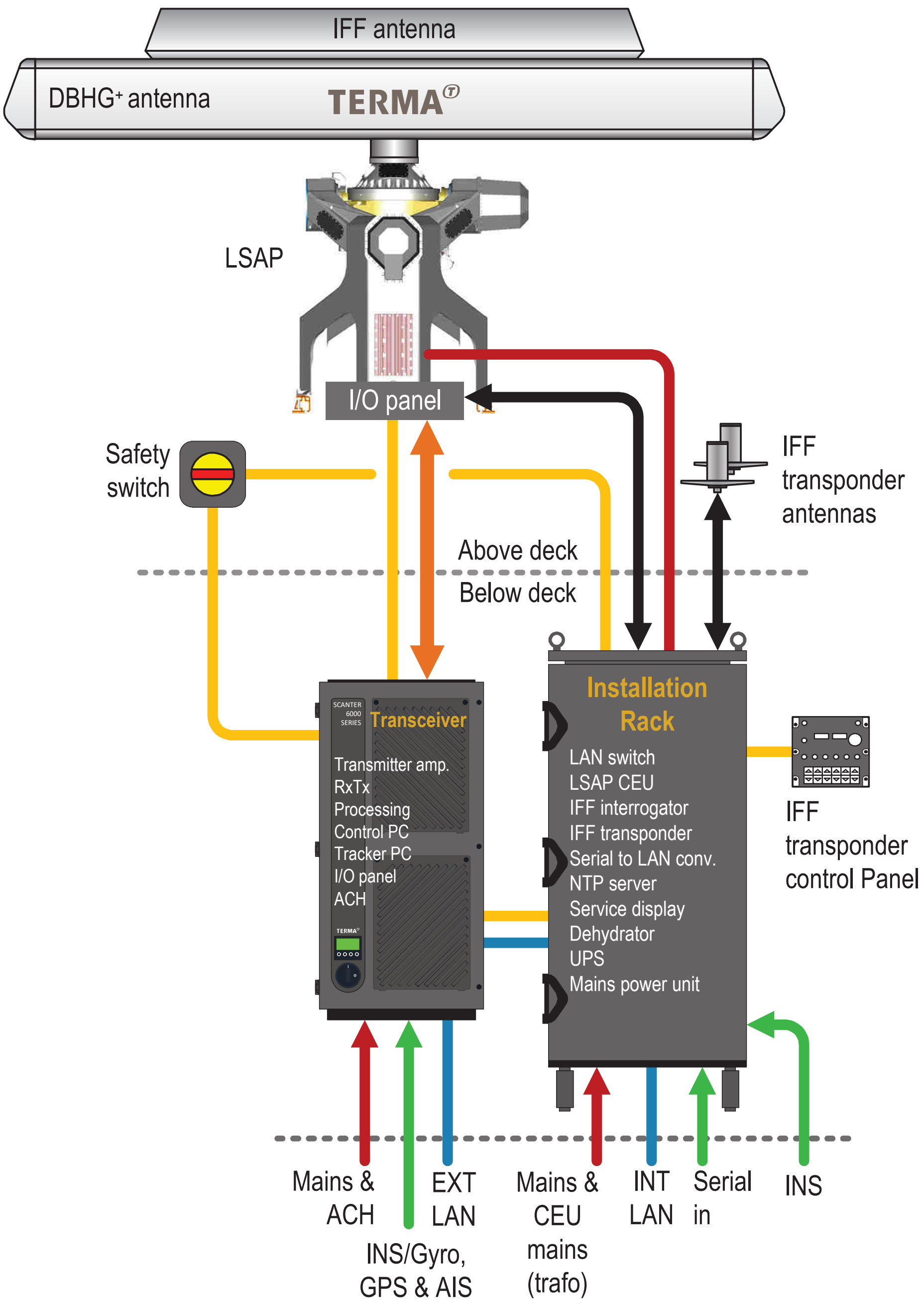


Fig. 2.4 Simplified system drawing (stabilized platform), with IFF antenna

2.2 SCANTER 6002 Product Technology and Features

SCANTER 6002 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 Solid State Power Amplifier (SSPA).

In order to support full frequency diversity, the receiver has two channels, receiving 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 after decimation. This data stream is input to the processing chain, which uses multiple Field Programmable Gate Arrays (FPGA) in a modular configuration to perform the calculations and data reduction needed to provide clear images with low probability of false alarms.

All components but the transmitter amplifier and receiver front-end are purely digital. The necessary processing power is added in the form of plug-in Common Platform 4 (CP4) processing boards. The CP4 boards are identical, but are programmed differently, according to desired functions.

The embedded tracker (ET2) efficiently implements the currently most accepted and advanced tracking algorithms. The ET2 tracker is described in detail in section 4 (p. 61).

The radar provides:

- Software-defined functionality.
- Waveform diversity (frequency diversity and time diversity).
- Full coherency and pulse compression.
- Transmitter power level control in sectors
- Sub-clutter visibility and Doppler shift processing.
- Environment adaptation.
- Control / Profiles / BITE
- SCM interface

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

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 SCANTER 6002 product features and options are listed in the below table.

Featuring		
Surface Coverage, Normal and Coherent Radar	●	
Air coverage by Coherent (MTI) processing	●	
Manual mode with external gain, clutter and STC control	●	
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	●	
FiveStepVideoPassing™	●	
Frequency		
Programmable frequencies within 9.0–9.2 GHz or 9.225–9.5 GHz	●	
Up to 16 sub bands	●	
200 W Transmitter		
Equivalent pulse power, programmable up to 300 kW (using pulse compression)	●	
Receiver		
Digital Sampling on IF, = 140 dB amplitude span of signals handled	●	
Embedded Tracker 2 and plot output		
Surface 500 tracks and air 150 tracks	●	
External interfaces		
Analog, Digital and IP network radar video	●	
Control and monitoring through IP network	●	
Serial communications ports	●	
Design		
Open architecture, wall mounted, ruggedized housing	●	
Antennas		
7´, 9´ or 12´ Compact – HP – $cosec^2$		○
9' or 12' Dual Beam High Gain Plus ($DBHG^+$) – $cosec^2$		○
Light stabilized antenna platform (LSAP)		○
Turning unit (TU)		○
IFF add-on to $DBHG^+$ antenna		○
Standards		
IEC 60950-1, 2nd ED., ITU-R SM.1541-6 Annex 8, ITU-R SM.329-12, Cat. B,		

● Standard feature ○ Add-on (optional) feature

Fig. 2.5 SCANTER 6002 features and options

2.2.1 Doppler-based (MTI) Processing

Doppler-based processing allows the transceiver to separate moving targets from background clutter and provides an additional video channel with moving objects. The Doppler processing includes an additional CP4 processing board in the transceiver.

3 Functional Description

The transceiver is the central component in the radar system. See Fig. 3.1 (p. 39).

The SCANTER 6002 transceiver transmits and receives radar waves through the waveguide connected to the antenna system. Video processing is also carried out in the transceiver. It is connected to the external signal distribution through single or redundant IP network(s). Serial communication lines are available, allowing easy integration into other sub-systems. The video outputs are available in analog, 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 (SNR). This allows for transmission of long frequency modulated pulses (chirps) with relative low peak power, while achieving high range resolution and probability of detection.

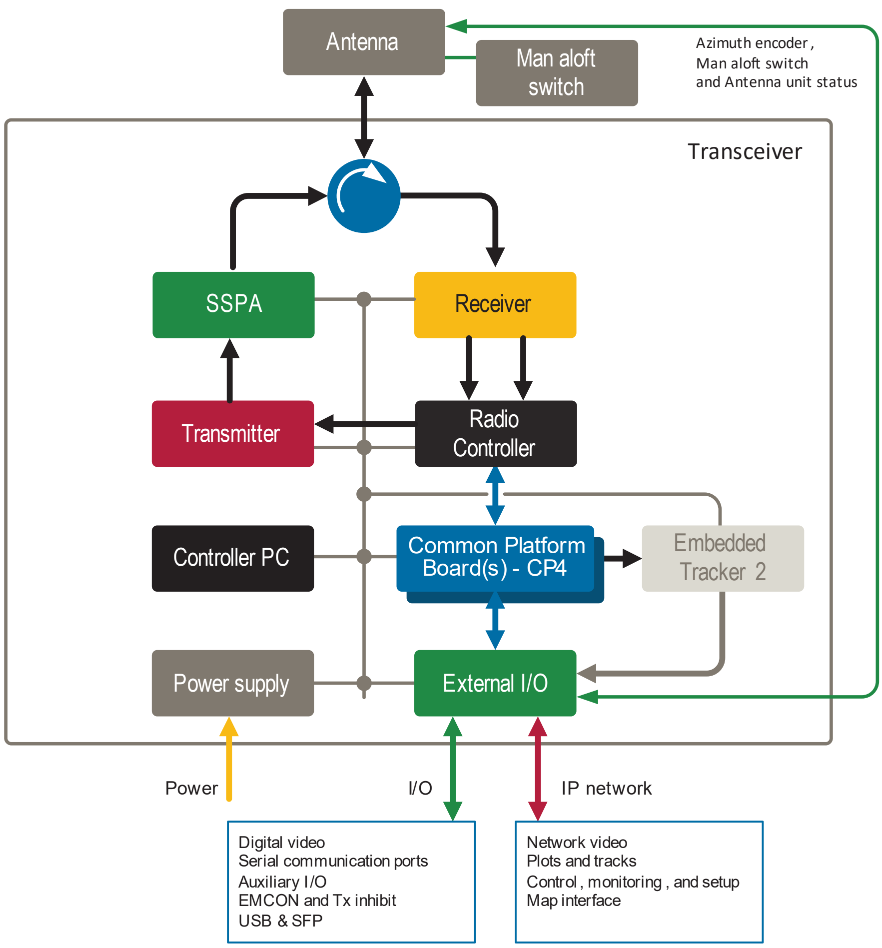


Fig. 3.1 Transceiver block diagram

The receiver has two channels in order to support simultaneous reception of two frequency bands. Optimum SNR performance is ensured by low noise amplifiers.

The required frequency band depends on the application and is selected, by the Digital Frequency Synthesis unit. The signal is generated in the Radio Controller and up-converted to Radio Frequency (RF) in the transmitter. The receiver automatically tunes to the transmitted frequency bands, down-converts to Intermediate Frequency (IF), and passes the received signal to the Radio Controller, which samples the signals.

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.

The transceiver delivers IP network video (recommended video interface) as well as digital video. In order to maintain compatibility with existing radar installations the transceiver can also deliver analog video.

Embedded tracking is available as an option (with a separate plug-in module), making plots and tracks available on the IP network.

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

Transceiver hardware components are described in section 5 (p. 63).

3.1 Software-defined Functionality

Multiple types of SCANTER radars are based on the same hardware modules and can therefore utilize identical core software architecture. This ensures commonality and increases robustness. Furthermore, the architecture enables a high level of test-ability, ensures deployment flexibility and makes it easy to add new functionality.

This in combination with the use of multiple, identical and powerful, common platform processing modules leads to the concept *“Software defined functionality”.*

A variety of radar signal processing techniques are included to meet increasingly difficult challenges. Multiple functions, such as automatic adaptation to weather scenarios etc. are performed simultaneously.

Functions relevant for the individual application are invoked as appropriate. It is also possible to switch between different modes of operation by modifying both the synthesized transmit waveforms and receiver signal-processing tasks, even on the fly. Additional parallel coherent transmit and receive channels enables the *FiveStepVideoPassing™.*

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

3.2 Solid State Power Amplifier (SSPA)

The SSPA modules for the SCANTER 6002 are designed using state-of-the-art MMIC (Monolithic Microwave Integrated Circuit) power transistor amplifiers.

Each Power Amplifier (PA) module consists of 8 power transistors. The PA amplifies the signal to be transmitted and produces 50 watt of output power. The output power from 4 PA modules is combined in one SSPA, to produce the final output power of 200 watt.

The Power sector mode feature allows the SSPA output power to be adjustable in azimuth sectors. This is achieved by sector wise attenuating the input signal into the SSPA from the transmitter.

Fig. 3.2 200 watt SSPA with 4 x 50 watt PA modules

3.2.1 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 a few power transistors will only result in a 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.

Fig. 3.3 (p. 42) illustrates the relation between loss of modules, peak power and free space range performance of the radar. When 50% of power transistors have failed, 25 % output power remains, however, 70% of the free space range is achievable.

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

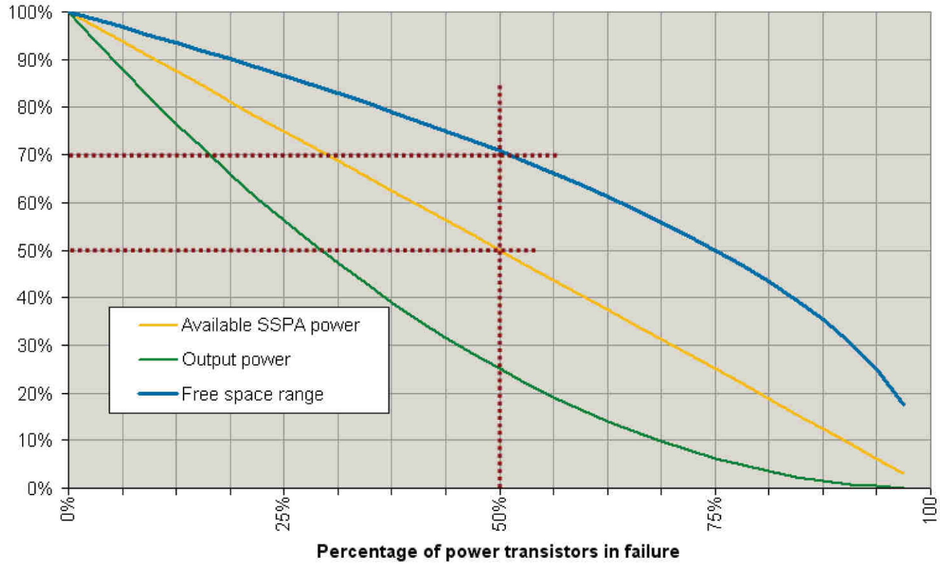


Fig. 3.3 Free space range and power vs. power transistor failure

3.3 Frequency and Time Diversity

The effect of the Terma SCANTER Frequency and Time Diversity processing is to reduce fluctuation of the echoes from desirable targets, and thereby enhancing targets relative to clutter. In combination with full coherence and pulse compression the radar images become crisp and clear.

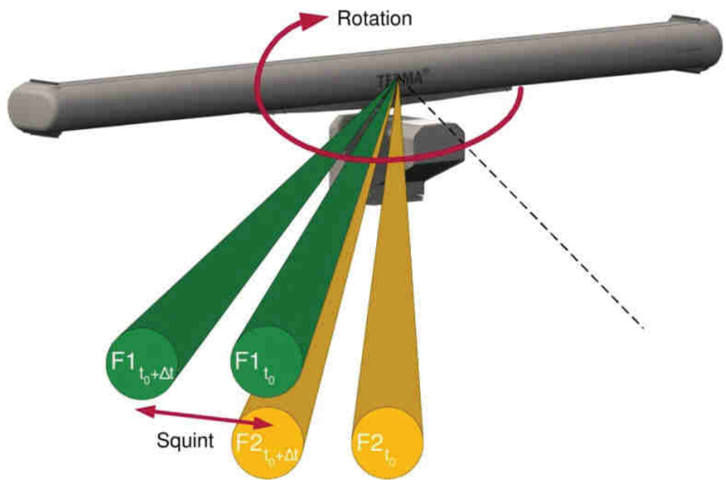


Fig. 3.4 Frequency diversity and time diversity

The transceiver operates with Frequency Diversity (FD). FD is sequential transmission on six different frequencies followed by recombination of the echoes from the different frequencies.

Each of the six different base frequencies are frequency modulated with chirps. Three chirp lengths are utilized. A long chirp to increase RF energy for long-range detection, short chirps to ensure high definition short-range detection, and medium chirps to cover the range between short chirp maximum range and long chirp minimum range.

The FD enhances detection of very small targets like rubber dinghies, even under unfavorable weather and climatic conditions.

The primary advantage of FD operation is that target fluctuations are reduced after integration of signals from independent pulses. FD also removes second time around echoes, and improves interference resilience.

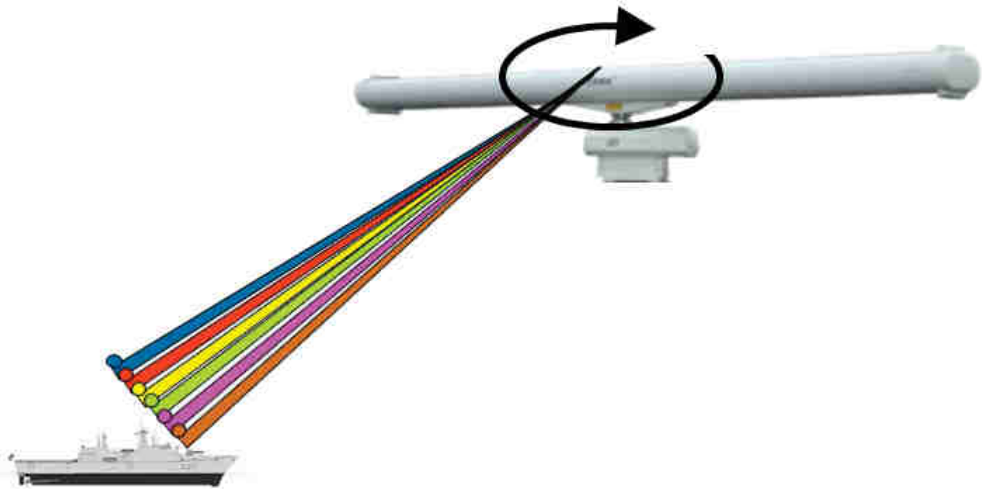


Fig. 3.5 Squint of slotted waveguide antenna.

The use of modulated RF and multiple chirps on a slotted waveguide antenna will result in the actual beam directions being different from the antenna direction (and the apparent bearing of the target). This is illustrated in Fig. 3.4 (p. 42). The beam offset due to frequency is illustrated by colors (yellow and green). This phenomenon is called squint.

The offset due to transmission timing and rotation (with same frequency component) is shown by indexes (t_0 and $t_0+\Delta t$) in Fig. 3.4 (p. 42). The return signals, corresponding to a given antenna direction (dashed line in the figure), need to be combined and corrected by alignment in range and in azimuth. The linear array antenna with the SCANTER 6002 will transmit the chirps of the six carrier frequencies in different directions as illustrated in Fig. 3.5 (p. 43). The targets and clutter will be hit by the independent beams at different times as the beams corresponding to different carrier frequencies are separated by the difference in squint angle.

The additional benefits from correlation, integration, and time delay due to the squint lead to additional performance compared to single frequency only.

Fig. 3.6 (p. 44) shows a typical transmission pattern. The boxes on the figure represent the individual chirped pulses. The chirp pulse width is illustrated by the width of the boxes (long, medium, and short chirps). The color of the chirp represents the base frequency (six distributed along the ordinate). The abscissa shows relative time.

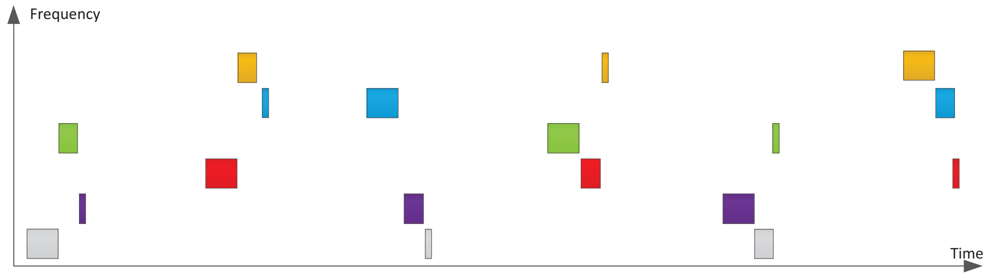


Fig. 3.6 Typical transmission pattern.

The long, medium and short RF chirps are transmitted immediately after one other. Clutter usually has rapid Radar Cross Section (RCS) variations. This means that radar echoes from clutter will average rather than add up between illuminations of the beams with different carrier frequencies.

The RCS of actual targets is usually constant within consecutive sweeps, consequently target echoes will add up rather than average. This processing reduces target fluctuations and enhances target paints relative to clutter, resulting in a more stable the video presentation.

The illumination time between chirps with different base frequencies due to frequency dependent squint is typically 10-40 ms. Sea clutter typically varies more rapidly, especially during heavy wind conditions.

Compared to traditional scan-to-scan correlation, this process enhances targets without the risk of losing fast moving targets in the scan-to-scan correlation process.

The squint phenomenon is thereby turned into an additional advantage, in effect providing both Time and FD.

The benefit of the reduction in target fluctuations is highly dependent on the target characteristics. However, based on Terma's experience with different and challenging weather conditions, the performance improvement when detecting small fluctuating targets is approximately 8-10 dB, when FD is combined with slotted waveguide antennas.

The SCANTER radar obtains full benefit from the FD by automatically adapting the dynamic characteristics to actual weather/location situations.

3.4 Full Coherency

The SCANTER 6002 is fully coherent utilizing amplitude and phase information during transmission and reception. A common, phase stable reference oscillator is used for transmission and reception. Pulse compression is achieved by comparing a recorded copy of the transmitted chirp with the echo signals returned from targets and clutter. Further, coherency 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.

Doppler processing (MTI) is available as default. This improves detection of radial (i.e. in range along the same bearing) moving targets and with speeds different from clutter.

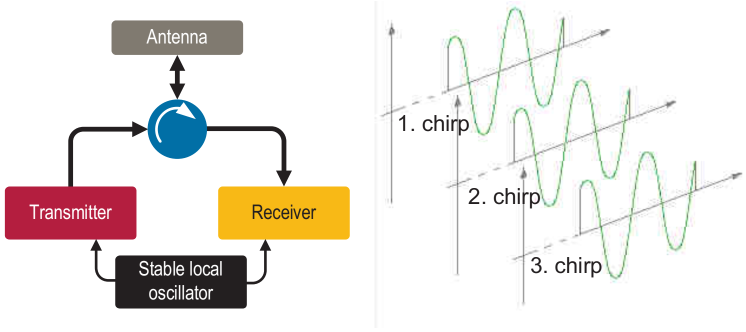


Fig. 3.7 Coherency principle

3.5 Pulse Compression

In order to maximize the detection range of targets, the SCANTER 6002 transmits longer chirps than typical pulse radar systems.

To avoid significant loss of range resolution, advanced signal processing is necessary. The SCANTER 6002 transceiver utilizes frequency modulation (chirping or frequency sweeping) and pulse compression to increase the range resolution as well as the SNR.

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. 3.8 (p. 45).

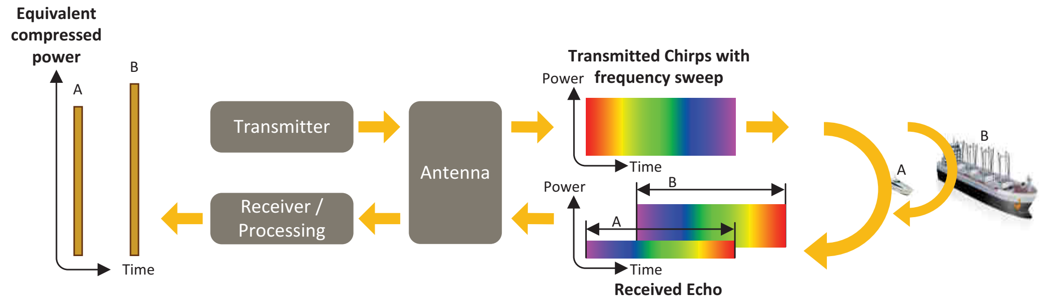


Fig. 3.8 Frequency sweep

Pulse compression is performed in the frequency domain. By pulse compression, the SNR and resolution is improved by thee effective bandwidth of the transmitted chirps. pulse compression gain, a factor, equivalent to the chirp length multiplied with th

A special feature of the pulse compression technique is that the resulting radar signal-to- noise ratio (SNR) is independent of the resolution bandwidth. The resulting SNR is therefore proportional to the transmitted power divided by the overall receiver noise figure. Consequently the bandwidth is configurable e.g. to minimize the clutter power, bearing in mind that too fine a resolution will introduce a 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 as long as range straddling loss is avoided.

A drawback from the transmission of long chirps is an extended minimum range – the radar is blind during transmission. In order to compensate for this, the radar uses a mixture of short, medium and long chirps. Because there is a short delay between transmission and reception of an echo from a target close to the antenna, short chirps are used for short ranges. However, since detecting small targets at long distance requires more energy, long chirps are used for long distances while medium chirps are used for covering the intermediate range. This is illustrated in Fig. 3.9 (p. 46).

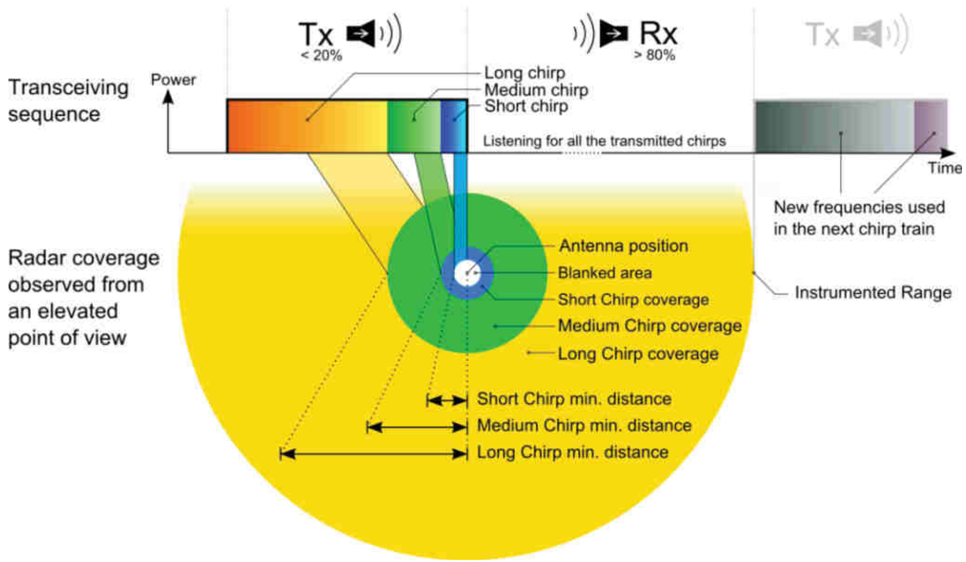


Fig. 3.9 Principle of transmission sequence

Up to 6 frequency bands in each of the 16 profiles can be used and the sequence of pulse patterns is fully software defined and can be adapted to the actual situation. The chirp combination (Transmission sequence) is defined as part of the individual profile set-up.

By nature, pulse compression will create time side lobes in a radar image, see Fig. 3.10 (p. 47). These are imperfections in range, where a target will appear with “artificial” targets before and/or after the actual target. Similar effects may appear in azimuth and are called antenna sidelobes.

Side lobes are unwanted, as they will limit the size of small RCS targets that can be detected next to large RCS targets. 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 6002 radar. The result is that time side-lobes are strongly reduced, in the order of 60 dB below the peak level.

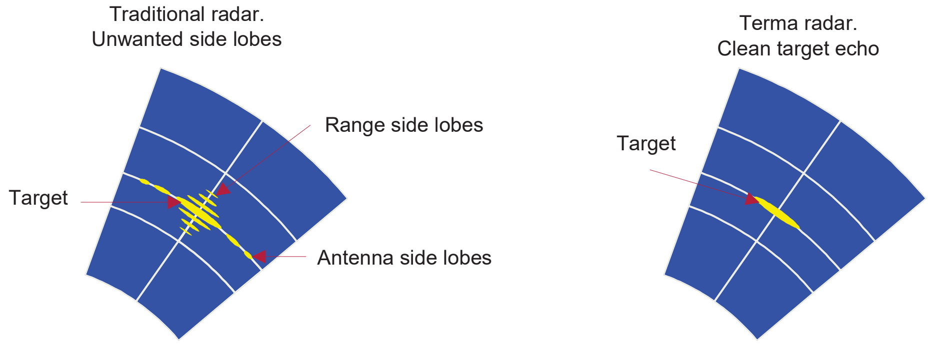


Fig. 3.10 Traditional and Terma SCANTER side lobe behaviour

3.6 Power Sector Transmission

In order to avoid interference from strong echoes from large stationary targets like buildings and mountains 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

The sectors are aligned relative to north or to the ships heading. The size of each sector may be chosen between 10° and 359°. Each sector may be given individual power attenuation. The system will perform an automatic sector wise power adaptation to the specified level. Prohibit sectors take precedence over transmit sectors.

For the transmit sectors the power may be attenuated, thus providing a mode with low probability of interception or interference. In a reduced power sector, the TX power can be reduced at least 16 dB. Fig. 3.11 (p. 48) shows an example of how two overlapping radars can use Power Sector Transmission to limit radar transmission over land area.

The SCANTER radar can also use a single scan to improve operational awareness in situations where limited transmission is desired.

Fig. 3.11 Use of power sector transmission

3.7 Sub-clutter Visibility and Doppler-based Processing

The transceiver supplies two channels at the same time: Normal radar video and Doppler-processed radar video. All targets and clutter will be present in the normal radar channel.

Stationary and near-stationary targets such as earth ground clutter (land, buildings, trees, grass fields, etc.) will have zero or low Doppler shifts, while targets with faster radial speed (aircraft, vehicles, etc.) will produce higher Doppler shifts. Stationary targets and clutter are suppressed by the use of a series of proprietary adaptive MTI filters and correlators. Special proprietary algorithms adjusts the filters to the speed of sea and rain clutter, suppressing clutter even if it is moving, resulting in a clean and crisp display of moving targets only. See Fig. 3.12 (p. 49).

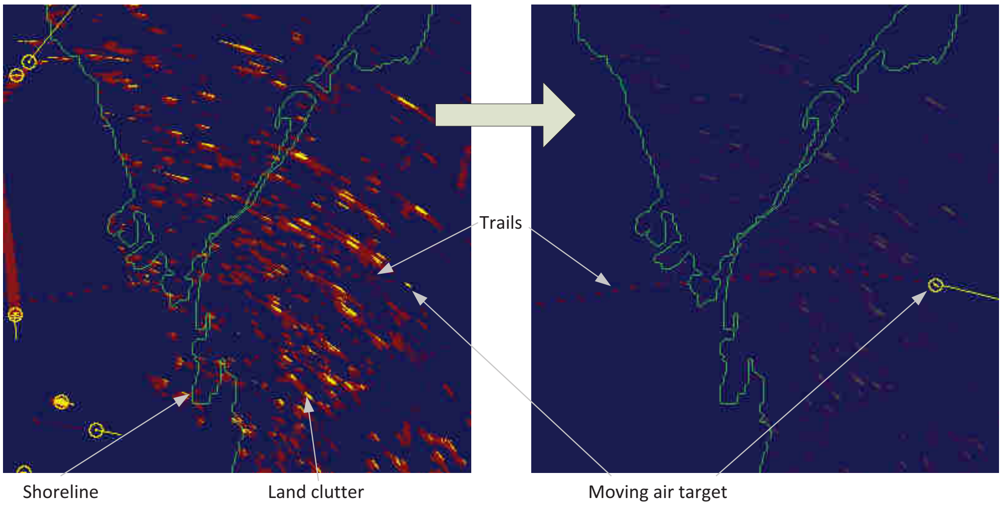


Fig. 3.12 Normal radar video (left) and air video (right)

3.7.1 Air Targets

It can be assumed that air targets of interest will have speeds substantially different from the surroundings, or in the case of helicopters, will have high-speed moving parts. Aircrafts will in most cases have zero radial speed only for short periods, and the majority of air targets will furthermore have large radar cross section when flying tangentially. Basic detection is therefore based on Doppler information. Information from the normal radar is added when desirable.

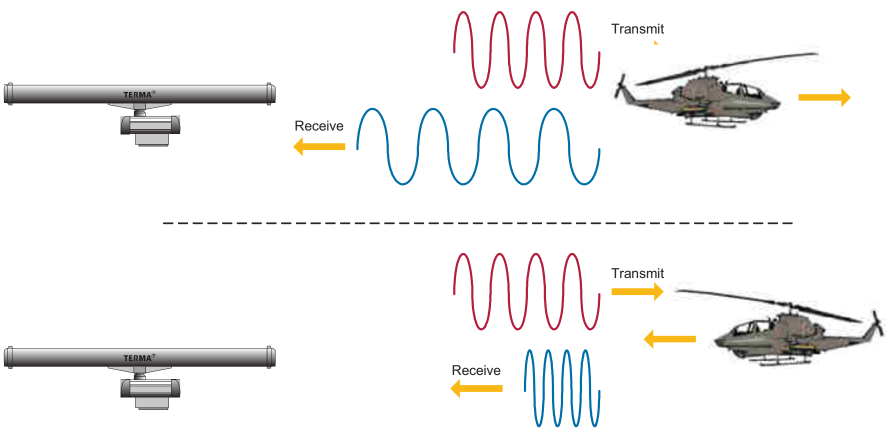


Fig. 3.13 The Doppler effect seen from the radar

3.7.2 Helicopters

The helicopter rotor, particularly the construction between the rotor shaft and the rotor blades, will reflect radar pulses with Doppler shifts determined by the rotor rotation. This makes detection of a helicopter possible in MTI processed radar video when the helicopter is moving and when it is hovering.

In adverse weather conditions, the MTI processing ensures that only the targets of interest are detected, while land, sea and rain clutter is suppressed.

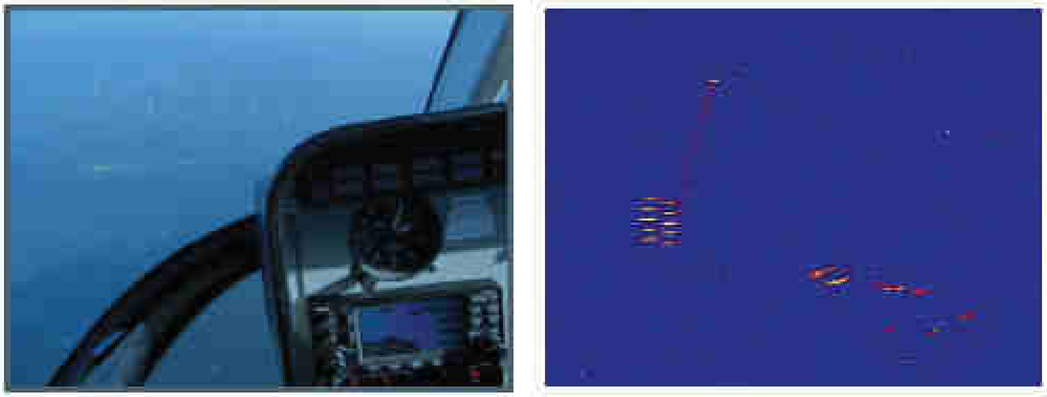


Fig. 3.14 Helicopter near wind turbine farm (left) and radar image of a helicopter near a wind turbine farm (right).

In Fig. 3.14 (p. 50), the helicopter and the moving wings of the wind turbines are detected in the Air video. Note that the video trails (in red) indicate helicopter detection very near to the wind turbines.

3.7.3 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 in the Doppler based processed video.
- Most small surface targets have radar cross section virtually independent of their aspect angle, hence large echoes cannot be expected for small tangentially moving surface targets.

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

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

A weighted combination of the two channels is forwarded for presentation and tracking.

3.8 FiveStepVideoPassing™

After down conversion in the receiver to Intermediate Frequency (IF), the signal is sampled with 14 bit at 400 MHz, demodulated, pulse compressed and MTI processed. Normal radar video as well as MTI-processed video is forwarded for display and tracking through the SCANTER *FiveStepVideoPassing*™.

As shown in Fig. 3.15 (p. 51), several techniques have been combined into the *FiveStepVideoPassing*™, enabling discrimination of targets of interest from noise and clutter, based on statistical properties of the signal.

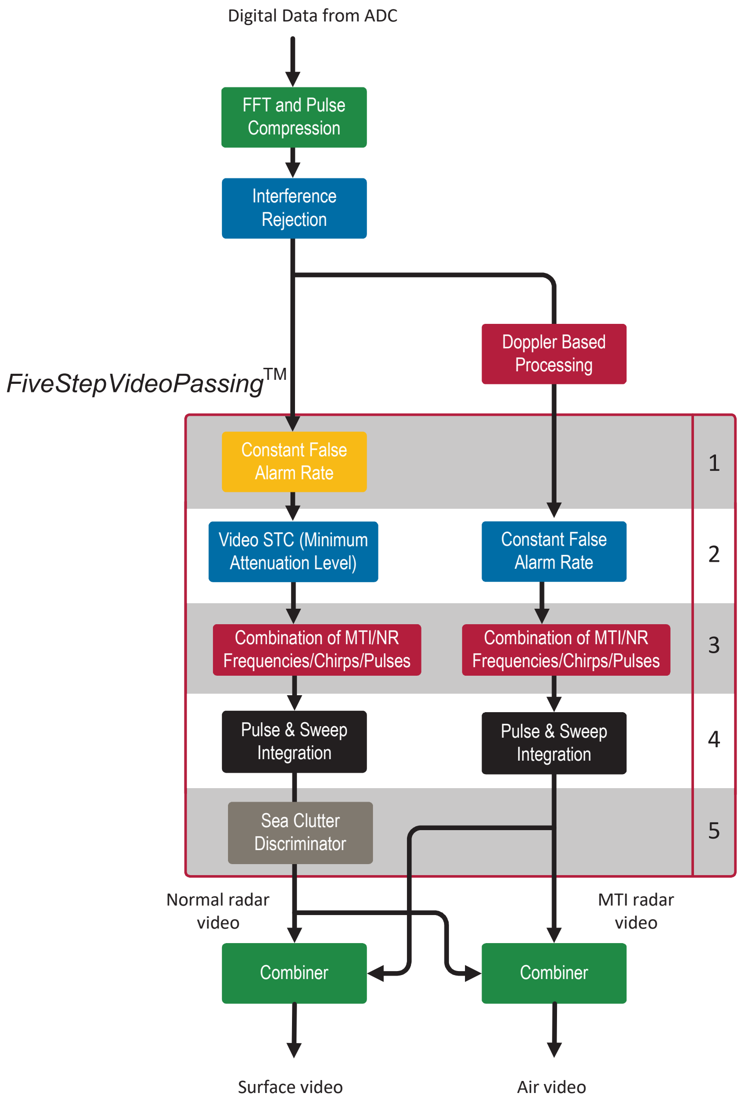


Fig. 3.15 Signal processing, simplified

The processes include automatic adaptation to the environment (see section 3.9 (p. 52)).A smart channel combiner and interference filtering suppresses asynchronous interferences and second/multiple time around returns, by the use of staggered transmission sequences.

The Doppler processing will simultaneously suppress stationary targets as well as moving clutter. The dominant speed and movement directions of clutter are determined automatically and compensated for in the MTI processing.

Adaptive parameter settings are used in the filters, in the FD combiners and in the integration processes to reduce beam shape and other losses as well as to optimize sensitivity.

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

3.9 Environment Adaptation

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

The SCANTER 6002 series makes automatic adjustments to provide a flat noise floor. This is obtained by utilizing ordered statistics Constant False Alarm Rates (CFAR) and other adaptation techniques, like the Sea Clutter Discriminator (SCD).

Fig. 3.16 (p. 52) is an example of a radar image of the Aarhus bay in Denmark. The Visual Range Markers (VRM) and A-scopes show the echo of a catamaran ferry at a range of 11.88 nmi. Because of the high resolution, the ferry superstructure is clearly visible in the A-scope.

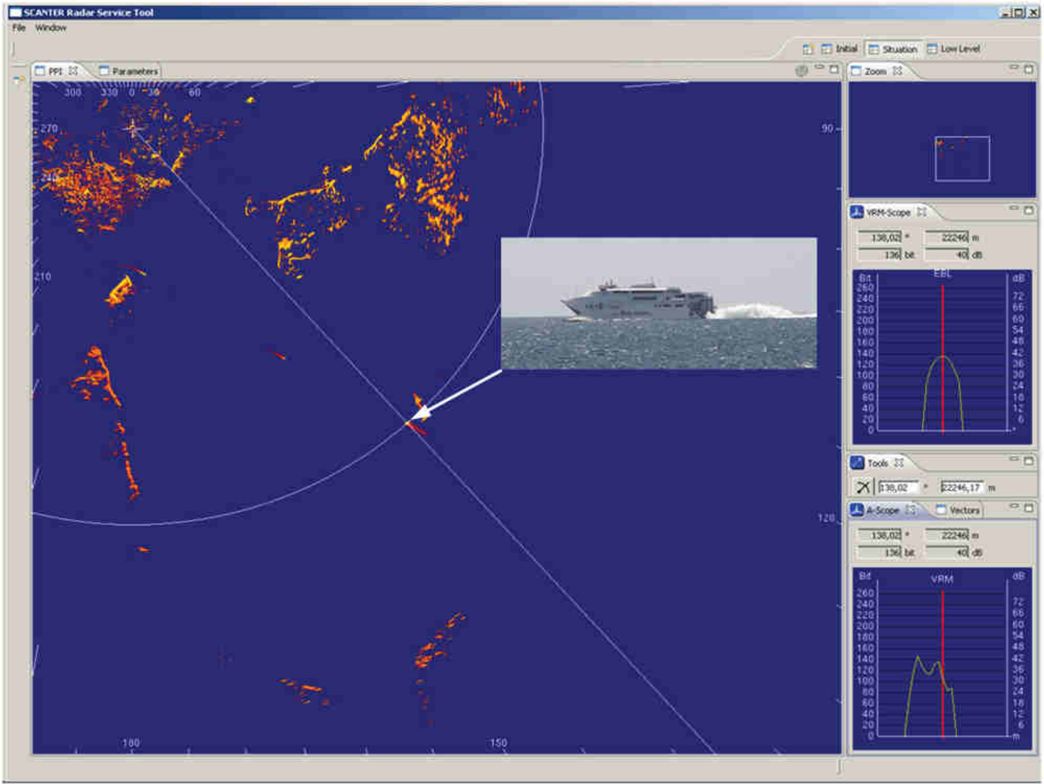


Fig. 3.16 SCANTER 5000/6000 series radar image from Aarhus Bay Denmark

3.10 Cross Coupling

Terma can supply a redundant SCANTER system with cross coupling of the radar video at the start of the digital processing chain. The active transceiver is capable of distributing data packages prior to pulse compression and signal processing, and the passive transceiver is able to pulse compress and process the received data packages resulting in a video output along with plots and tracks if an ET2 is present. The cross coupled data in the passive receiver is handled in the same way as live radar data.

The transceiver uses the redundant state to automatically determine whether it should receive or distribute cross-coupled data.

The cross coupling can be used in two ways:

- To allow the passive transceiver to have a complete situational picture incl. radar video and tracks (if this option is installed) available when a switchover is forced manually or initiated because of a failure in the active transceiver.
- To allow the passive transceiver to be used for training purposes without disturbing the active transceiver.

3.11 Sensitivity Time Control (STC) Curves

Fixed STC curves can be generated. The shape of the STC curves is configurable by means of a few parameters.

These STC curves can be used for optimizing radar performance under specific conditions.

3.12 Controlling and Using the Radar

3.12.1 Local and Remote Control

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

- The transceiver itself has a display, which will show system status, BITE status and key system parameters. It has four control buttons to navigate through menus and submenus.
- The Radar Service Tool (RST)is a software package, which connects to the Transceiver(s) via an IP network connection. From the software package all parameters, settings, BITE measurements and errors can be accessed via an IP network connection. From the software package all parameters, settings, BITE measurements and errors can be accessed. Furthermore, a Plan Position Indicator (PPI) view is included in the RST.
- Via an open IP network protocol, all parameters, settings, BITE measurements and errors can be accessed remotely.

Radar video is available as analogue video, digital 8 bit Low Voltage Differential Signaling (LVDS) video and UDP/IP network video (Terma proprietary protocol or ASTERIX CAT240 protocol)

3.12.2 Profiles

Profiles are predefined parameter-sets used by the radar software, to set optimal Transceiver performance according to varying weather conditions or specific operational demands. Up to 16 profiles may be defined. During system installation and setting to work, individual profiles that are optimized for the particular installation will be created. Thus, during daily operation, just one or two profiles are typically needed.

The profiles eliminate the risk of miss-adjustment of the radar and reduce the operator need to acquire detailed knowledge about radar characteristics.

At any time, the operator may set a specific radar parameter, e.g. chirp length, frequencies, chirp pattern, antenna rpm, to over-ride the definition of the profile.

The profiles are selectable directly on the Transceiver, via the RST or per remote IP network.

3.12.3 Exclusive Access

Exclusive Access is used for requesting 'master control mode' of the radar. This mode allows the user to gain exclusive access to the radar, i.e. lock the configuration parameters for sole use. Three values can be chosen; 'Disabled', Optional' or 'Mandatory'. If the parameter is set to 'Mandatory', the user must request master control mode before being able to change configuration parameters.

3.12.4 Secure Protocol

Parameter Control Data protocols newer than v. 2.0 and all Track Control Data protocols can be secured by a certificate. For each of these protocols, the user may specify whether the protocol should be secured by the certificate, by enabling "Secure Protocol Extensions". These extensions provide encrypted, authenticated wrappers of the corresponding protocols of the SCANTER Transceiver. Encryption and authentication is based on industry-standard X.509 client/server certificates and TLS version 1.2.

3.12.5 User Authentication

The Transceiver Control Interface protocol supports Secure Protocol Extensions for encrypted, authenticated access, which means that no third party can gain access without the suitable certificate, which is generated and uploaded via RST.

3.12.6 Built-in Test Equipment (BITE)

BITE, see Fig. 3.17 (p. 55), is continuously monitoring performance parameters such as Mains-on time, SSPA status, forward power, noise figure, internal voltages and temperatures, turning unit status etc.

An advanced error handling system gives a quick overview as well as a detailed description of any error in the system.

Both features make up a powerful tool for preventive maintenance and fast and efficient repair in case of failure.

All measurements and errors are stored in a log for inspection and later reference.

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 these is internally assessed and automatically initiate appropriate actions to maintain operation to the extent possible, when an error is detected. The BITE reporting 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 (LRU) at fault.

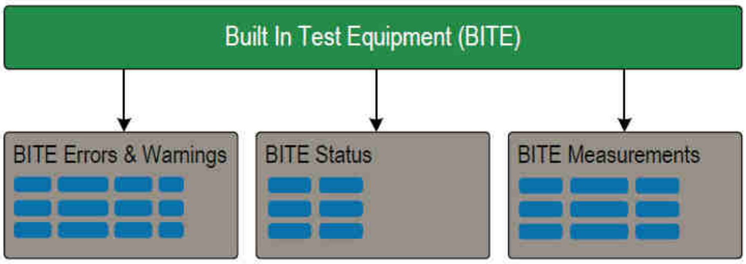


Fig. 3.17 Built-In Test Equipment (BITE)

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 and reverse power Status from motor, gear and optional inputs providing antenna status
BITE status:	Displays transceiver components status
BITE measurements:	Temperatures Internal power supplies Noise figure, indicative power level

If parameters exceed specifications, warning 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 IP network interfaces.

3.12.6.1 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.

3.12.6.2 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".

3.12.6.3 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.

3.12.6.4 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. 3.18 (p. 57).

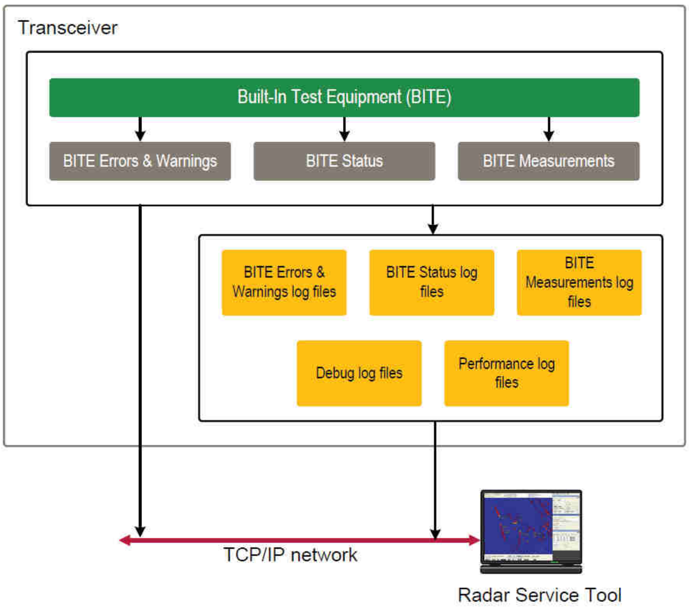


Fig. 3.18 System and performance logs

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.

Each BITE log and the parameter log store a log file per day. The storage period of log files in these logs can be configured to max.180 days (default is 90 days).

Furthermore, max. disk size for the three BITE logs can be configured. If the storage period is exceeded, a log file per day will automatically be deleted, starting with the oldest file. If the disk size is exceeded before expiration of the storage period, the oldest log files will be deleted to free space on the disk.

In addition, there is a performance log where performance parameters such as noise figure, forward power, etc. are measured periodically. In this log, files are stored for 10 years (storage period cannot be configured).

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

Automatic shutdown is based on a combination of autonomous HW circuitry and 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 via TCP/IP (LAN/WAN) and typically accessed from the Service PC using the RST software.

3.13 Remote System Management via Radar Service Tool

The sensor system can be accessed for management and monitoring from a remote location through the Radar Service Tool running on a PC connected to the radar IP network.

The Radar Service Tool provides the following functionality to the maintainer:

- Situation Display with track overlay
- High-Level Control/BITE
- High-Level set-up and Service Tools
- Low-Level Parameter and BITE Access
- Documentation Library

The Radar Service Tool provides the user with a consistent user interface, see Fig. 3.19 (p. 58),across the various features implemented. It supports different perspectives, where each perspective corresponds to a particular arrangement and subset of Radar Service Tool windows. The user may define, store and recall individual perspectives.

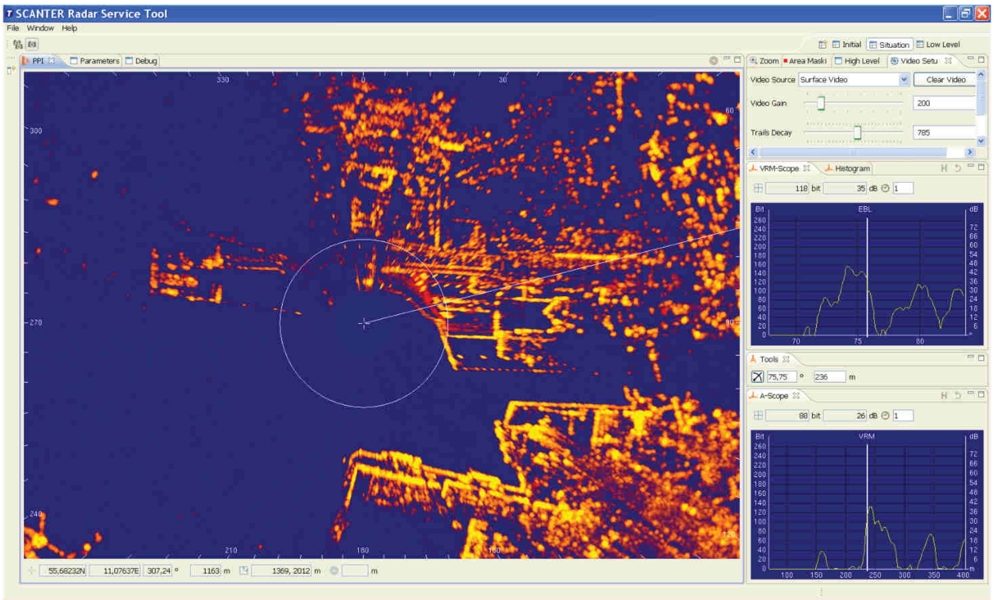


Fig. 3.19 Radar Service Tool GUI.

3.13.1 Profile Setup

All parameters affecting the radar performance and processing can be saved in a named profile, which will provide a complete set of radar parameters. When the parameters have been defined, the profile is saved with a profile name. The profiles are easily selected in a drop-down menu in the Radar Service Tool.

3.13.2 Status Monitoring

The Radar Service Tool provides status on radar functions and performance as well as detailed status on all modules in the system. All BITE information available about the modules is shown together with any status or error message issued by the module, see Fig. 3.20 (p. 59).

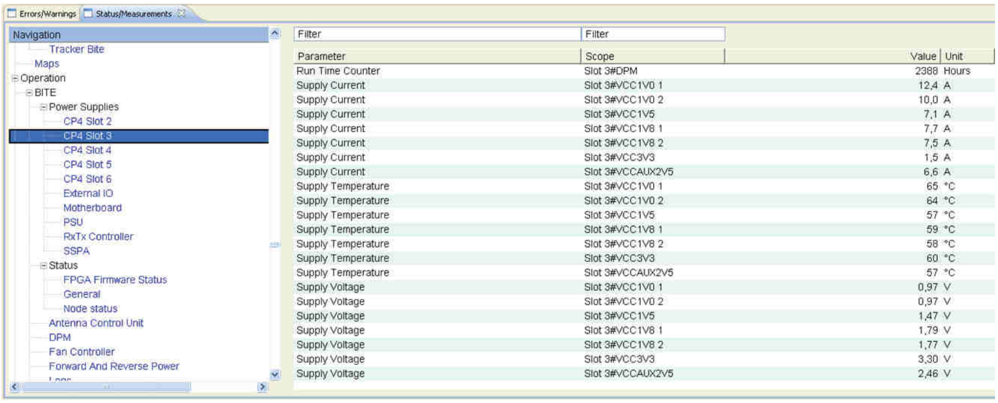


Fig. 3.20 Example of CP4 module status.

3.14 Dehydrator

As a result of temperature fluctuations and other environmental effects, pressure differences can arise between the inside and outside of the waveguide. Under these conditions, wet air can enter the waveguide system, and humid air can also diffuse through antenna windows and connections.

The SCANTER 6002 can be equipped with an active waveguide drier of the regeneration type. The waveguide drier should run continuously after completion of the Setting-to-Work activities and during longer periods where the system is non-operational. Static desiccators may be used if power is unavailable for longer periods.

(Intentionally left blank)

4 ET2 - Embedded Tracking (Optional)

4.1 General Information

The embedded tracker (ET2) is a modern, knowledge-based tracker, which efficiently implements the currently most accepted and advanced tracking algorithms. The ET2 is based on years of intensive product development and frequent tests with all kinds of targets ranging from swimmers, jet skis, and small RIBs to super tankers, from ultra-light aircraft, fighter aircraft, and helicopters to large airliners. Tests have been conducted in a number of countries, under different weather conditions, both on ground based or moving platforms.

Fig. 4.1 Target Examples

The purpose of the embedded tracker is to automatically identify target echoes in the radar image and to describe the movement of each real life target as a confirmed track with associated track parameters as illustrated in the figure below:

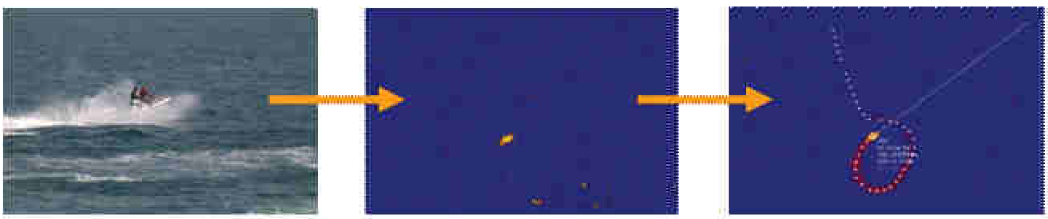


Fig. 4.2 Real life advanced video processing to confirm track.

The identified targets are assigned unique id numbers, and position, speed, and course are determined. The embedded tracker follows the track of each target by predicting and updating its kinematic state and other target-related features from scan to scan and makes this information available to the radar image presentation and possible external users.

The ET2 works on an optional PC board integrated in the transceiver and with the transceiver software. A processing diagram of the ET2 is shown. The Normal Radar/Surface Video stream is present in the SCANTER 6002 standard configuration. The Doppler Processing/Air Video branch can be added for air target surveillance and improvement of surface target detection.

The two video streams are processed, followed by plot extraction in each stream. The plots from the two streams are merged and sent to the tracking process. The primary output is tracks on surface and air targets. The tracks are provided on a transceiver network port (a LAN port) to the relevant track consumers such as e.g. an Operations Room and the radar service display.

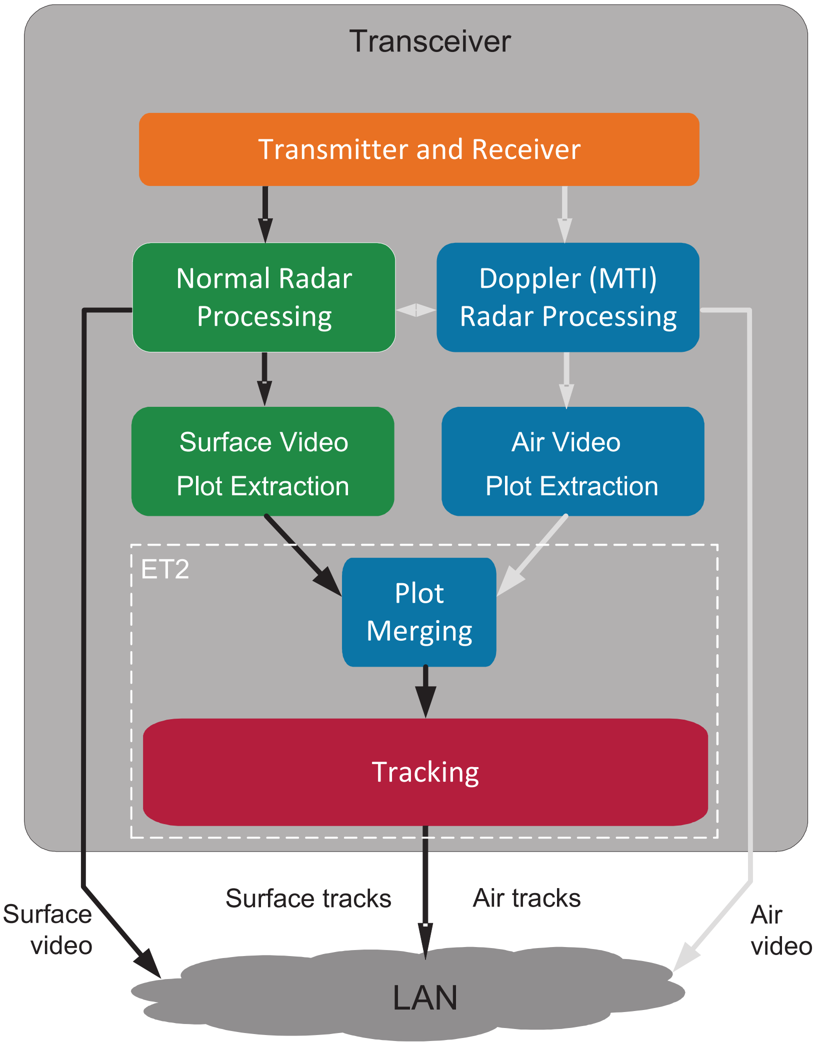


Fig. 4.3 ET2 Processing diagram.

When tracking stationary objects or slowly moving surface objects like boats, the tracker operates on the surface video, while faster targets like helicopters and aircraft are tracked in the air video. However, the Doppler based processed video provides enhanced discrimination between moving targets and background clutter for surface targets with radial speeds significantly different from the radial speed of nearby clutter. In this case, an enhanced tracking of moving objects or of objects with large moving parts e.g. hovering helicopters can be obtained by a combined use of the air and the surface videos.

Please refer to 615730-DP Product Specification Embedded Tracker (ET2) for further details.

5 Transceiver

5.1 Transceiver Building Blocks

The transceiver is parted up in a radio section and a processing section. It consists of a number of Line Replaceable Units (LRUs) shown below.

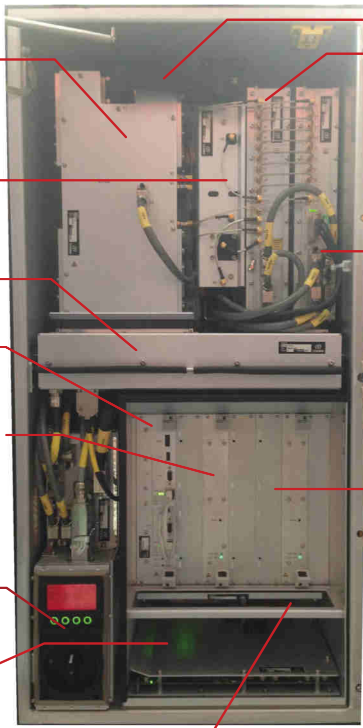


Fig. 5.1 Transceiver building blocks

5.2 Dimensions

The transceiver design and dimensions are outlined below.

All transceiver dimensions can be found in doc. no. 606002-ZD.

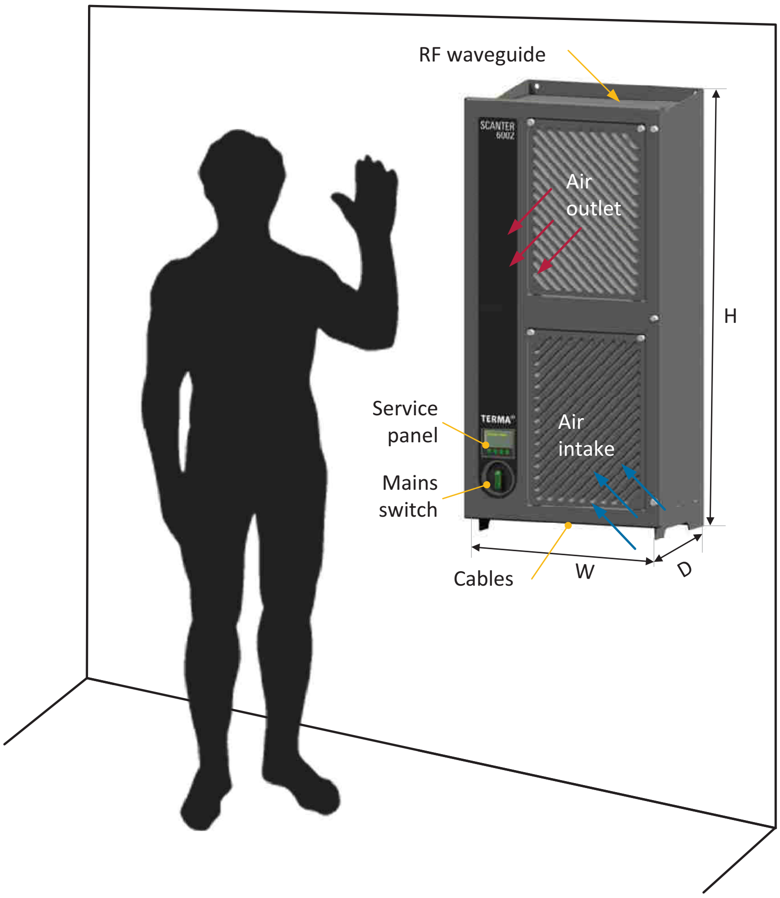


Fig. 5.2 Wall-mounted transceiver dimensions

Weight:	Approx. 77 kg installed
	Approx. 120 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

5.2.1 Transceiver Block Schematic

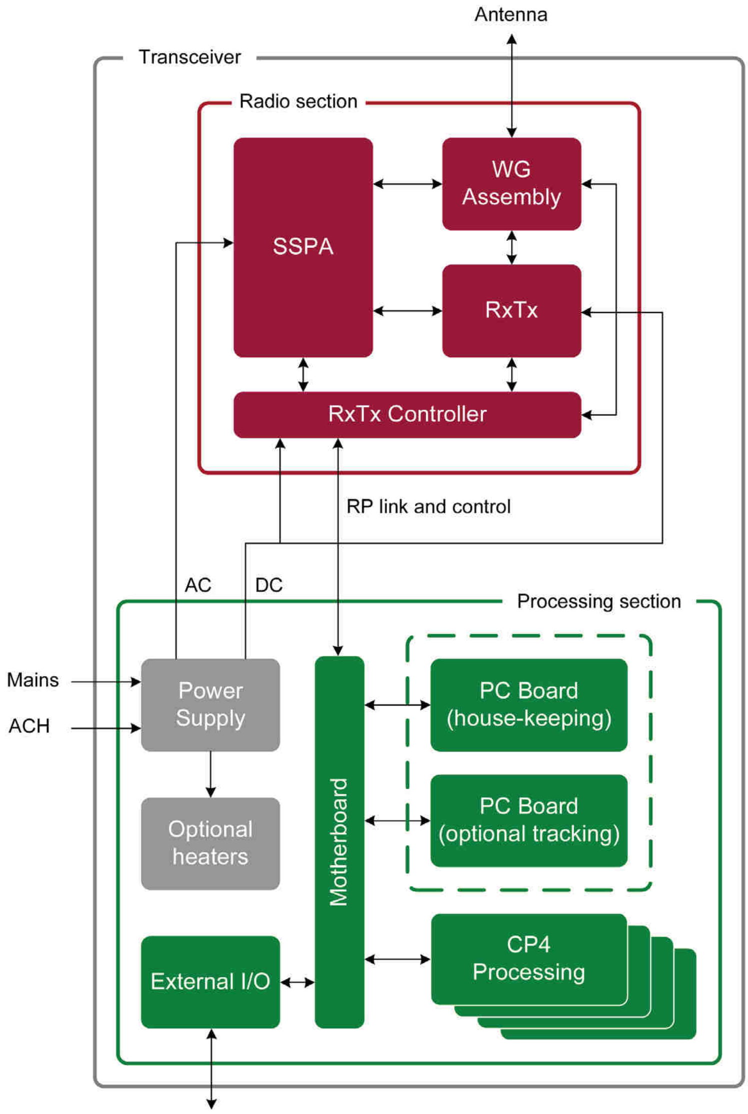


Fig. 5.3 Block schematic

5.2.2 Part Numbers

All part numbers for spare parts, consumables and tools are listed in section 10.2 (p. 126).

5.3 Hardware Structure

5.3.1 Internal Cabling

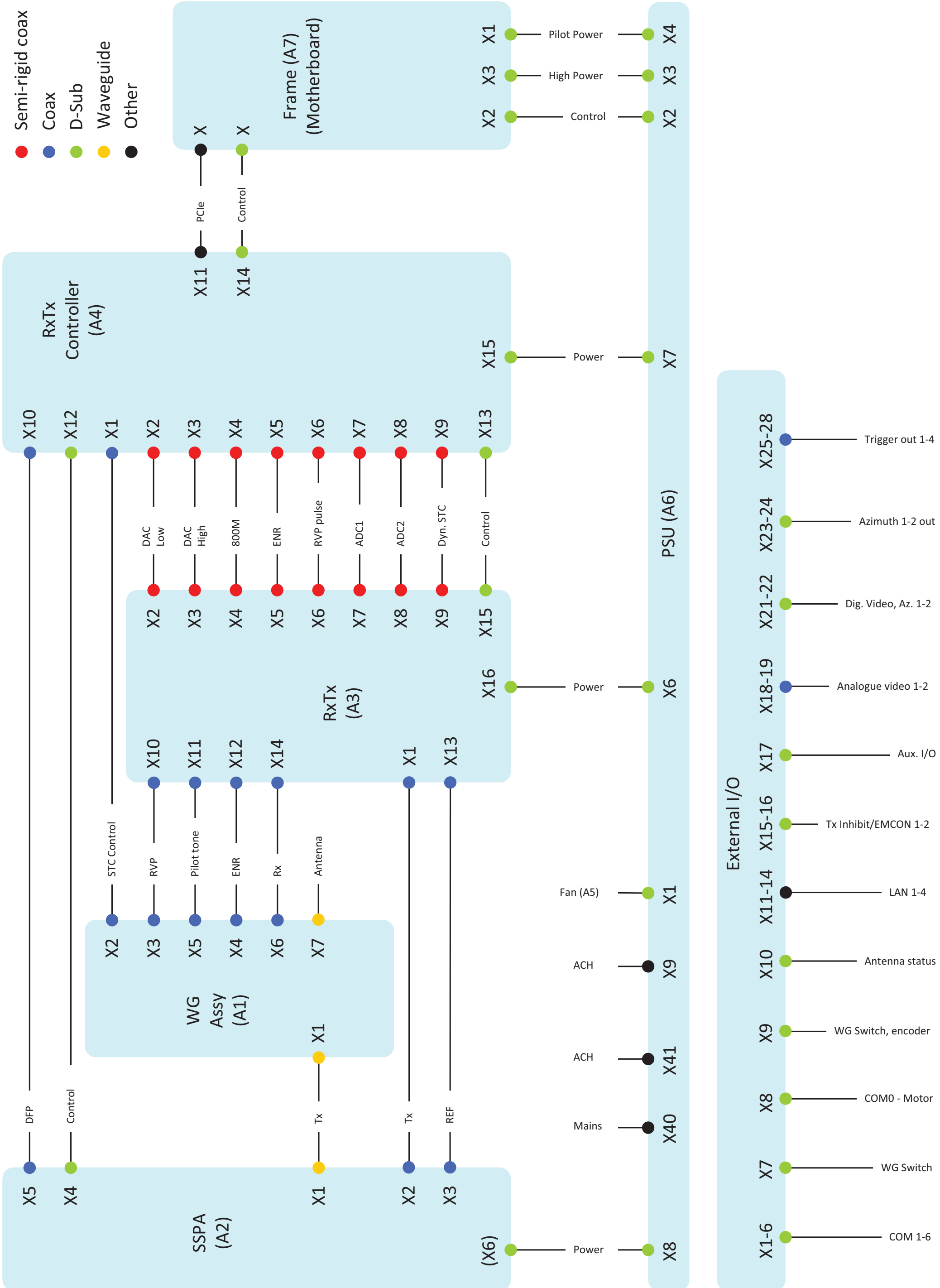


Fig. 5.4 Internal cabling

5.4 Modules

5.4.1 SSPA - Solid State Power Amplifier

The SSPA modules for the SCANTER radars are designed on the basis of state-of-the-art MMIC power transistors. See Fig. 5.5 (p. 67).

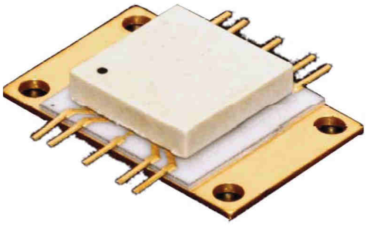


Fig. 5.5 Power transistor

Each 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 31 dB.

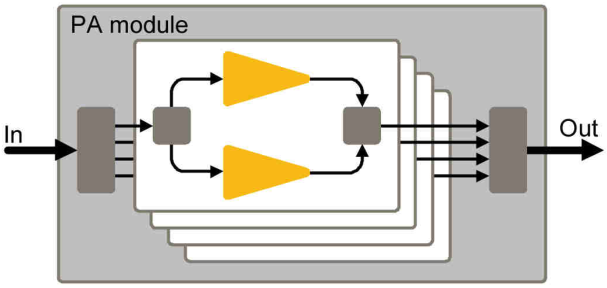


Fig. 5.6 50 W SSPA module

5.4.1.1 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 6002 SSPA provides 200 W output power by combining 4 x 50 W PA modules. It consists of 6boards mounted on a common profile. The integrated waveguide power combiner is also integrated in the profile.

Fig. 5.7 SCANTER 6002 SSPA module - 4 x 50 W PA modules

A block schematic of the 200 W SSPA is shown in Fig. 5.8 (p. 68).

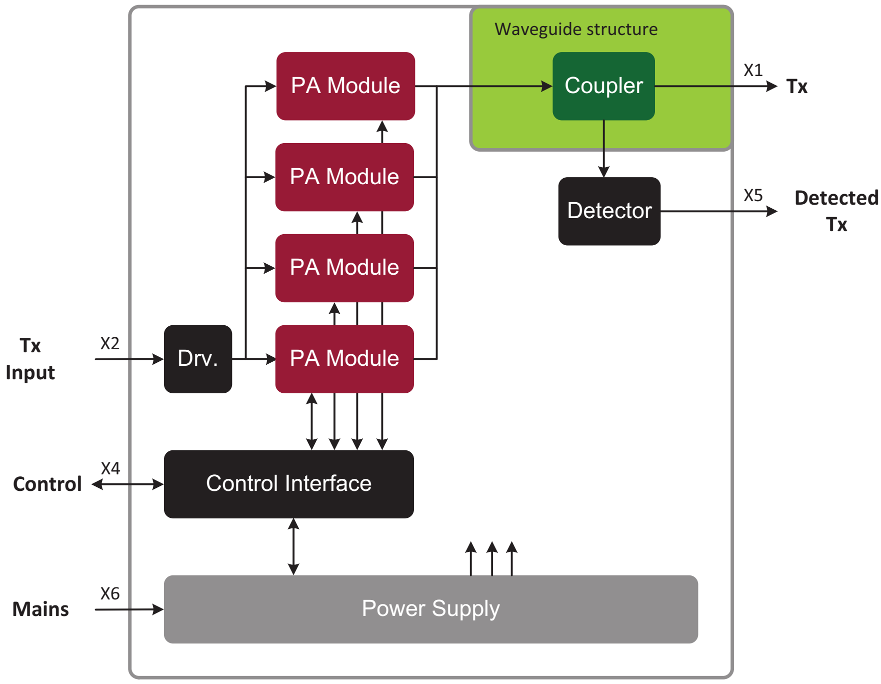


Fig. 5.8 SSPA module block diagram

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.

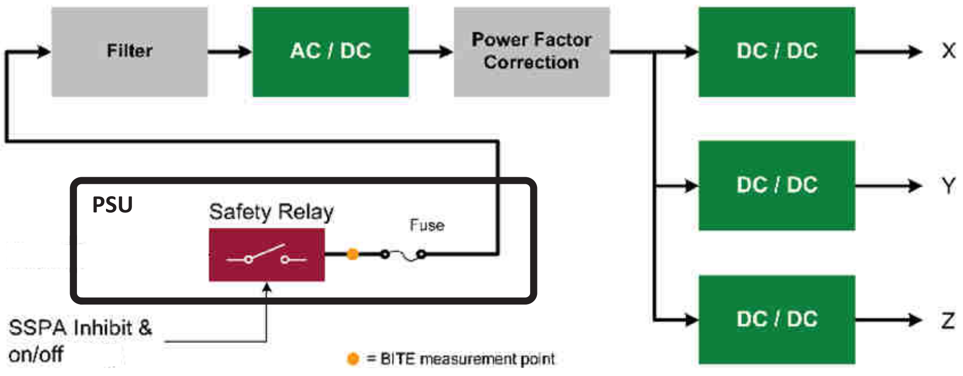


Fig. 5.9 Power Supply, SSPA

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.

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

- Temperature on all PC boards.
- 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:

	SSPA
Output peak power	200 W
Power consumption (@ 20% duty cycle)	410 W
Weight	15 kg
Dimensions h x w x d (foot print)	352 x 217 x 249 (227) mm

5.4.1.2 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.

5.4.2 Waveguide Assembly

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.

Waveguide Assy	Conn.	Function
	X1	Waveguide (SSPA)
	X2	STC Control
	X3	Measurement port
	X4	Test port
	X6	Rx port
	X7	Waveguide (antenna)

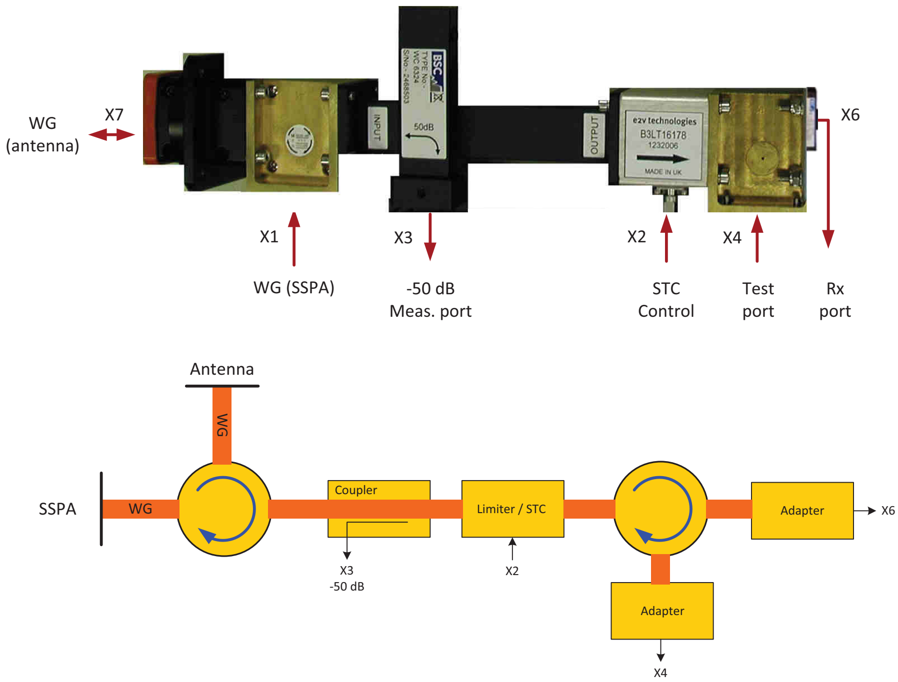


Fig. 5.10 Waveguide assy - block schematic

In the block schematic in Fig. 5.10 (p. 71), the RF signal from the SSPA is applied a circulator and guided to the antenna.

The received signal from the antenna is applied the same circulator and guided through a cross coupler where -50 dB and -20 dB signals are available. After the coupler the received signal is applied the Limiter/STC, where attenuation of the signal takes place - the Limiter/STC is able

5.4.3 Anti Condenstion Heater

The anti condensation heater (ACH) is functionally isolated from the remaining radar and has its own power input. The purpose of the ACH is to avoid build up of condensation inside the equipment when the radar equipment is switched off; e.g. when the ship is alongside the quay and temperatures are low in the equipment room.

The ACH power supply is connected to the ships general power supply and switched on when the remaining radar equipment is switched off.

The temperature is controlled by a bimetallic thermostat operating at the following temperatures:

- Open above 13 ±3 °C
- Close below 4 ±4 °C

5.4.4 RxTx

The RxTx is part of the Radio Section in the transceiver. The RxTx is connected to the RxTx control and the SSPA. The functionalities of the RxTx include:

- Tx upconverter
- Rx downconverter
- 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 Control
- Measurement system for monitoring noise figure, forward and reverse power

The position of the RxTx in the system is shown in Fig. 5.11 (p. 72).

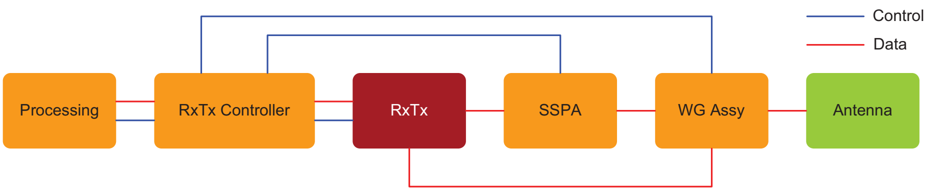


Fig. 5.11 RxTx

RxTx Module	Conn.	Function
	X1	TX out
	X2	Tx Input Low
	X3	Tx Input High
	X4	800 MHz CTRL
	X5	Noise control
	X6	Rev. Power Env.
	X7	RX ADC1
	X8	RX ADC2
	X9	STC2
	X10	Rev. power in
	X11	Not in use
	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. 5.12 (p. 73).

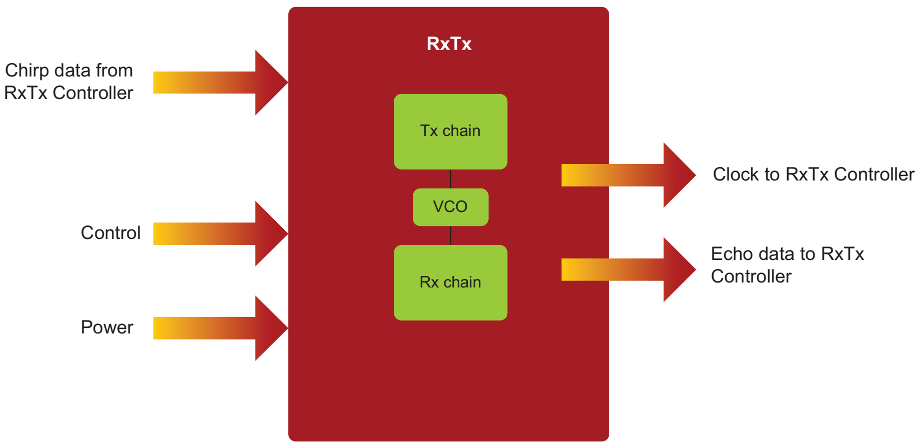


Fig. 5.12 Signal categories to and from RxTx

5.4.5 RxTx Control

The main tasks of the RxTx control is to:

- 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 control in the system is shown in Fig. 5.13 (p. 74).

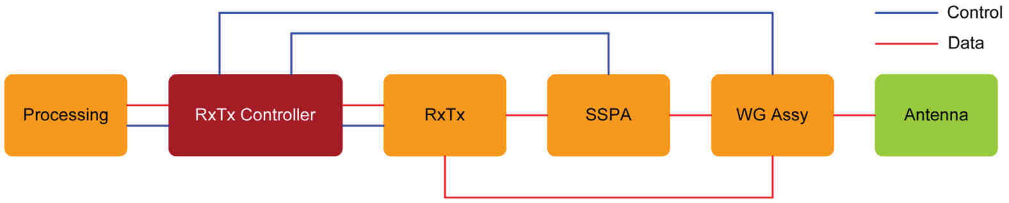
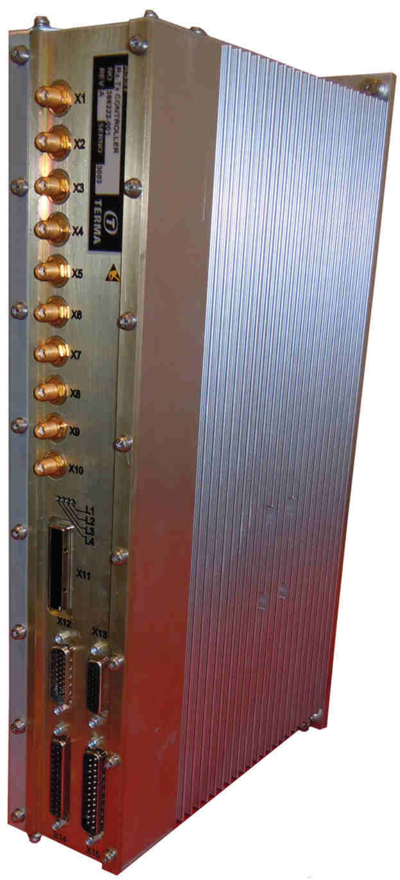


Fig. 5.13 RxTx Control in the system

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	Forward power input

The I/O categories to and from the RxTx control are PCIe, control, power, chirp data to RxTx, echo data from RxTx, transceiver control and transceiver clock as shown in Fig. 5.14 (p. 75).

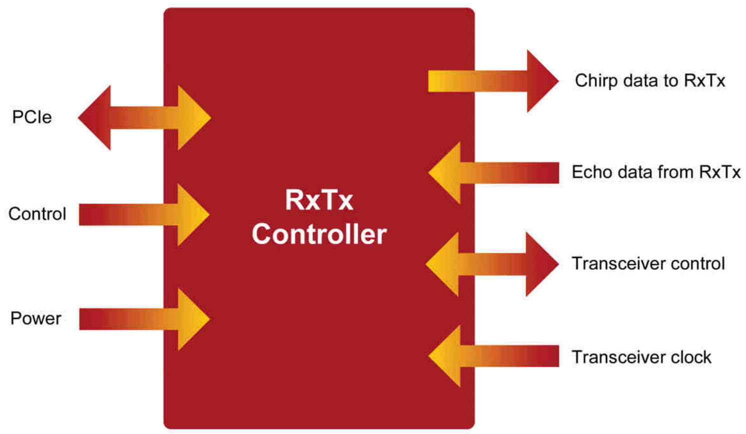


Fig. 5.14 Signal categories to and from RxTx Control

5.4.6 Blower Assy

Fig. 5.15 Blower assy

5.4.7 Crate Assy incl. Motherboard

The motherboard is a part of the Crate Assy and is one unit - the spare part “Crate Assy” also includes the motherboard.

The motherboard is part of the SCANTER 6002 transceiver processing section. In addition to the motherboard, the processing section consists of up to three 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 crate. The PC Carrier Board and the CP4 Boards are plug-in modules, mounted in slots in a crate. See Fig. 5.16 (p. 77).

Fig. 5.16 Crate assy, shown with Ext. I/O and a CP4 board

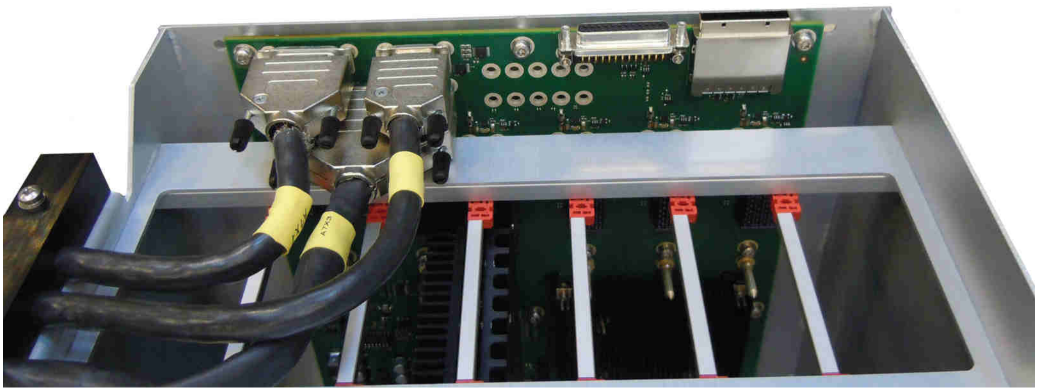


Fig. 5.17 Motherboard and connections shown in crate assy

The block schematic for the motherboard and its peripherals is shown in Fig. 5.18 (p. 78). The external interfaces are:

- PC Controller board interface (VITA 46.4, PCIe x4 + x4)
- 3 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 Board)
- External I/O board control signals (through Interconnection Board)
- External I/O board PCIe x8 (through Interconnection Board)
- RxTx Control control signals
- RxTx Control PCIe x8
- 1 x USB interface (through Interconnection Board)
- I2C interface

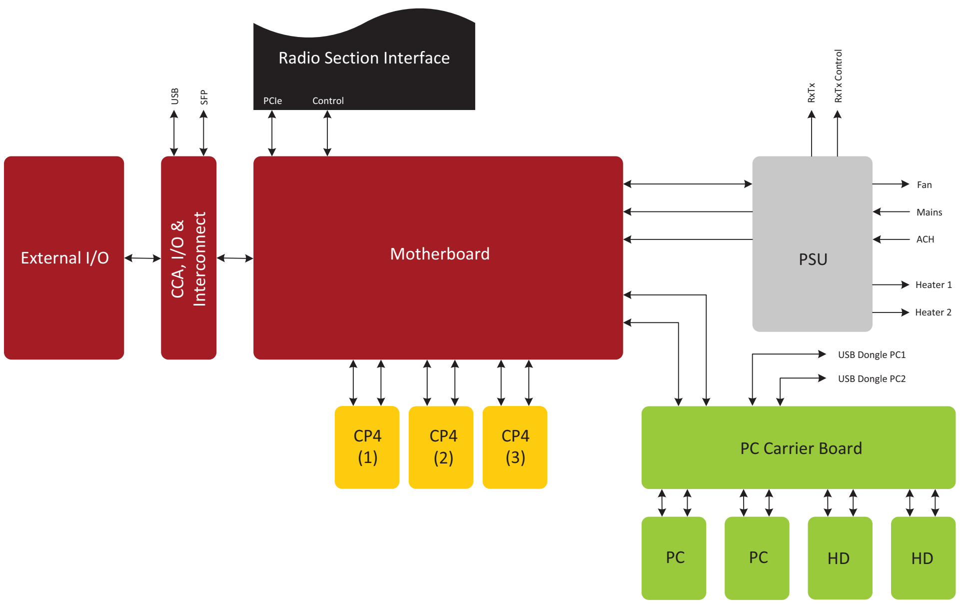


Fig. 5.18 Motherboard and surrounding units

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.

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 the plug-in module keying device to be mated with the backplane pin, no matter the angle (an un-keyed module).

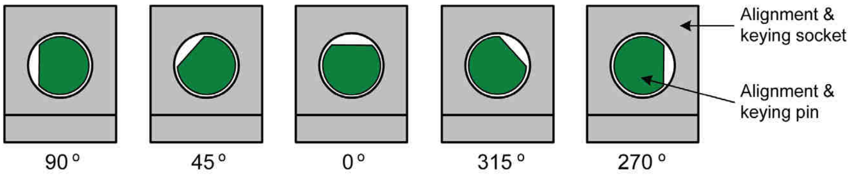


Fig. 5.19 Keying of modules

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

5.4.8 PC Controller Board

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

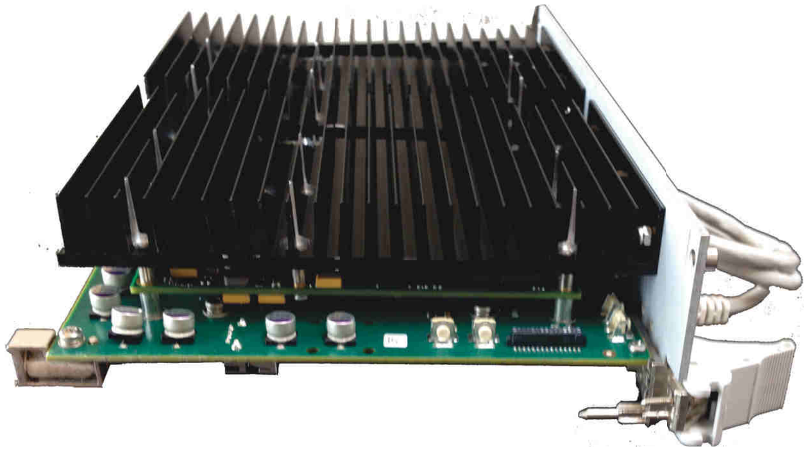


Fig. 5.20 PC Controller Board

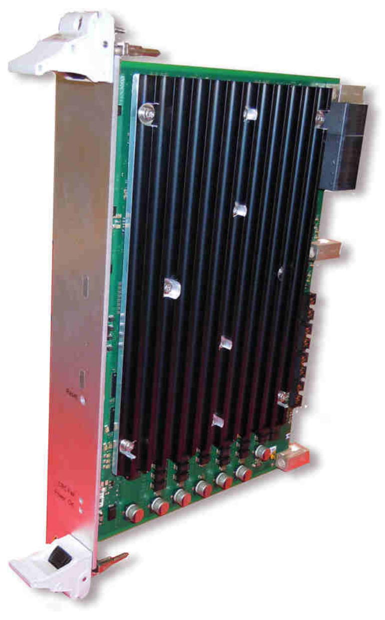
The PC Controller Board is based on a medium performance processor. It comprises the PCIe root complex, handle the PCIe initialization, use the PCIe bus to upload new firmware to CP4 boards, External I/O Board, and the RxTx Control. Furthermore, it also controls the display, the push buttons, controls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

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.

5.4.9 Common Platform 4 (CP4) Board

The crate in the transceiver can hold three Common Platform 4 (CP4) boards - the task of the CP4 board is to process the video coming from the RxTx control and depending on the required processing 1 to 3boards 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 tells that an error has occured.

The CP4 board consists mainly of four Field Programmable Gate Arrays (FPGA) which take care of all signal processing - each FPGA having its own memories, SDRAM, SRAM and Flash.

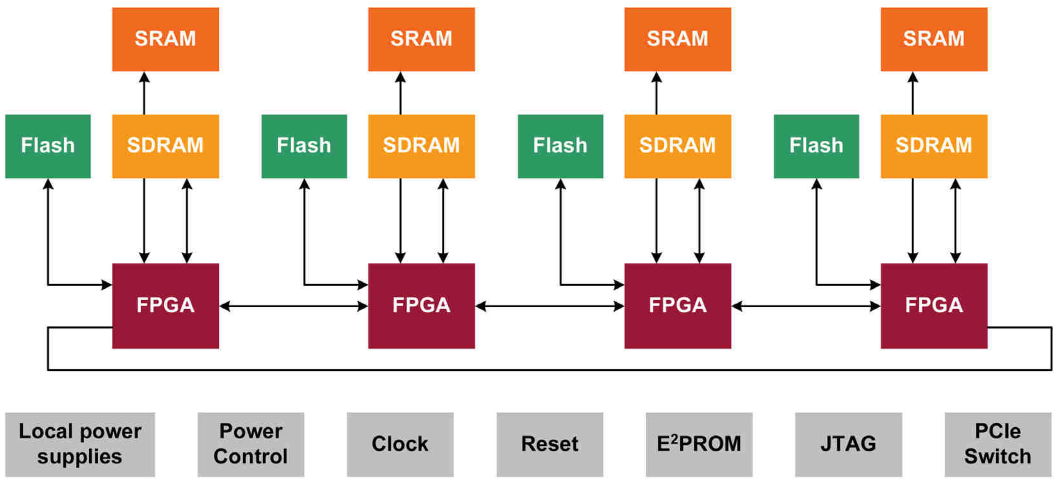


Fig. 5.21 CP4 board, block schematic

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

5.4.10 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 mains from the PSU 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.

5.4.10.1 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 Control, power
	X8	SSPA, AC power
	X9	ACH, AC power (optional) Heater, power (optional)
	X40	Mains, AC power
	X41	ACH, AC power (optional)

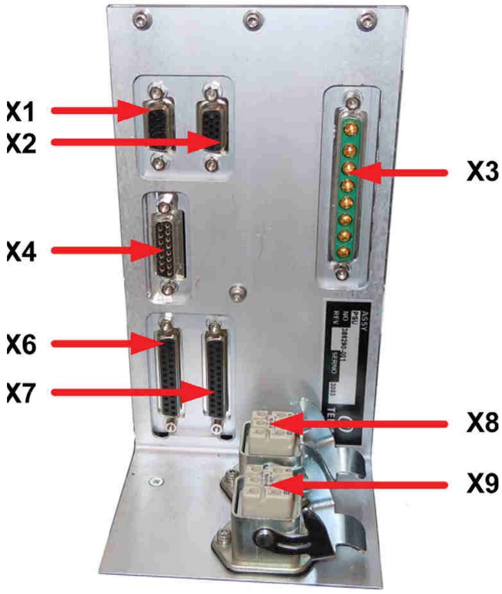


Fig. 5.22 PSU connections, top

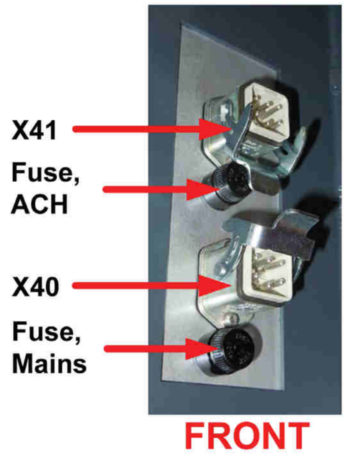


Fig. 5.23 PSU connections, bottom

5.4.10.2 Block Schematic, Supplies

Referring to Fig. 5.24 (p. 83), mains is applied - when turning the mains switch on and presuming the fuse is not blown - to a relay controlled by a circuit which checks the mains supply and the temperature in the PSU. If the temperature falls to 4 ±4 ° C the ACH is turned on but if the ACH is unable to raise the temperature to above 0 ° C the Transceiver will not turn on.

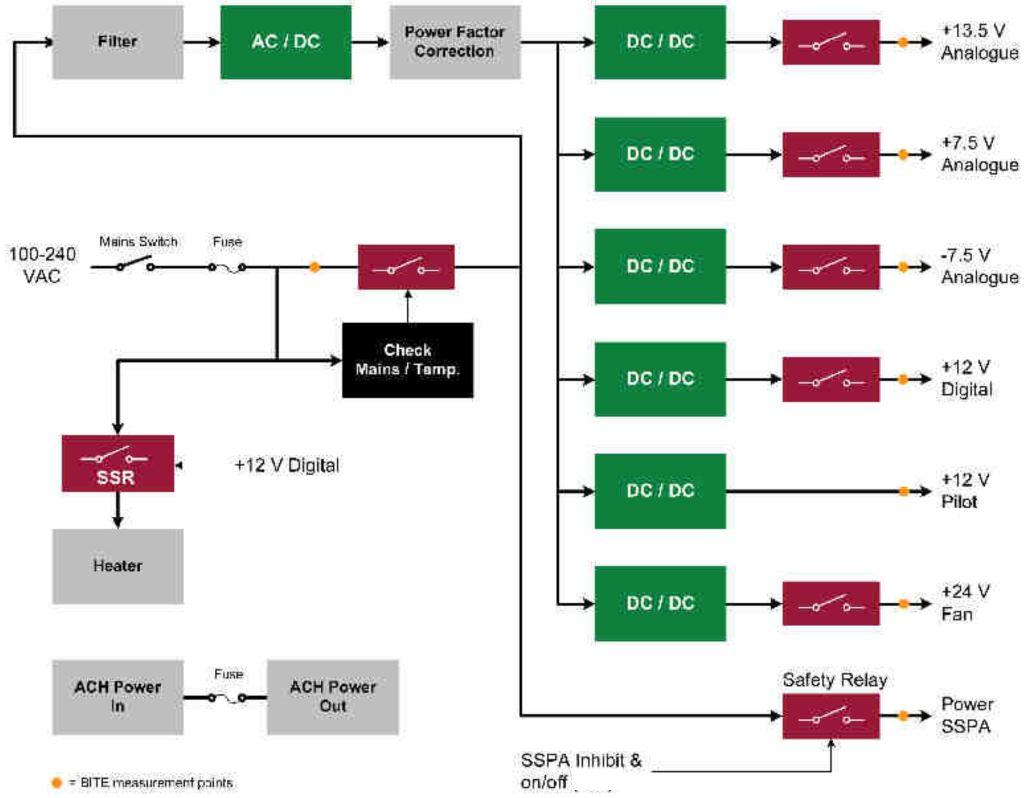


Fig. 5.24 Block schematic, supplies, PSU

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 a AC/DC converter and a Power Factor Correction circuit, a DC voltage is applied to 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, this is done by turning Mains ON on the Transceiver. 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 3 CP4 modules) is shown in the following table.

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

5.4.10.3 Block Schematic, SPI and I2C buses

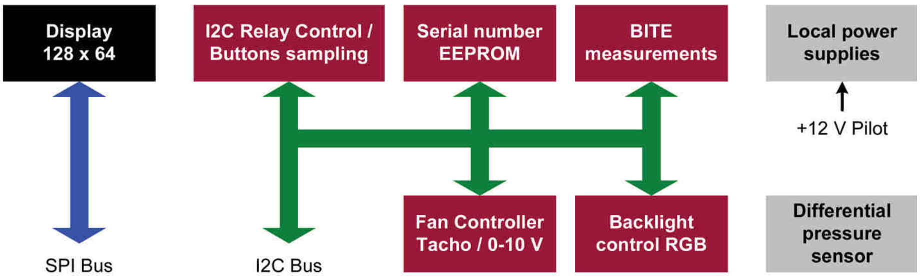


Fig. 5.25 Block schematic, SPI and I2C buses, PSU

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. In addition, a circuit monitors the pressure out of the fan (a differential measurement to monitor the air flow).

An 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.

5.4.10.4 Operator's Panel

The display has more 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 blue 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.

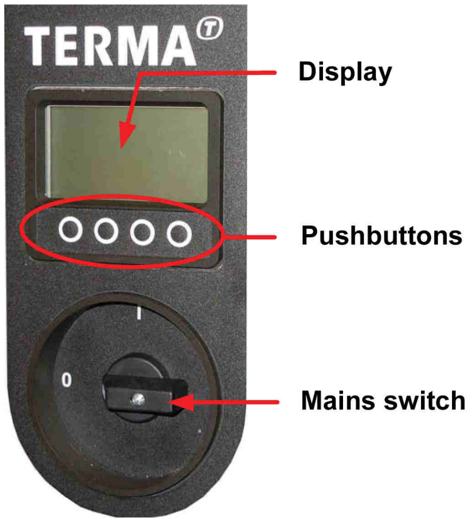


Fig. 5.26 Display and buttons

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 be 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.

5.4.11 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 6002 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 an FPGA with an included UART.

5.4.11.1 Connections

Note: The listed connections are indicative. For latest updates and further details, refer to doc. no. 386300-DI.

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
	X12 - X14	LAN 1-3
	X15 - X16	Tx Inhibit / EMCON
	X17	Aux I/O
	X18 - X19	Analog Video Output
	X21 - X22	Digital Video and Azimuth Output
	X23 - X24	Azimuth Output
	X25 - X28	Trigger Output

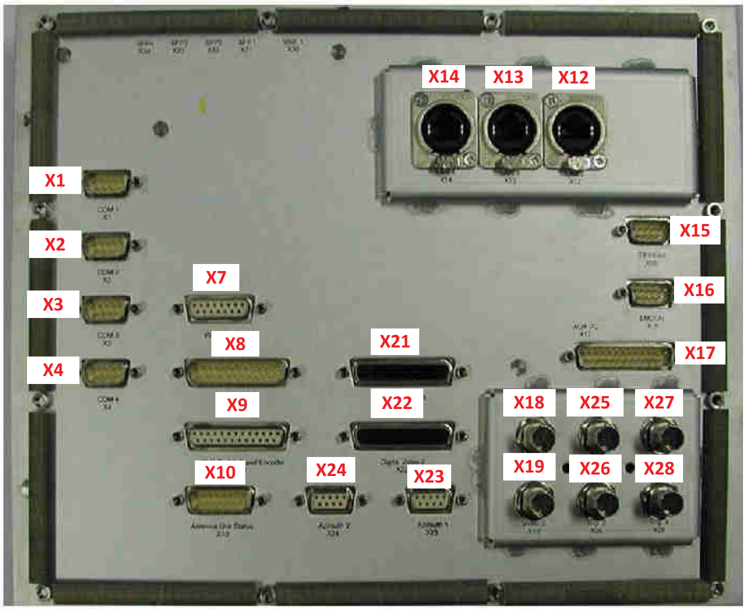


Fig. 5.27 External I/O, connections

5.4.11.2 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.

Description	Data or Settings
Communication speed	1200 - 115200 bps

Description	Data or Settings
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

5.4.11.3 X7, WG Switch

X7, Waveguide Switch, can be used to control a switch in the antenna. 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

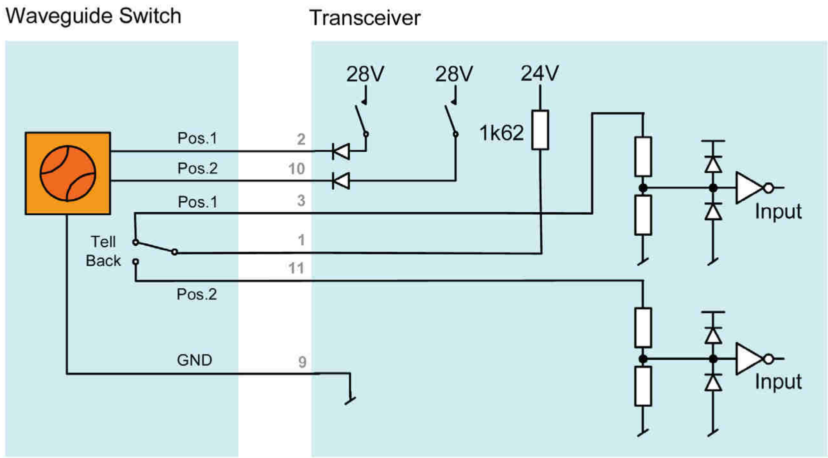


Fig. 5.28 Waveguide switch X7

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		

5.4.11.4 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

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		

5.4.11.5 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

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)

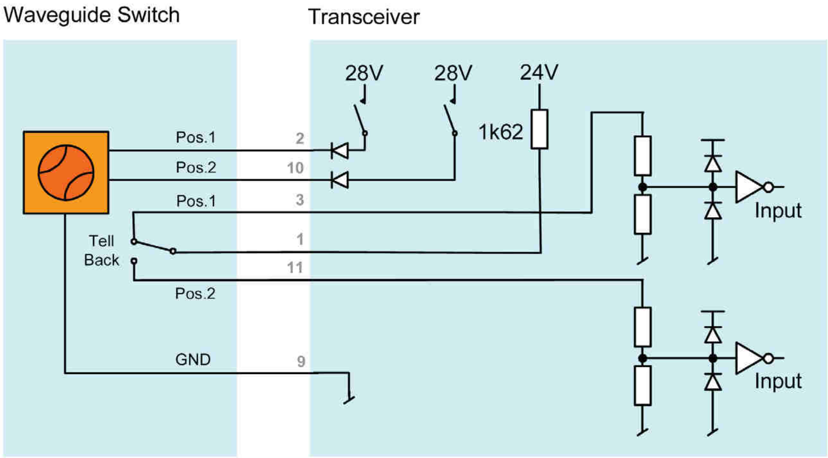


Fig. 5.29 Waveguide switch X9

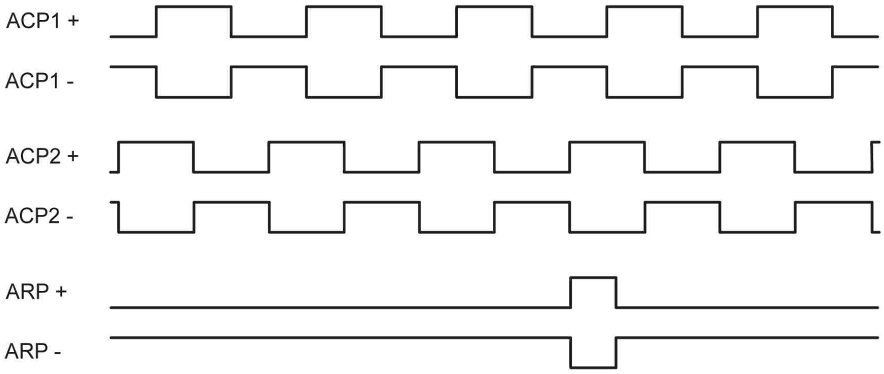
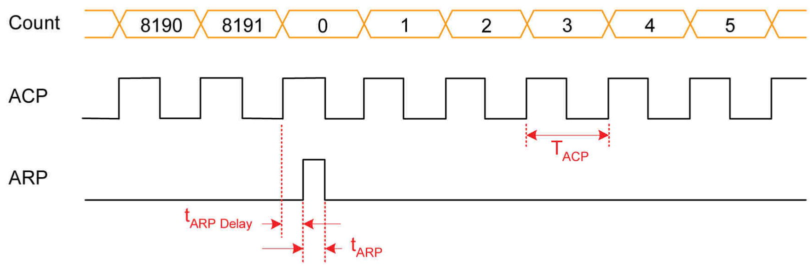


Fig. 5.30 Wave forms measured relative to GND. Antenna rotation CW



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

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

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

Fig. 5.31 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		

5.4.11.6 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	Mac. 100 Ohms

Description	Data or Settings
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 warn-ing
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		

5.4.11.7 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

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

Terminal	Function	Terminal	Function
5	BI_DC-		

5.4.11.8 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

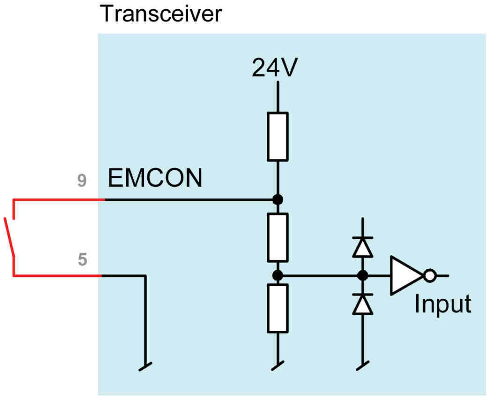


Fig. 5.32 Input circuit for Tx Inhibit

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

5.4.11.9 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

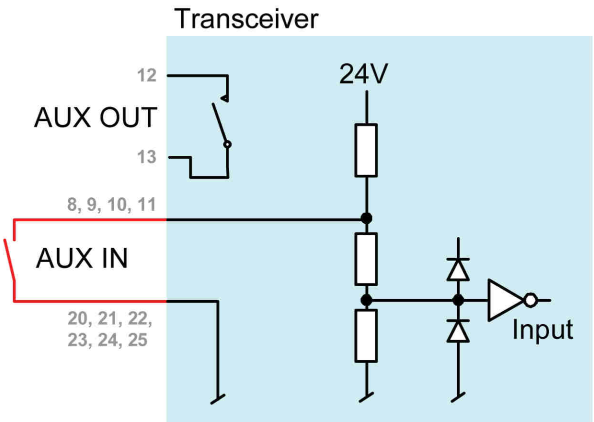


Fig. 5.33 Input circuit, AUX inputs/output

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
12	AUX1 OUT	25	AUX 0 V
13	AUX1 OUT		

5.4.11.10 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

5.4.11.11 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
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.

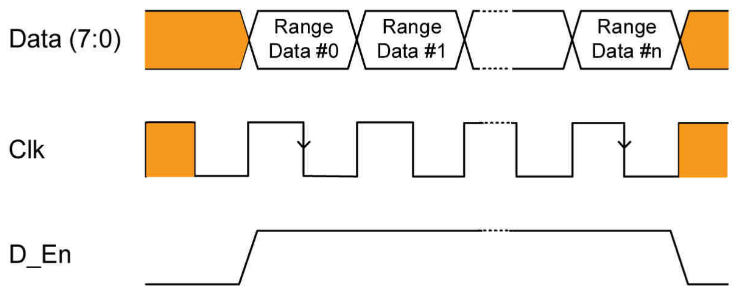


Fig. 5.34 Digital video timing

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.

Re-timing factor, status signals definition:

	Status1	Status0
Re-timing factor 1	0	1
Re-timing factor 2	1	0
Re-timing factor 4	1	1
Re-timing factor 8	0	0

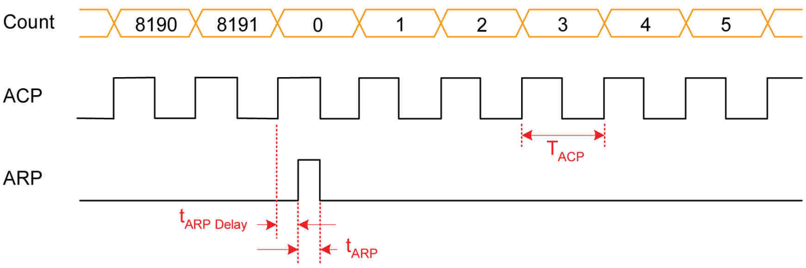
5.4.11.12 X23-X24, Azimuth Output 1-2

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.

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

Description	Data or Settings
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. 5.35 Azimuth timing specification

5.4.11.13 X25-X28, Trigger Output 1-4

Description	Data or Settings
Number of outputs	4, each is individual programmable. The output can also be used for RF transmitting status and 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%)

Description	Data or Settings
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.