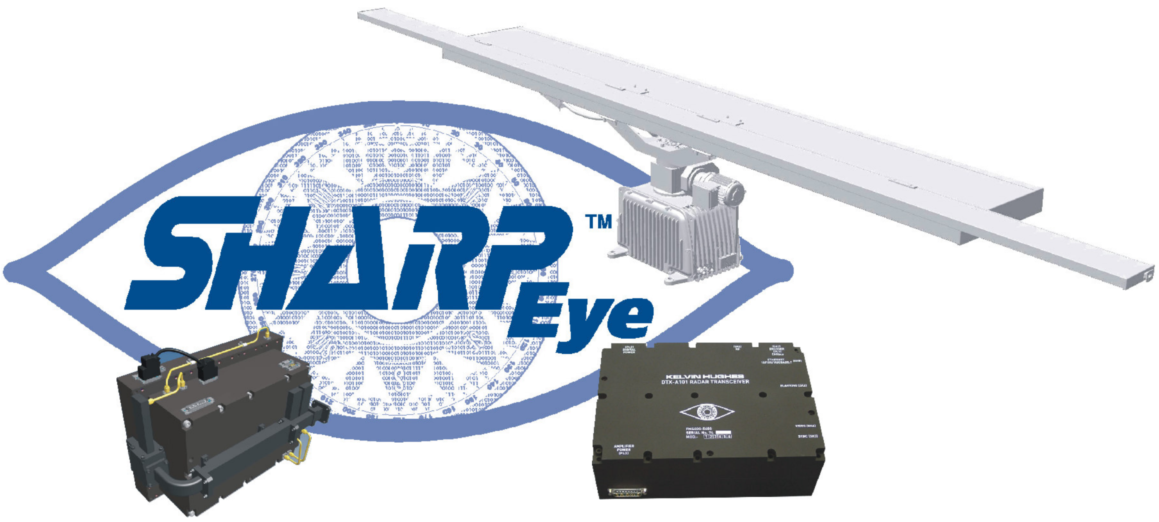
SETD-1482

Product Specification for *SharpEye*™ VTS Sensors



Issue 1

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CHANGE HISTORY

DATE	ISSUE	SUMMARY OF CHANGE	NAME
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SOURCE DOCUMENT LIST

The following documents, at issue status shown, form part of this product specification to the extent specified herein.

Document Reference	Issue	Title	Design Authority
	2008	IALA VTS MANUAL	IALA
V-128	Edition 2.0 June 2005	Operational & Technical Performance Requirements for VTS Equipment	IALA
ITU-R M.1172-2		Techniques for Measurement of Unwanted Emissions of Radar Systems (1995-1997-2000)	International Telecommunication Union – Radiocommunication Sector
ITU-R SM.1541		Unwanted Emissions in the Out of Band Domain	International Telecommunication Union – Radiocommunication Sector

RELATED DOCUMENTS LIST

The following documents, at issue status shown, form part of this product specification to the extent specified herein.

Document Reference	Title	Design Authority
491-501001	PrimaGraphics Message Passing Format Specification	Curtiss- Wright Controls Embedded Computing
EIA/TIA-RS232-E	Industry Standard for Data Transmission	Electronic Industries Association / Telecommunication Industry
EIA/TIA-RS422-A	Industry Standard for Data Transmission	Electronic Industries Association / Telecommunication Industry
EIA/TIA-RS423-A	Industry Standard for Data Transmission	Electronic Industries Association / Telecommunication Industry
IEEE 802.3	Ethernet Standards	Institute of Electrical & Electronic Engineers
ISO 9001	Quality Control & Quality Assurance	International Organisation for Standardisation

GLOSSARY

A/D	Analogue to Digital
AC	Alternating Current
ACP	Azimuth Change Pulse
ARM	Availability Reliability Maintainability
ARP	Azimuth Reset Pulse
ASSY	Assembly
BIT	Built In Test
BITE	Built In Test Equipment
CAE	Commercial Antenna
CAT	Category
CFAR	Constant False Alarm Rate
CSX	Coastal Surveillance Sensor
CW	Continuous Waveform
D/A	Digital to Analogue
dB	Decibel
DC	Direct Current
DNV	Det Norske Veritas
EMC	Electro-Magnetic Compatibility
FIAC	Fast Intruder Attack Craft
FPGA	Field Programmable Gate Array
GHz	Giga-Hertz
HL	Heading Line
Hz	Hertz (cycles per second)
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
IGMP	Internet Group Management Protocol
IP	Internet Protocol
ISO	International Standards Organisation
ITU-R	International Telecommunication Union – Radiocommunication
KH	Kelvin Hughes
kts	Knots
kW	Kilowatt
LAN	Local Area Network
LF	Low Frequency
LPA	Low Profile Antenna

LRU	Line Replaceable Unit
LS0H	Low Smoke Zero Halogen (Cable)
m	Metre
MAS	Man Aloft Switch
Max	Maximum
MDS	Minimum Discernible Signal
MF	Medium Frequency
MHz	Mega-Hertz
MPF	Message Passing Format
µs	microsecond
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MDV	Minimum Discernible Velocity
MUV	Maximum Unambiguous Velocity
NAE	Naval Antenna
NB	(nota bene) means "**note** well".
nm	Nautical Mile
NT	New Technology
NTX	Naval Transmitter
ONF	Overall Noise Figure
PRFD	Pulse Repetition Frequency Discrimination
PRI	Pulse Repetition Interval
PSU	Power Supply Unit
RDU	Radar Distribution Unit
RF	Radio Frequency
RJ45	Registerd Jack Type 45 (Industry standard LAN connector)
RMS	Root mean square
RNU	Radar Normalisation Unit
RPI	Reduced Probability of Intercept
RPM	Revolutions Per Minute
S/N	Signal to Noise (Ratio)
SETD	Systems Engineering Technical Document
SNMP	Simple Network Management Protocol
STC	Short Time Constant
Std	Standard
STW	Setting To Work
T0	Time of Zero Range Video
TBD	To Be Defined
TCP	Transmission Control Protocol
Tm	Transmission Time

Tx/Rx	Transmitter/Receiver
UDP	User Datagram Protocol
V	Voltage
VA	Voltage Amps (Power)
VSWR	Voltage Standing Wave Ratio
VTS	Vessel Traffic Services
W	Watt
WRT	With Respect To

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1. GENERAL DESCRIPTION

1.1 PURPOSE

The solid state radar sub-system with patented SharpEye™ technology is a “range unambiguous” radar utilising a coherent receiver, pulse compression and Doppler processing techniques to provide sub-clutter visibility of targets.

The radar is designed to exceed the IALA recommendations for a VTS radar sensor.

The high technology, low cost design makes the radar ideal for all three capability categories defined by IALA and where the detection of very small vessels is of paramount importance for safety, search and rescue and security reasons.

As such, the NT radar is designed to meet the following requirements:

- Operation in either X or S frequency bands or both
- Detection of small targets in rough weather conditions
- High reliability and availability

1.2 MAIN COMPONENTS

The sensor sub-system comprises of two main components plus optional Track Extractor and Video Compressor:

- SharpEye™ radar. These are mast mounted units with the transceiver or transceivers integrated within the antenna turning mechanism. All units have been designed for high reliability and zero preventative maintenance. To achieve this, the transceivers operate efficiently from low voltage supplies thereby obviating the need for any output stage cooling fans. Single band radars are fitted with dual redundant power supplies for increased availability. An upmast unit negates the need for expensive waveguide with the benefit of superb short-range detection, greatly reduced system losses and ease of installation.

  Four versions of SharpEye™ radar are available:

CSX-A1	Surveillance Radar Dual Band (5.5m & 3.9m)
CSX-A2	Surveillance Radar X Band (5.5m)
CSX-A3	Surveillance Radar X Band (3.7m)
CSX-A4	Surveillance Radar S Band (3.9m)

- Radar Distribution Unit (RDU). This unit interfaces the radar with the display sub-system and other sub-systems. An industrial Layer 2 LAN switch provides the distribution of radar video and plot data to associated radar displays. Control and status monitoring of the radar is also effected over this LAN. Analogue radar signals are provided for “standard” or legacy display systems.
- Available at extra cost, KH can supply a Track Extractor, which can generate up to 500 tracks from the radar digital plot data. A Radar Video Compressor software module can also be included to compress raw radar video into a format suitable for distribution of radar video over a 100BaseT LAN to external systems.

1.3 TRANSCEIVER TECHNICAL OVERVIEW

The SharpEye™ radar has the following features, all parameters nominal unless stated otherwise:

- Typical instrumented range of 24nm (up to a maximum of 48nm)
- Antenna rotation rates of 12 or 24 RPM
- Solid state transmitter for high reliability
- "Simultaneous" short, medium and long pulse transmission
- Digital Pulse Compression to 15m range cell size out to maximum range (subject to export control licence)
- Time or Range side lobes >-65dB
- Pulse Doppler processing for rain and sea clutter rejection providing:
  - Sub-Clutter visibility improvement factor of 25dB:
- Dynamic range of 126dB (inc. STC and Pulse Compression gain) ensures simultaneous detection of large and small targets
- Minimum Discernible Signal (MDS) of -125dBm
- Pulse Repetition Frequency Discrimination
- Frequency Diversity option
- Digital and Analogue video outputs
- Plot data output on 1000BaseT LAN (UDP)
- Internal monitoring – no external RF components required to monitor operation.

To meet the latest ITU regulations regarding RF emissions, the SharpEye™ radar operates within the following bands:

- X Band 9210MHz – 9490MHz (I Band)
- S Band 2920MHz – 3080MHz (E/F Band)

- ITU-R M.1177-2 Latest Draft – Techniques for Measurement of Unwanted Emissions of Radar Systems (1995-1997-2000)
- ITU Recommendation SM. 1541 – Unwanted Emissions in the Out of Band Domain.

SharpEye™ radar radically departs from conventional marine navigation radar practise through the transmission of low power RF pulses. The transceiver has a nominal peak output power of 170W into the antenna system operating with duty ratios of up to 13%. This high duty ratio, possible due to transmitter design and pulse compression techniques in the receiver results in an equivalent transmitted peak power of 170kW assuming a maximum pulse compression ratio of 1000:1.

The solid state transceiver normally outputs a frame of transmission pulses in a specified sequence to satisfy the requirements of short, medium and long range detection. The frame comprises of a 0.1µs of gated CW (short pulse), and two pulses (medium & long pulse) containing a non-linear frequency modulated chirp with a swept bandwidth of approx. 20MHz. This combination of pulse length and coding results in each transmission within a frame being unique in both length and coding thereby permitting pulse compression.

The transceiver(s) are connected to co-located low profile polyrod radar antennas via a dual channel rotating joint.

Received signals are Doppler processed and compared with a variable threshold (CFAR) to declare the presence or absence of targets. A digital pulse compressor restores the medium and long pulse chirps to an equivalent range resolution of 15m (0.1µs TX pulse), subject to UK export licence restrictions.

The receiver(s) output both analogue and digital radar data via an industry standard 1000BaseT LAN to an associated RDU or directly to a display system.

In a dual frequency system, the RDU also provides a composite video output of both X and S band transceivers.

1.4 ANTENNA TECHNICAL OVERVIEW

A gear driven antenna pedestal powered by a synchronous AC motor rotates the antenna at 12 or 24RPM in a clockwise direction (viewed from above). Antenna speed selection is effected at the controlling display.

One or two antennas can be co-mounted. Both antennas are horizontally polarised and utilise the latest polyrod end fed slotted array technology.

The use of Doppler and pulse integration techniques negate the need for “lossy” circular polarisation.

The arrays are enclosed in separate white polycarbonate plastic cases:

	Length (m)	Horizontal Beamwidth °
X Band	3.7m or 5.5m	< 0.7 or < 0.45
S Band	3.9m	< 2.0

1.5 SAFETY

Interlocks are not fitted within the NT radar unit. However provision for maintenance safety switches is provided.

- A safe to rotate keyswitch is fitted in the RDU which when set to OFF inhibits rotation and transmission.
- As an extra cost option, an externally mounted (IP56 rated) Man Aloft Switch (MAS) can be fitted adjacent to the antenna maintenance platform to inhibit rotation and transmission. Refer to APPENDIX A for details of the Man Aloft Switch, NAN-A27-1.

1.6 MAINTENANCE

Routine maintenance is not required for normal operation of the unit other than general housekeeping tasks i.e. external cleaning of the unit.

1.7 INTERFACING

The SharpEye™ radar system has been designed for ease of interfacing with third-party display sub-systems.

The SharpEye™ radar utilises a combination of KH proprietary messages and standard messages from the Curtiss Wright Controls Embedded Computing, Radar Video Processing Message Passing format specification permitting easy integration with a Track Extractor or other product from their equipment range. Please contact Kelvin Hughes for further guidance on interfacing with third party and Curtiss Wright Controls Embedded Computing equipments. For more specific details refer to DIGITAL RADAR DATA INTERFACE in Section 7.2.

1.8 SharpEye™ RADAR CONTROL

Control of the radar is via a 100/1000BaseT LAN. Radar control is normally from a dedicated maintenance display. Available controls are:

- TX WAKEUP/SLEEP
- TRANSMIT/MUTE
- TRANSMISSION MODE/PROFILE
- ANTENNA ROTATION SPEED 12/24 RPM
- GAIN/SEA/RAIN anti-clutter

1.9 SECTOR TRANSMISSION

The **SharpEye™** radar can be configured to inhibit transmission over pre-defined arcs to avoid transmission over bridges, buildings other structures or inland.

1.10 BITE

Comprehensive BIT facilities provide on-line monitoring of the following parameters:

- RF Output Power
- Antenna system VSWR
- Receiver Sensitivity
- Temperature
- Power Supplies

Should a fault be detected which could lead to early failure of the transceiver e.g. high VSWR, then the transceiver, where appropriate will revert to Low Power operation (-7dB) until corrective maintenance can be effected.

1.11 PAINT FINISH

The pedestal, rotating joint and antennas will be finished in white.

2. SUMMARY OF DATA – TRANSCEIVER

Note: All values are nominal unless otherwise specified.

2.1 OPERATING FREQUENCIES:

	Freq, GHz	No. of Freq Bands
X Band	9.21 to 9.49	14
S Band	2.92 to 3.08	8

Operation will be within one of the pre-selected frequency bands, each band being 20MHz wide. Transmission bands will be capable of being configured during commissioning to prevent mutual interference between **SharpEye**™ radars and to avoid conflict with systems operating within the same or adjacent frequency

2.2 WARM-UP TIME

Solid state transistors obviate the need for a warm-up time. The radar will be powered at all times by the mains supply. On detection of a master display, the unit will "wake up" and be ready for transmission within 5 seconds.

2.3 TRANSMISSION POWER

Solid state transistor amplifiers will output a nominal peak power of 170W at a maximum duty cycle of 13% into the rotating joint. BIT monitoring outputs a "Low RF Power" warning message when the RF power output falls below 100W. The transistors are "fail-soft" thereby providing graceful degradation in the event of a single or multiple failure.

2.4 VSWR

The **SharpEye**™ radar is designed to operate into a VSWR of ≤ 1.4:1. Continuous monitoring of the VSWR is employed, if the VSWR is ⩾ 2:1, an "Antenna VSWR" warning message is output to the master display and the transceiver will reduce output power to prevent damage to the output stages.

2.5 INSTRUMENTED RANGES

The standard instrumented range is 24nm. This range can be configured as required dependant on the sensor role or physical location. For example, if a lower range is required, the transmission frame can be modified to enable a higher PRF with narrower pulses. The higher PRF will permit the integration of more received frames per dwell time thereby improving velocity resolution, MUV and detection performance in clutter. Multiple transmission modes can be programmed for dynamic selection as required. Conversely a lower PRF with longer duration pulses can be provided where detection range is important.

2.6 NORMAL TRANSMISSION MODES

The radar will operate in a number of modes as standard, each mode being optimised for a particular operational requirement. KH will liaise closely with the local VTS authority in order to customize each radar's transmission pattern to its local area and role. Standard and optional modes are detailed below:

- River/Canal Surveillance
- Estuary Surveillance
- Coastal Surveillance
- Low Power Mode
- Reverse Sweep Mode
- Helo Guidance (search & Rescue) – Extra cost option
- Frequency Diversity – Extra cost option

For each mode, a particular transmission pattern or "frame" will be utilised. Detailed below is a typical pattern for general navigation. Selection of the operating pulse pattern frame will be determined by the operation mode, range and antenna rotation rates demanded by the radar operator.

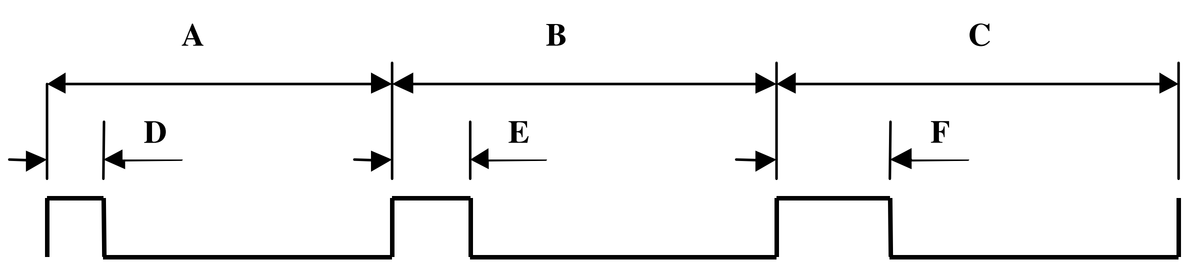


Figure 1 Typical Pulse Pattern Frame

Frame Type		A (Short PRI)	B (Medium PRI)	C (Long PRI)	D (Short Pulse)	E (Medium Pulse)	F (Long Pulse)
RPM	Range Mode						
24	24nm	12µs	64µs	365µs	X: 0.1µs S: 0.1µs	X: 8µs S: 5µs	X: 40µs S: 33µs
12	24nm	12µs	64µs	365µs	X: 0.1µs S: 0.1µs	X: 8µs S: 5µs	X: 40µs S: 33µs

Table 1. Typical Pulse Length and Pulse Repetition Intervals

2.7 LOW POWER TRANSMISSION MODE

For use in close waters or in a high clutter environment where a high output power may produce excessive unwanted reflections from buildings, bridges and vessels. The transceiver will utilise the standard frame pattern but with output power reduced by 7dB, peak output power will typically be 33W. Because of the reduced output power, range performance will be reduced.

2.8 REVERSE SWEEP MODE

To minimise in-band asynchronous interference from other **SharpEye**™ radars in the same locality, the operator will be able to select a "reverse chirp" mode for transmission on medium and long pulse. Note that this function supplements the PRFD in the receiver section.

2.9 HELO GUIDANCE OPTION

As an extra cost option, the radar can be supplied with a Helo Detection and Guidance mode. This mode has a modified transmission waveform permitting unambiguous velocity detections up to ± 300kts at ranges up to 6nm.

2.10 FREQUENCY DIVERSITY OPTION

At extra cost, the **SharpEye**™ radar can be supplied with an additional receiver and modified transmission waveforms permitting frequency diversity operation.

Frequency diversity will provide the user with a further performance advantage in sea and rain clutter environments. The effect of multipath will also be reduced, this is of particular interest where a large number of helicopter movements will be evident.

Transmission frequency will be selectable from one of four (S) or eight pairs (X) of 20MHz frequency bands when operating in this mode.

2.11 PRESET PROFILES

The operator can manually select various transmission modes and other parameters as required. However, to ensure optimum performance and efficient operation, up to sixteen preset profiles can be programmed into the **SharpEye**™ radar during commissioning for specific tasks i.e. FIAC detection, surface detection or helicopter detection. The operator can therefore select the profile relevant for the particular application obviating the need for multiple selections, fine-tuning the parameters as required.

2.12 VELOCITY RESOLUTION & DISCRIMINATION

The use of Pulse Doppler techniques within the **SharpEye**™ radar enables the measurement of the radial component of target/object velocity. The resolution of the radial velocity measurement is a function of the radar PRF and hence will vary depending upon the operator selected radar configuration.

The predicted Velocity Resolution performance for the **SharpEye**™ radar is shown in Table 2.

RPM	Range Mode	Velocity Resolution S Band	Velocity Resolution X Band
24	24nm	8 Knots	10 Knots
12	24nm	4 Knots	5 Knots

Table 2 Predicted Velocity Resolution Performance

The predicted Minimum Discernible Velocity (MDV) for a moving radar contact that can be discriminated from stationary objects for the **SharpEye**™ radar is shown in Table 3.

RPM	Range Mode	S Band	X Band
24	24nm	4 Knots	5 Knots
12	24nm	2 Knots	2.5 Knots

Table 3 Predicted Minimum Discernible Velocity (MDV)

2.13 VELOCITY AMBIGUITY

The use of Pulse Doppler techniques introduces an upper limit for the unambiguous measurement of target/object velocity (Maximum Unambiguous Velocity, MUV).

Note that the Maximum Unambiguous Velocity (MUV) does not constrain the detection of moving targets in clutter. Targets that are moving at velocities greater than the MUV will continue to be separated from clutter and hence detected by the radar.

The predicted MUV values for the **SharpEye**™ radar is shown in Table 4.

Range Mode	MUV S Band	MUV X Band
24nm	+/-100 Knots	+/-37 Knots

Table 4 Predicted Maximum Unambiguous Velocity (MUV) versus Range Mode

2.14 RECEPTION

SharpEye™ radar utilises a superhetrodyne coherent receiver system with Doppler processing and CFAR:

- X Band Triple Superhetrodyne
- S Band Double Superhetrodyne

The receiver system has the following characteristics:

- ONF of measured at the A/D output:
  - X Band ≤ 5.5dB
  - S Band ≤ 4dB
- Dynamic range of 126dB (inc. STC and Pulse Compression gain)
- Pulse Compression ratios of up to 1000:1 subject to UK export licence
- Sub-Clutter visibility improvement factor of 25dB typical
- Pulse Repetition Frequency Discrimination
- Gain/Sea and Rain control from maintenance display
- Scan to Scan Correlation/Clutter Map
- Digital and Analogue Video Output with Display Trigger
- Digital Plot Data Output
- Optional second receiver for Frequency Diversity at extra cost

2.15 RECEIVER SENSITIVITY (MDS)

The minimum detectable signal is at least -125dBm. BIT monitoring produces a “Receiver Sensitivity Warning” when a signal of –100dBm cannot be detected.

2.16 DYNAMIC RANGE

The receiver has a dynamic range of at least 65dB at the output of the A to D converter. Application of STC at the receiver front end increases the dynamic range to 96dB. When operating on medium and long pulse frames, the pulse compression gain increases the dynamic range further to 126dB.

2.17 INTEGRATION OF TRANSMISSION PULSES

To improve the S/N ratio and Doppler resolution, a number of transmission/reception frames shown in Figure 1 are integrated per antenna beamwidth on the target (dwell time). The value of N is a function of Radar Display Mode (24, 46 or 96nm) and Antenna Rotation rate. The values of N are shown in Table 5:

RPM	Range Mode	Pulses Integrated (N) S Band	Pulses Integrated (N) X Band
24	24	32	16
12	24	64	32

Table 5 Number of Pulses Integrated

2.18 CLUTTER REJECTION

Sea and rain clutter rejection is obtained by CFAR being applied in the receiver front end under control of the maintenance display's Sea and Rain controls. Doppler filtering provides an additional typical clutter improvement factor of 25dB.

2.19 PULSE REPETITION FREQUENCY DISCRIMINATION

To minimise in-band asynchronous interference from other radars in the same locality, the PRF Discriminator continuously monitors and rejects, erroneous responses due to reception of other radar emissions.

2.20 SCAN TO SCAN CORRELATION

A clutter map is generated by correlating detection amplitudes over a number of antenna scans. This enables the "boosting" of weak echoes that correlate thereby improving the S/N ratio. Similarly, echoes such as sea clutter that do not correlate are gradually attenuated.

2.21 DIGITAL AND ANALOGUE VIDEO OUTPUT WITH DISPLAY TRIGGER

The receivers combine the received frames of processed data into composite video outputs.

Un-compressed digital video is output directly on the 1000BaseT LAN as a multicast UDP message when required. The adoption of the Curtiss Wright Embedded Computing MPF standard for radar video permits easy integration with legacy systems.

For displays requiring analogue video, a D to A converter outputs a conventional video PRI, synchronised with the Display Trigger. These signals are then buffered in the RDU, providing three outputs for use as required.

In a dual frequency system, the RDU also provides a composite video output (digital and analogue) of both X and S band transceivers. Each video output can be dynamically controlled to provide X, S or combined video output.

For more specific details refer to DIGITAL RADAR DATA INTERFACE Section 7.2 and ANALOGUE RADAR DATA INTERFACE Section 7.3 respectively.

2.22 DIGITAL PLOT DATA

Range collapsed plots are output directly on the 1000BaseT LAN as a multicast UDP message when required. The adoption of the Curtiss Wright Embedded Computing MPF standard for plot data permits easy integration with a Track Extractor.

For more specific details refer to DIGITAL RADAR DATA INTERFACE Section 7.2

Plots are typically accurate (RMS) to within ±0.5° in bearing and 4m in range.

3. SUMMARY OF DATA – ANTENNA SYSTEM

Note: All values are nominal unless otherwise specified.

3.1 CHARACTERISTICS

The S and X band antenna systems have the following characteristics at 3GHz & 9.41GHz respectively as detailed in Table 6 below:

	X Band		S Band
	LPA-A37	LPA-A55	LPA-A3
Overall Length	3.7m	5.5m	3.9m
Turning Circle Diameter	3.8m	5.6m	4m
Frequency Band	9.22 to 9.44 GHz		2.92 to 3.08GHz
Gain	32.7dB	34.5dB	27.5dB
Horizontal Beamwidth @ -3dB	< 0.7°	< 0.45°	2° max.
Vertical Beamwidth @ -3dB	25°		26.5°
Horizontal Sidelobes within ±10° of main beam	< -26dB		At least -28dB down on main beam
Horizontal Sidelobes outside ±10° of main beam	< -33dB		At least -35dB down on main beam

Table 6 Antenna Characteristics

3.2 ANTENNA ROTATION

The antenna drive system is “maintenance free” due to the use of a synchronous AC motor via a direct drive gearbox. Two antenna speeds are selectable:

- 12 RPM
- 24 RPM

4. DIMENSIONS, WEIGHTS & CONNECTIONS

4.1 DIMENSIONS AND WEIGHTS

Figure 2 details the dimensions and weights of the RDU equipment.

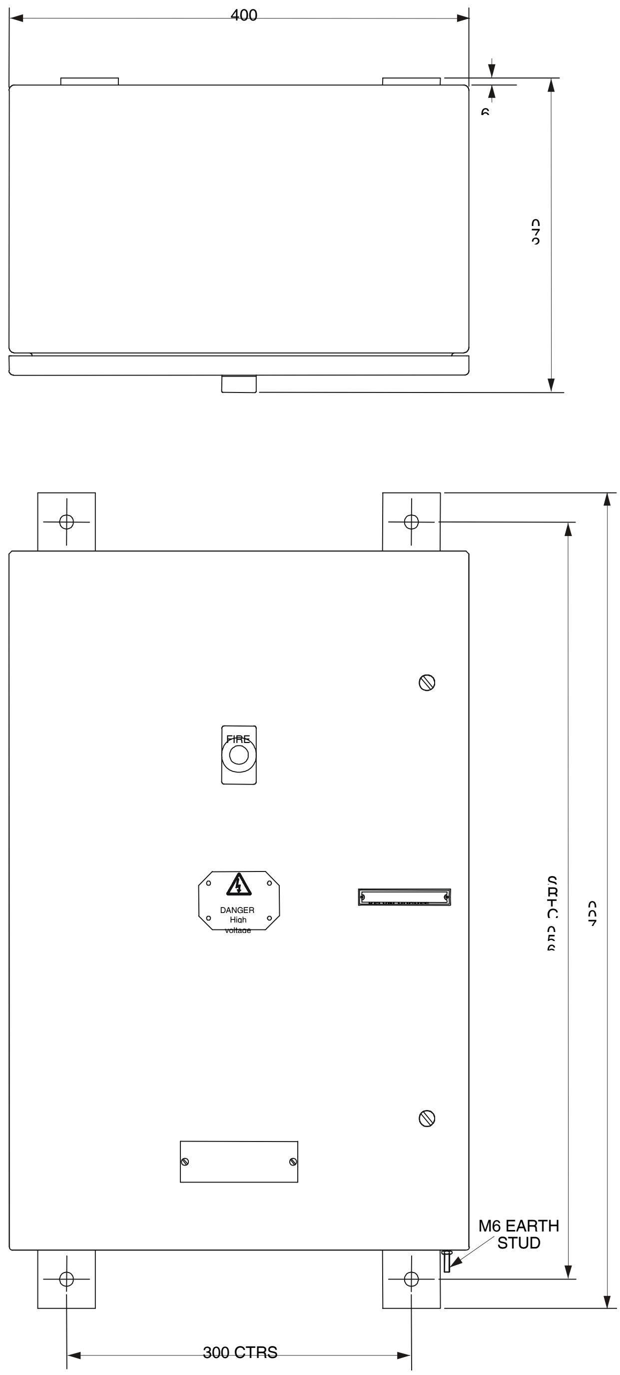
Figures 4 to 7 detail the dimensions and weights of the **SharpEye**™ radars.

4.2 MAINTENANCE ACCESS

The RDU has been designed such that when fully installed, all normal maintenance can be carried out from the front of the equipment, access to the sides is not required.

The recommended access requirements are shown in Figure 3.

The **SharpEye**™ radars are to be installed for ease and safety of maintenance.



ALL DIMENSIONS IN mm

ALL DIMENSIONS NOMINAL

WEIGHT: 21 kg (Estimated)

Figure 2 NTX-A32 RDU Dimensions

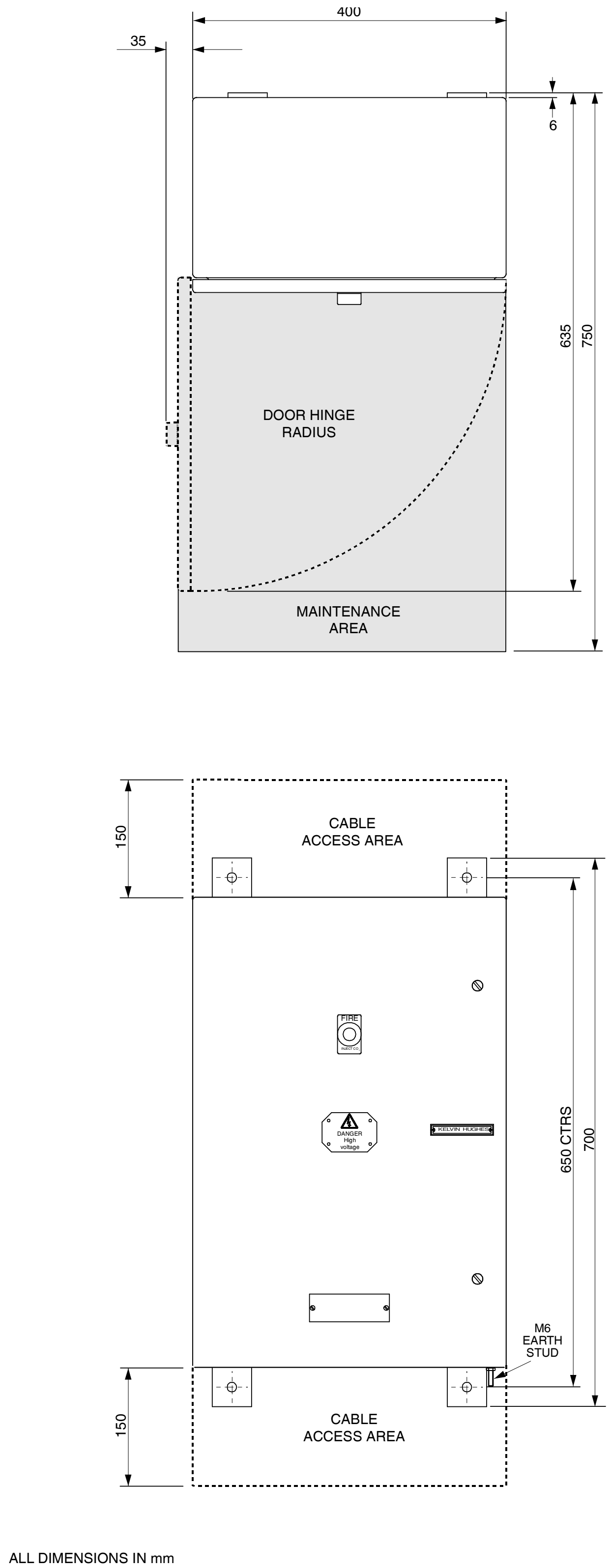


Figure 3 NTX-A32 RDU Maintenance Access

CSX-A1-* Comprises of:

LPA-A3-* NT Low Profile Antenna 3.9m (S Band)

LPA-A55-* NT Low Profile Antenna 5.5m (X Band)

DTX-A1-* SharpeEye TX/Rx Gearbox (Dual Freq)

CSX-A101 Dual Channel Rotating Joint

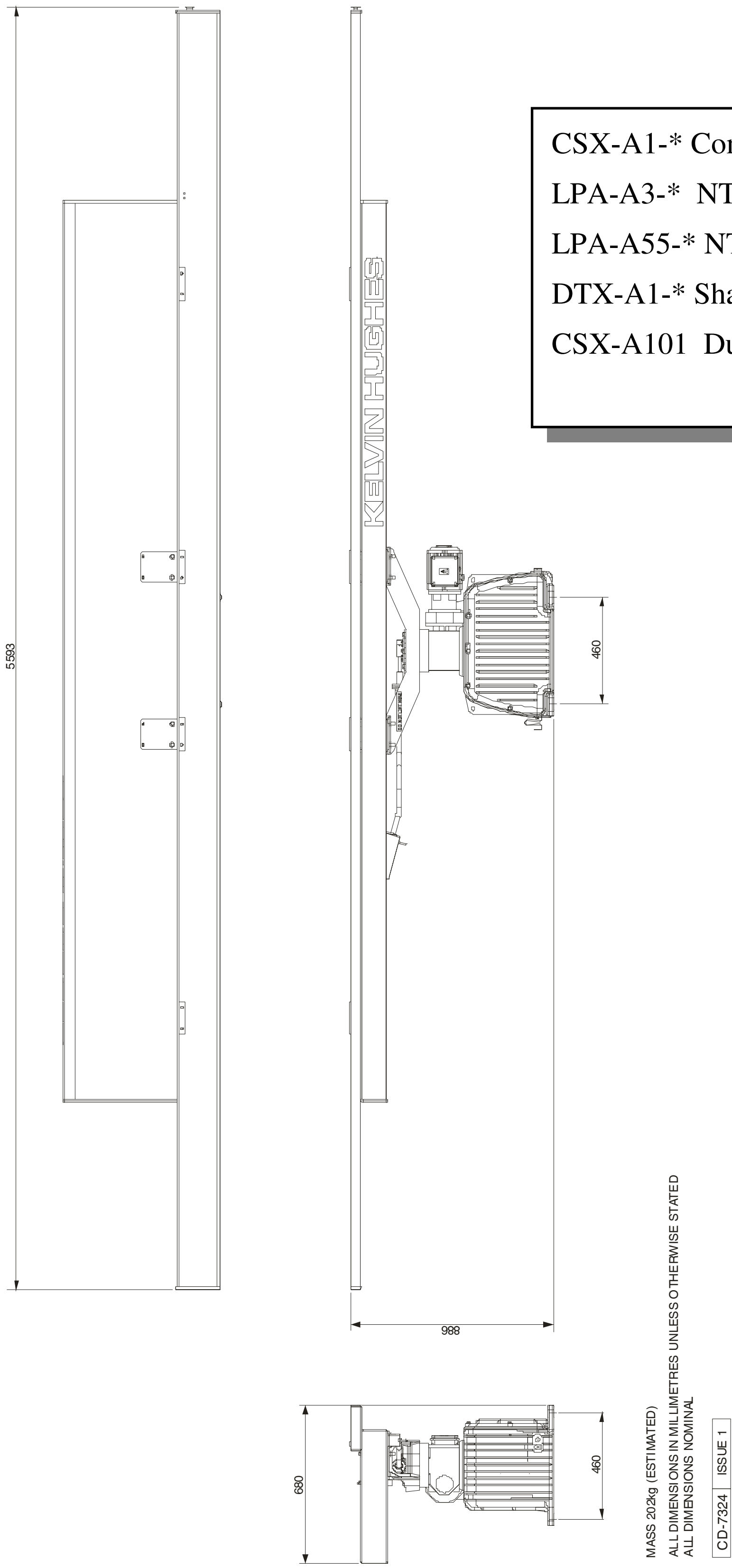


Figure 4 CSX-A1-* Overall Dimensions & Mass

CSX-A2-* Comprises of:

LPA-A37-* NT Low profile Antenna 3.7m

DTX-A1-* SharpeEye TX/Rx Gearbox (I Band)

CSX-A101 Dual Channel Rotating Joint

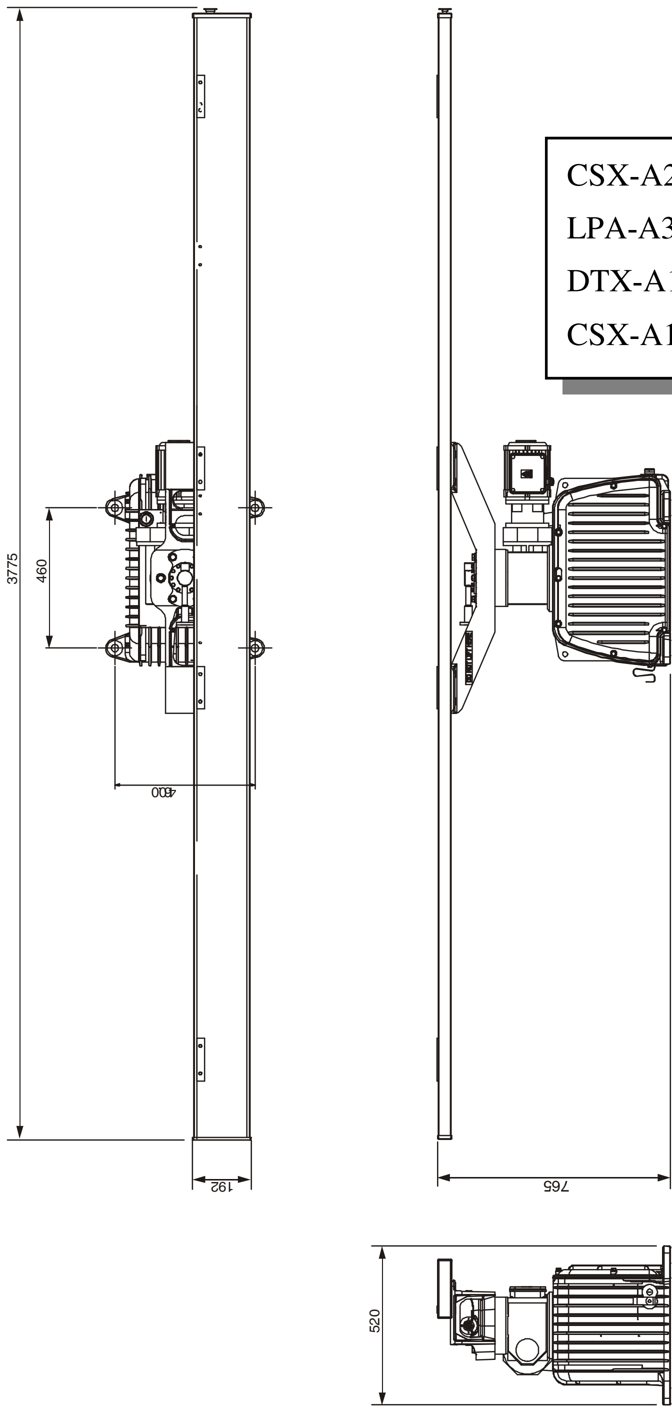


Figure 5 CSX-A2-* Overall Dimensions & Mass

CSX-A3-* Comprises of:

LPA-A55-* NT Low profile Antenna 5.5m

DTX-A1-* SharpeEye TX/Rx Gearbox (I Band)

CSX-A101 Dual Channel Rotating Joint

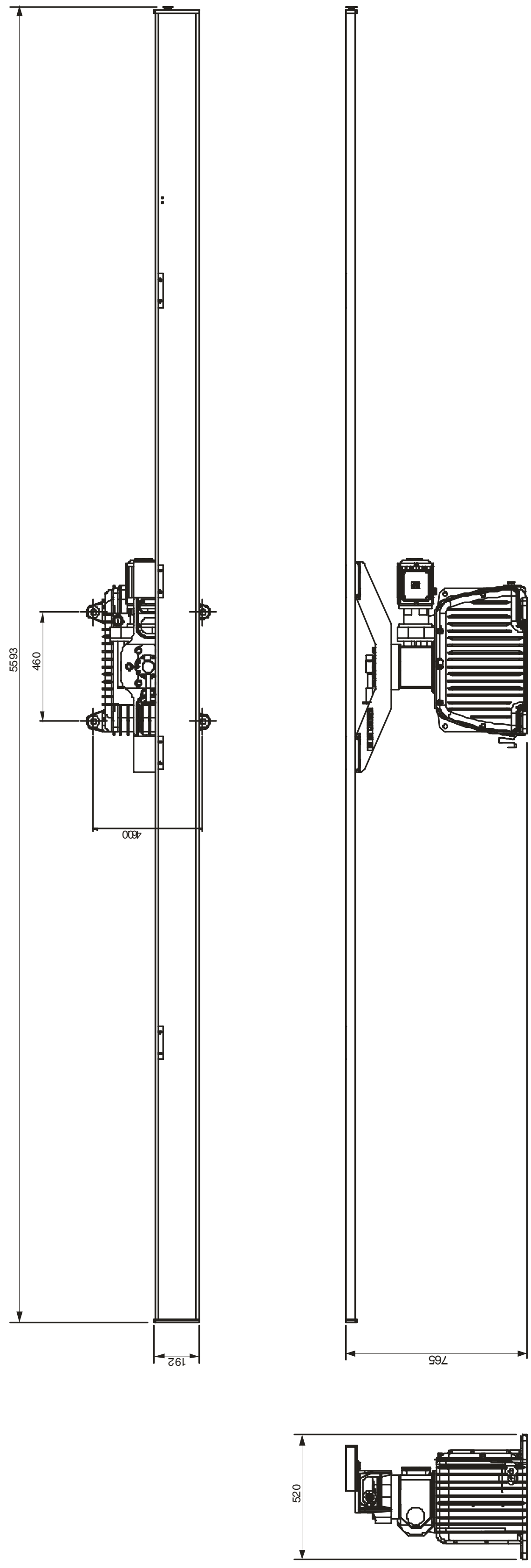


Figure 6 CSX-A3-* Overall Dimensions & Mass

CSX-A4-* Comprises of:

LPA-A3-* NT Low Profile Antenna 3.9m (S Band)

DTX-A1-* SharpeEye TX/Rx Gearbox (S Band)

CSX-A101 Dual Channel Rotating Joint

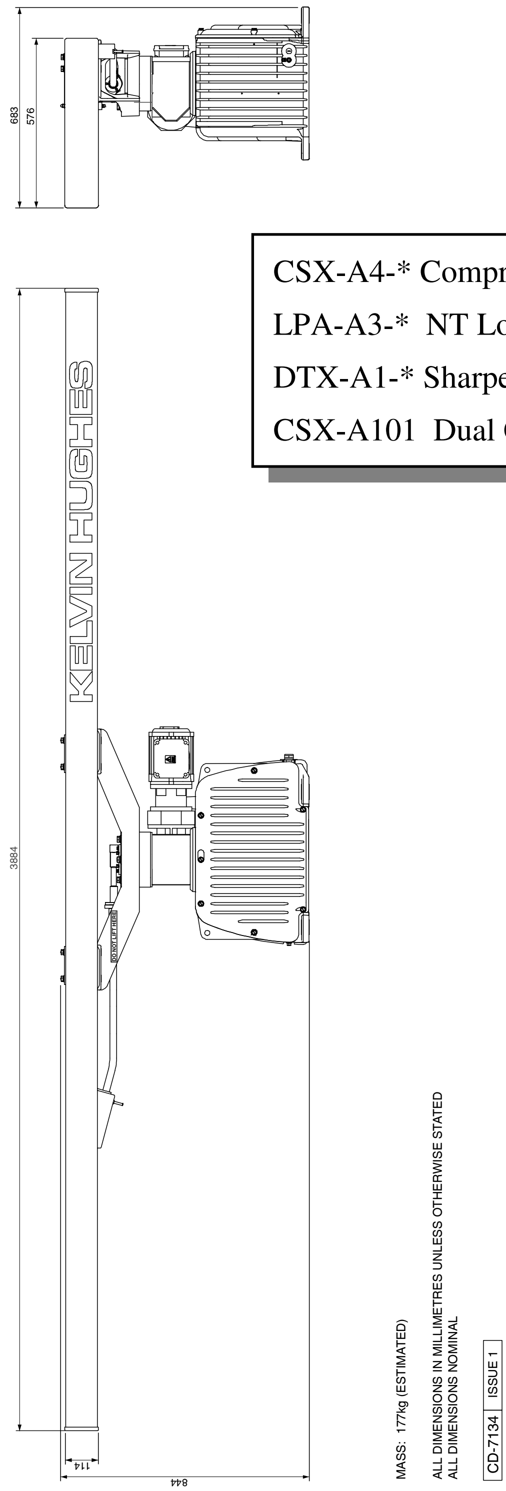


Figure 7 CSX-A4-* Overall Dimensions & Mass

5. REGULATING AUTHORITIES

5.1 SPECIFICATIONS

The **SharpEye**™ radar is designed to meet the following:

- IALA Recommendation V-128 Edition 2.0 June 2005

  Operational and Technical performance Requirements for VTS Equipment
- IALA VTS Manual 2008
- ITU-R M.1177-2 Latest Draft – Techniques for Measurement of Unwanted Emissions of Radar Systems (1995-1997-2000)
- ITU-R Recommendation SM. 1541 – Unwanted Emissions in the Out of Band Domain.
- Maritime Navigation and Radio Communication Equipment and Systems – General Requirements IEC60945

6. GENERAL DESIGN & ENVIRONMENTAL SPECIFICATIONS

6.1 GENERAL DESIGN AND CONSTRUCTION

Designed and constructed to Kelvin Hughes' standards of practice.

6.2 QUALITY CONTROL AND QUALITY ASSURANCE

Kelvin Hughes is an ISO 9001 accredited company.

6.3 SAFETY PRECAUTIONS

Designed and constructed to Kelvin Hughes' own standards of practice.

6.4 HUMAN ENGINEERING

Designed in order to minimise the possibility of degrading quality and reliability through human error.

6.5 VIBRATION

Designed to meet the requirements of IEC 60945.

All frequencies between:

5Hz and 12.5Hz	excursion ±1.6mm ±10%
12.5Hz and 25Hz	excursion ±0.38mm ±10%
25Hz and 50Hz	excursion ±0.1mm ±10%

15 minutes to cover each octave, including resonance search.

6.6 ELECTROMAGNETIC COMPATIBILITY – EMC

Designed to meet the requirements of IEC 60945 clause 4.5 for exposed and protected equipments, for both emissions and immunity.

6.7 ACOUSTIC NOISE

Designed to meet the requirements of IEC 60945**.**

6.8 STORAGE TEMPERATURE

Designed to meet the requirements of IEC 60945.

Class B protected equipments operational temperatures of between +55°C and -15°C

Class X exposed equipments operational temperatures of between +70°C and -25°C

6.9 OPERATIONAL TEMPERATURE

Designed to meet the requirements of IEC 60945.

Class B protected equipments operational temperatures of between +55°C and -15°C

Class X exposed equipments operational temperatures of between +55°C and -25°C

6.10 HUMIDITY

Designed to meet the requirements of IEC 60945.

Note: +40°C ± 3°C for 10 hours at 93% ±3% relative humidity

6.11 SALT SPRAY

Designed to meet the requirements of IEC 60945 clause 8.12 for all grades of equipment.

Salt spray at +20°C on all exposed surfaces for 1 hour, equipment then stored at +40°C at 90-95% relative humidity for 7 days. Cycle repeated 4 times; Visual inspection, no undue corrosion.

6.12 RADAR EMISSIONS

Designed to meet the requirements of ITU-R M.1177-2 Latest Draft – Techniques for Measurement of Unwanted Emissions of Radar Systems (1995-1997-2000) and ITU Recommendation SM. 1541 – Unwanted Emissions in the Out of Band Domain.

6.13 MONTREAL PROTOCOL

The Equipment is constructed using materials that comply with the Montreal Protocol.

6.14 FIRE

All Kelvin Hughes specified installation cables are Low Smoke Zero Halogen (LS0H).

6.15 WATER TIGHTNESS

Class X equipment designed to meet the requirements of IEC 60945.

6.16 WIND

Class X equipment is designed not to deteriorate in performance in relative wind speeds up to 100kts.

6.17 SOLAR RADIATION

Externally mounted equipment is designed to withstand the maximum thermal emission from solar radiation. This is equivalent to a heat flux of 1120 W/m^2 acting for a period of 4 hours.

6.18 ICE ACCRETION

Externally mounted equipment is designed to withstand an ice accretion rate of 6.4mm/h with a total loading of 24 kg/m^2 and remain operational and safe.

7. INTERFACING

Note: All values are nominal unless otherwise specified.

7.1 SharpEye™ RADAR WITH RDU - ANALOGUE

The following interfaces are considered to be "KH internal" signals. However, if the NT radar is used in isolation without an RDU then these interfaces are available for third party equipments.

115V MAINS SUPPLY TO NT FROM RDU

This supply will power the NT Transceiver

Main Equipment Power	
Voltage:	Single Phase 115V ± 7% or 230V ± 7%
Frequency:	50/60Hz ± 1.8Hz
Power:	500VA S Band 550VA X Band 1050VA Dual Band
Max. Earth Leakage Current:	600µA at 230V (Twin PSUs, 300µA per PSU)

380/440V MAINS SUPPLY TO NT FROM RDU

This supply will power the antenna motor only and will be derived from a static inverter housed within the RDU.

Main Equipment Power	
Voltage:	Three Phase 380/440V ± 7%
Base Frequency:	50/60Hz ± 1.8Hz
Power:	2200VA
Max. Earth Leakage Current:	300µA

PROCESSED VIDEOS TO RDU

Outputs:	Two, independent X and S band outputs as applicable.
	Video output occurs 25µs after Display Sync
Characteristics:	Linear pseudo analogue (D to A converted from 4 bits, 16 levels)
	Subjected to doppler processing and pulse compression
	Subjected to gain, sea and rain anti-clutter under control of master display
	Output in one PRI as a composite video stream normally derived from a frame of three transmission pulses
Range cell size:	15m if export licence approved
Polarity:	Positive
Amplitude:	5V ± 0.5V
Noise Level:	0.5V
DC Offset:	0V ± 0.1V
Impedance:	75Ω

DISPLAY SYNC TO RDU

Characteristics:	A single sync pulse output applicable for both X and S band video outputs Output for each video PRI, one pulse per transmission frame Pre-Syncs for displays and track extractors can be derived from the leading edge
Amplitude:	7V
Polarity:	Positive
DC Offset:	0V ± 0.5V
Impedance:	75Ω
Rise Time:	<200ns
Pulse Width:	2µs
PRF:	Between 600Hz and 3000Hz depending on TX mode
Pre-Time:	– 25µs wrt T_m (Transmission Time)

BLANKING PULSE TO RDU

Characteristics:	Output for each transmission pulse, normally three pulses per transmission frame. Normally used for generation of blanking pulses, which can be derived from the leading and trailing edges. Pre-Syncs can be derived from the leading edge where required for each transmission pulse.
Amplitude:	7V
Polarity:	Positive
DC Offset:	0V ± 0.5V
Impedance:	75Ω
Rise Time:	<200ns
Pulse Width:	Variable depending on transmission period
PRF:	Between 600Hz and 3000Hz depending on TX mode for repetition of specific pulses (i.e. short pulse to short pulse) Time between pulses within the transmit frame will be at a rate between 750 Hz and 83333 Hz.
Pre-Time:	– 25µs wrt T_m (Transmission Time)
Post-Time:	+0.1µs wrt T_m (Transmission Time)

AZIMUTH CHANGE PULSE (ACP) OUTPUT TO RDU

Type:	Incremental
Ratio:	4096:1 (pulses/rev)
Amplitude:	7V
Polarity:	Positive
DC Offset:	0V ± 0.5V
Impedance:	75Ω
Rise Time:	<200ns
Pulse Width:	1µs

AZIMUTH RESET PULSE (ARP) OUTPUT TO RDU

Type:	Pulsed
Amplitude:	7V
Polarity:	Positive
DC Offset:	0V ± 0.5V
Impedance:	75Ω
Rise Time:	<200ns
Pulse Width:	100µs

7.2 DIGITAL RADAR DATA INTERFACE

The **SharpEye**™ radar normally connects to a Layer 2 LAN switch housed within the RDU using a 1000BaseT LAN port. The switch will have another 2 or 3 (depending on the number of **SharpEye**™ radars per installation) RJ45 1000BaseT ports for connection with the display system and other RDUs.

Where more than one RDU is fitted, the switches will be linked via a 1000BaseF redundant backbone.

In addition the switch will also have multiple industry standard RJ45 100BaseT ports thereby providing means of connecting other external systems to the network subject to bandwidth availability.

To support UDP multicasting, the switches support Internet Group Management Protocol (IGMP) Snooping, one switch being allocated as the default IGMP querier of the group on installation.

1000BaseT LAN

The industry standard 1000MBit/s LAN is the primary interface of the NT radar via the RDU switch. It is used for control, status reporting and the output of raw uncompressed radar video and plot data.

If digital video is not required, then the 100BaseT LAN interface at the RDU will be sufficient for all other data and control including plot data.

The physical interlace is a single1000BaseT LAN i.a.w. IEEE Std. 802.3ab using all four twisted pairs of a CAT 5 shielded cable.

Standard Windows socket based protocols will be utilised including multicast UDP, TCP/IP and SNMP.

Message formats will comprise KH proprietary messages plus messages conforming to Curtiss Wright Controls Embedded Computing, Message Passing Format as detailed in Document Number 491-501001.

For TCP/IP messages, the typical latency for one switch is 7µs.

Messages will permit the exchange of the following data, final message formats to be defined:

- **<u>Data from radar to Display System via RDU:</u>**
- Multi-level detection video (4 bits), multicast UDP
- Range collapsed plots for the purpose of tracking, multicast UDP
- Comprehensive BITE, TCP/IP & SNMP:
  - Mode tellback/Heartbeat
  - PSU status
  - Azimuth & HL status
  - Software status
  - Health status

Data from Display System to radar via RDU, TCP/IP & SNMP as appropriate:

- X and S band control commands:
- Wakeup/Heartbeat
- Transmission Mode (1 of 16 profiles)
- Sector TX (3 relative sectors), Single scan
- Mute/Blank (Receive only)
- Rotation speed
- Gain/Sea/Rain
- Video controls
- Frequency Band Selection
- Reset
- Configuration Data (not limited to):
    - Sync timing
    - Blanking Sectors

DIGITAL VIDEO & PLOT DATA MULTICAST

Due to the 450Mbit/s bandwidth requirement of the uncompressed digital video, digital video and plot data will be output from the NT radar as multicast UDP messages.

If digital video is not required, then the 100BaseT LAN will be sufficient for all other data including plot data.

Multicast is the delivery of information to a group of destinations simultaneously using the most efficient strategy to deliver the messages over each link of the network only once and only creating copies when the links to the destinations split.

The word "Multicast" is typically used to refer to IP Multicast, the implementation of the multicast concept on the IP routing level, where routers create optimal spanning tree distribution paths for datagrams sent to a multicast destination address in realtime.

A multicast session with a KH display system is outlined below:

- Each **SharpEye**™ radar will output a message inviting all members on the local network to join the video and/or plot multicast.
- The displays will use this received message to make the local radar video and plot data softkeys active.
- An operator will select the required video/plot data stream, the display will output a “join request” message to its LAN switch.
- The LAN switch will then output a “start session message” to the SharpEye™ radar.
- The LAN switch will then route the received multicast data from the SharpEye™ radar at wire speed to all ports requiring the data.

If the data is no longer required, the operator will deselect the input, the router will then remove the recipient from the multicast session.

7.3 WEB BROWSER PAGE & SNMP

Each SharpEye™ radar will have an IP address and a simple in-built web page that can be browsed using any web browser. This web page will contain BITE and status information and will provide a simple user interface in order to control the radar.

Where multiple SharpEye™ radars are combined in a single system such as VTS, the embodiment of Simple Network Management Protocol (SNMP) readily enables a sophisticated remote control and monitoring infrastructure to be created within a managed network environment.

Each SharpEye™ radar is a managed device incorporating a SNMP agent. This agent monitors and collects data which is then made available to external Network-Management Systems (NMSs) running an appropriate application.

SNMP provides both remote control and status monitoring. If a fault occurs at any SharpEye™ radar, the inbuilt SNMP agent will automatically output this change of state to the host NMS.

7.4 ANALOGUE RADAR DATA INTERFACE

A single set of radar outputs will be provided at the RDU for an external display sub-system. Additional sets of radar outputs are available as an extra cost option.

All parameters are nominal unless stated otherwise.

PROCESSED VIDEO OUTPUTS

Outputs:	X Band Video
	S Band Video
	Composite X and S and Video
Characteristics:	Linear pseudo analogue (D to A converted from 4 bits, 16 levels)
	Subjected to doppler processing and pulse compression
	Subjected to sea and rain anti-clutter under control of master display
Range cell size:	15m (subject to export licence)
Polarity:	Positive
Amplitude:	5V ± 0.5V above mean noise level
Noise Level:	0.5V
DC Offset:	0V ± 0.1V
Impedance:	75Ω

DISPLAY TRIGGER OUTPUTS

Outputs:	X Band Sync
	S Band Sync
	Composite X and S Sync
Amplitude:	14V
Polarity:	Positive
DC Offset:	0V ± 0.5V
Impedance:	75Ω
Rise Time:	>30V/µs
Pulse Width:	5µs
PRF:	Between 600Hz and 3000Hz depending on TX mode
Pre-Time:	Adjustable in 50ns increments, – 24µs to + 1µs wrt T_0 (Zero Range Video)

ANTENNA DATA OUTPUTS

To provide the system integrator with a wide range of data outputs, the RDU can be supplied with one of three Output Modules, NTX-A323-* fitted into each output channel as detailed in the table below:

Type	Kelvin Hughes Part Number	
1	NTX-A323-1	RS422 output levels – Azimuth, Heading Line and North Mark pulses all output in RS422 format.
2	NTX-A323-2	Azimuth, Heading Line and North Mark pulses all output as +15V pulse outputs to drive into 1k ohm minimum
3	NTX-A323-3	Azimuth pulses output as a +15V pulse output to drive into 1k ohm minimum. Heading line and North Mark outputs as closing contact voltage free (contacts rated for 0.5amp at 30V D.C.)

<u>Azimuth Output Common Data for Output Modules Type 1, 2 and 3.</u>

Type:	Incremental Pulses
Ratio (PULSES/REV):	90/180/360/512/1024/2048/4096/8192:1
Pulse Width (µ):	1.0/10/25/50/75/100
Connector Identity at RDU	TBD
Connector Type at	TBD
Recommended Cable Type	TBD

<u>Azimuth Output – Type 1 (RS422)</u>

Amplitude:	Max >2.5V, Min <0.5V
Polarity:	+ve and –ve
Output Impedance:	1k ohm min

<u>Azimuth Output – Type 2 & 3</u>

Amplitude:	+14V
Polarity:	+ve

Heading line Output Common Data for output units type 1, 2 and 3.

Type:	Incremental Pulsed
Ratio:	1 pulse per revolution
Pulse Width (µs):	1.0/25/100/4000/50000
Polarity:	+ve
Connector Identity at	TBD
Connector Type at	TBD
Recommended Cable Type	TBD

Heading Line Output – Type 1 (RS422)

Amplitude:	Max >2.5V, Min <0.5V
Polarity:	+ve and -ve
Output Impedance:	1k ohm min

Heading Line Output – Type 2

Pulsed Amplitude:	+15V
Polarity:	+ve

Heading Line Output – Type 3

Type:	Voltage free closing contact Heading Line
Pulse Width (µs):	50000

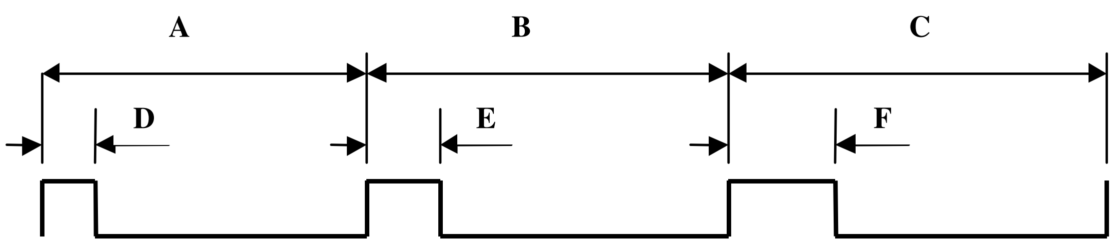
7.5 EXTERNAL BLANKING INTERFACE

One output will be provided at the RDU to blank an external system during SharpEye™ transmission periods.

All parameters are nominal unless stated otherwise.

The SharpEye™ radar normally transmits a "burst" of three transmission pulses in a single frame. The pulse duration and PRI vary according to antenna rotation speed and instrumented range.

A typical transmission "burst" is shown below noting that the transmission frame will vary dependant on transmission mode:



Frame Type		A (Short PRI)	B (Medium PRI)	C (Long PRI)	D (Short Pulse)	E (Medium Pulse)	F (Long Pulse)
RPM	Range Mode						
24	24nm	12µs	64µs	365µs	X: 0.1µs S: 0.1µs	X: 8µs S: 5µs	X: 40µs S: 33µs

PRE-SYNC/BLANKING COMMON PARAMETERS

Amplitude: 7V

Polarity: Positive

DC Offset: 0V ± 0.5V

Impedance: 75Ω

Rise Time: >30V/µs

Fall Time: >30V/µs

PRE-SYNC PULSE

Fixed duration, occurring a pre-set time before each transmission

Pulse Width: 5µs

Pre-Time Adjustable in 10ns increments, – 5µs to – 0.1µs wrt T_m (Transmission Time)

BLANKING PULSE

Variable duration, occurring a pre-set time before transmission and ending a pre-set time after transmission

Pulse Width:	Variable dependant on transmission mode
Pre-Time	Adjustable in 10ns increments, – 5µs to – 0.1µs wrt $T_{m\ (Transmission\ Time)}$
Post-Time	Adjustable in 10ns increments, + 0.1µs to + 5µs wrt $T_{m\ (Transmission\ Time)}$

7.6 EXTERNAL ANALOGUE CONTROL & STATUS

To permit control and status interfacing with legacy systems that do not have Ethernet LAN capability, KH can develop specific interfacing as required. Please contact KH for more information.

8. AVAILABILITY, RELIABILITY & MAINTAINABILITY

8.1 MAINTENANCE POLICY

Due to the solid state design of the SharpEye™ radar, planned maintenance requirements are minimal, with fault diagnosis and location being as automated and integrated as possible.

Repair is by replacement of sub-units noting that the SharpEye™ radar transceiver is a single sub-unit. Repair of the transceiver is by return to KH.

8.2 ARM SPECIFICATION

AVAILABILITY, RELIABILITY AND CORRECTIVE MAINTENANCE
1. A SharpEye™ radar system comprising of a single band upmast SharpEye™ radar, antenna system and an RDU is designed to meet a MTTR requirement of 60 minutes and to have an MTBF of better than 9,000 hours. The actual SharpEye™ transceiver sub-assembly is designed to have an MTBF of better than 50,000 hours.
2. The NT radar system is designed to have an Availability exceeding 99.9%.
3. Continuous software driven system integrity checks will be invisible to user unless a fault found.
4. BITE facilities enable isolation of a fault to a sub-unit or a group of sub-units by the operator.

PREVENTIVE MAINTENANCE
1. Preventive maintenance is to be at monthly, or greater, intervals.
2. Average preventive maintenance requirement is to be less than 2 hours per year by semi-skilled personnel.
3. Time to restore equipment to fully operational state from any stage of preventive maintenance operation will not exceed 5 minutes.

9. TECHNICAL PUBLICATION SPECIFICATION

9.1 HANDBOOK

The handbook will be supplied in a single volume, sub-divided into the following sections known as categories:

- Category 1, 3, 5, 6 & 7 Technical
- Category 2 Operation
- Category 4 Installation
- Category 8 Modifications

Due to the high level of component integration, surface mount and stripline technology employed in the system, the handbook will be written to a depth to support maintenance to sub-unit level i.e. functional, unit and signal flow descriptions to block diagram level.

Circuit descriptions, diagrams and component parts lists for the Kelvin Hughes designed propriety units will be supplied only when of practical value to support local "In-House" Maintenance activities.

9.2 ELECTRONIC DOCUMENTATION

In addition to traditional paper form, the handbook will also be available on CD-ROM as .PDF files (ACROBAT).

APPENDIX A– Mast Head Man Aloft Switch

MAN ALOFT SWITCH

The standard MAS NAN-A27-1 used by Kelvin Hughes is shown below. As the unit is rated to IP56 protection level, the unit is suitable for internal or external mast mounting:

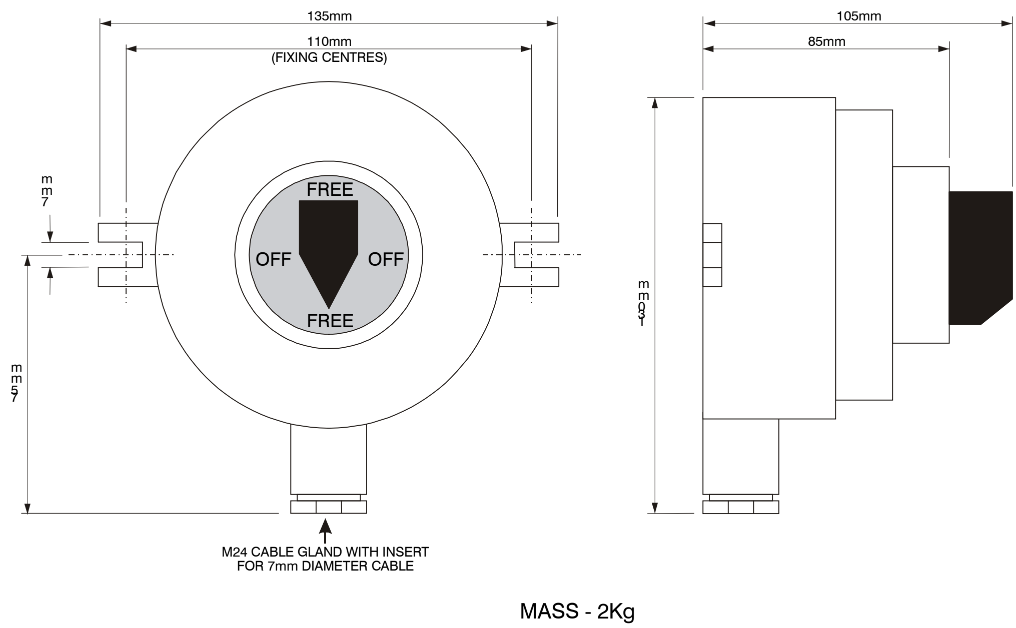


Figure 8 NAN-A27-1 Man Aloft Switch (IP56)