SAMPLE SPECIFICATIONS FOR DUAL-POLARIZATION RADARS

OPERA 2
Work Packages 1.4 and 1.5
Deliverable c

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1. Introduction

A questionnaire was sent to radar manufacturers to provide brief specifications for dual-polarization radars that they are currently able to supply. They were asked to supply the following information as a minimum for each model:

- ⇨ Antenna type
- ⇨ Antenna diameter
- ⇨ Half power beam width
- ⇨ Antenna feed (edge, centre, offset etc)
- ⇨ First sidelobe level
- ⇨ Recommended radome design
- ⇨ Frequency
- ⇨ Peak power
- ⇨ Pulse width(s)
- ⇨ Receiver location
- ⇨ Minimum Detection Signal
- ⇨ Dynamic range
- ⇨ Different transmission modes available
- ⇨ Polarization moments available
- ⇨ And any special design features of note

The information received were compiled into the tables below is based upon (but not a direct copy) of specifications supplied by the named manufacturers. It is intended to show the range of dual-polarization hardware now on offer from a selection of manufacturers. It is not an exhaustive list, either in terms of the manufacturers consulted or the ranges of radars offered by these manufacturers. Whilst every effort has been made to record the specifications correctly, the accuracy of the information cannot be guaranteed.

2. Baron Services

Radar Models	VHDD Series C	KHDD Series C (C band)
Transmitter Type	Coaxial Magnetron	Klystron
Antenna type	Solid parabolic	Solid parabolic
Antenna diameter	2.4m, 3.7m, 4.5m,	3.7m, 4.5m, 8.5m
Half power beam width	1.6°, 1.0°, 0.8°	1.0°, 0.85°, 0.45°
Antenna feed (edge, centre, offset etc)	Center fed – Scalar feed Offset feed optional	Center fed – Scalar feed Offset feed optional
First sidelobe level	Center fed: ≤ 27 to 28 dB Offset: ≤ 30 dB	Center fed: ≤ 27 to 28 dB Offset: ≤ 30 dB
Recommended radome design	Low loss, tuned	Low loss, tuned
Frequency	Tunable 5300-5825 MHz	Tunable 5600-5650 MHz
Peak power	350 kW & 1000 kW	250 kW
Pulse width(s)	0.4, 0.8, 1.0, & 2.0 μsec	0.8, 2.0, 6.0 μsec Compressed 0.25 μsec
Receiver location	Antenna mounted electronics or in the radar Electronic Enclosure	Antenna mounted electronics or in the radar Electronic Enclosure
MDS	-110 dBm (0.8 μsec pw) -114 dBm (2.0 pw)	-110 dBm (0.8 μsec pw) -114 dBm (2.0 pw)
Dynamic range	95 dB typical	95 dB typical
Different transmission modes available	Simultaneous (STAR mode) Independent H or V	Simultaneous (STAR mode) Independent H or V
Polarization moments available	Depending upon the mode selected, all the possible covariance matrix forms are computed by the Doppler Signal Processor, including Z_{DR}, LDR, Φ_{DP}, ρ_{HV}, and Φ_{HV}. Standard T, Z, V, and W moments are also computed.	Depending upon the mode selected, all the possible covariance matrix forms are computed by the Doppler Signal Processor, including Z_{DR}, LDR, Φ_{DP}, ρ_{HV}, and Φ_{HV}. Standard T, Z, V, and W moments are also computed.
Special design features of note	Software: Hydrometeor classification	Software: Hydrometeor classification

Radar Models	**KHDD Series S (S-band)**	**VHDD Series X**
Transmitter Type	Klystron	Coaxial Magnetron
Antenna type	Solid parabolic	Solid parabolic
Antenna diameter	3.7m, 4.5m, 8.5m	1.2m, 2.4m, 3.7m
Half power beam width	2.0°, 1.6°, 0.95°	2.1°, 0.95°, 0.65°
Antenna feed (edge, centre, offset etc)	Center fed – Scalar feed Offset feed optional	Center fed – Scalar feed Offset feed optional
First sidelobe level	Center fed: ≤ 27 to 28 dB Offset: ≤ 30 dB	Center fed: ≤ 27 to 28 dB Offset: ≤ 30 dB
Recommended radome design	Low loss, tuned	Low loss, tuned
Frequency	Tunable 2700-2900 MHz	Tunable 8500-9600 MHz
Peak power	750 kW	230 kW
Pulse width(s)	0.8, 2.0, 6.0 µsec Compressed 0.25 µsec	0.4, 0.8, and 2.0 µsec
Receiver location	Antenna mounted electronics or in the radar Electronic Enclosure	Antenna mounted electronics or in the radar Electronic Enclosure
MDS	-110 dBm (0.8 µsec pw) -114 dBm (2.0 pw)	-109 dBm (0.4 µsec pw) -115 dBm (2.0 pw)
Dynamic range	95 dB typical	95 dB typical
Different transmission modes available	Simultaneous (STAR mode) Independent H or V	Simultaneous (STAR mode) Independent H or V
Polarization moments available	Depending upon the mode selected, all the possible covariance matrix forms are computed by the Doppler Signal Processor, including Z_{DR}, LDR, Φ_{DP}, ρ_{HV}, and Φ_{HV}. Standard T, Z, V, and W moments are also computed.	Depending upon the mode selected, all the possible covariance matrix forms are computed by the Doppler Signal Processor, including Z_{DR}, LDR, Φ_{DP}, ρ_{HV}, and Φ_{HV}. Standard T, Z, V, and W moments are also computed.
Special design features of note	Software: Hydrometeor classification	Software: Hydrometeor classification

3. SELEX – Sistemi Integrati

Antenna Systems	CDP10	CDP07	CDP05	SDP13	SDP10
Frequency band	C	C	C	S	S
Diameter (m)	4.2	6.4	8.5	6.4	8.5
Beamwidth (deg)	1.0	0.7	0.55	1.3	1.0
Antenna gain (dB)	44.5	47	50	42	44
H/V gain deviation (dB)	<0.5	<0.5	<0.5	<0.5	<0.5
H/V beamwidth deviation	<0.03	<0.03	<0.03	<0.03	<0.03
Cross polarization (dB)	-25	-25	-25	-25	-25
Rotation rate (rpm)	0.2-6	0.2-6	0.2-6	0.2-6	0.2-6
Elevation step response (sec)	<1	<1.5	<1.5	<1.5	<1.5
Radome	Not essential max operating wind speed 130km/h	Quasi random	Quasi random	Quasi random	Quasi random

Transmitters	TXS600	TXC600	TXC650	TXS1000	TXC1000
Frequency band	S	C	C	S	C
Peak power (kW)	850	250	500	750	250
Pulse width (us)	0.8-3.3	0.5-3.3	0.5-3.3	0.5-3.3	0.5-3.3
Max PRF (Hz)	1500	2000	2000	1200	1200

Receivers	RXC600/1600
Overall noise figure (dB)	2
Dynamic range (dB)	105
Matched filter bandwidth (MHz)	0.3-2.4
Location	Below pedestal (above elevation to special order)

Polarimetric variable: Z_{DR}, Φ_{DP}, K_{DP}, ρ_{HV}, LDR

Use of Polarimetric Variables in Product Generation

⇨ Correction for attenuation
⇨ Rainfall rate estimation
⇨ Hydrometeor Classification

4. Enterprise Electronics Corporation (EEC)

All the radars presented below in the following 3 tables can be configured for dual-polarization to provide the following moments:-

- ⇨ Uncorrected Reflectivity - Horizontal & Vertical (UH & UV),
- ⇨ Corrected Reflectivity - Horizontal & Vertical (Z_H & Z_V),
- ⇨ Radial Velocity - Horizontal & Vertical (VH & VV),
- ⇨ Spectrum Width - Horizontal & Vertical (WH & WV)
- ⇨ Differential Reflectivity (Z_{DR}),
- ⇨ Linear Depolarization (LDR),
- ⇨ Correlation Coefficient (ρ_{HV}),
- ⇨ Differential Phase (Φ_{DP}) and Specific Differential phase (K_{DP}).

S-band radars		
Model	**DWSR-8501S**	**DWSR-8501S/K**
Transmitter type	magnetron	Klystron
Antenna diameters	8.5, 6.1, 4.3	8.5, 6.1, 4.3
Half-power beam width	1.83, 1.28, 0.99 deg	1.83, 1.28, 0.99 deg
Antenna feed	Orthogonal polarimetric waveguide horn	Orthogonal polarimetric waveguide horn
Sidelobe level	<-25dB within 12 deg	<-25dB within 12 deg
Radome	SFC 6.7, 9.4m TMG 12.4m *	SFC 6.7, 9.4m TMG 12.4m *
Frequency band	2.7-2.9GHz	2.7-3.0GHz
Peak power	850kW	850kW
Pulse widths	0.4-2.0 us	0.4-4.5us
Receiver location	Above elevation (below elevation as option)	Above elevation (below elevation as option)
MDS	-110(short pulse)--114dBM	-110(short pulse)--114dBM
Dynamic range	>100dB	>100dB

* SFC: 3 layer sandwich foam core; SLF: solid laminate fibreglass; TMG: thin membrane geodesic

C-band radars				
Model	**DWSR-2501C-SDP**	**DWSR-2501C/K**	**DWSR-3501C**	**DWSR-10001C-SDP**
Transmitter type	magnetron	klystron	magnetron	magnetron
Antenna diameters	4.3, 6.1m	4.3, 6.1m	4.3, 6.1m	4.3, 6.1m
Half power beam width	1.0, 0.65deg	1.0, 0.65deg	1.0, 0.65deg	1.0, 0.65deg
Feed	Prime focus orthogonal polarimetric horn	Prime focus orthogonal polarimetric horn	Prime focus orthogonal polarimetric horn	Prime focus orthogonal polarimetric horn
Sidelobe level	<-25dB within 12 deg	<-25dB within 12 deg	<-25dB within 12 deg	<-25dB within 12 deg
Radome	SFC 6.7 or 9.4m	SFC 6.7 or 9.4m	SFC 6.7 or 9.4m	SFC 6.7 or 9.4m
Frequency	5.6-5.65GHz	5.6-5.65GHz	5.3-5.7GHz	5.6-5.65GHz
Peak power	250kW	250kW	350kW	1000kW
Pulse widths	0.4-2.0us	0.4-4.5us	0.4-2.0us	0.4-2.0us
Receiver location	Above elevation (below elevation to special order)	Above elevation (below elevation to special order)	Above elevation (below elevation to special order)	Above elevation (below elevation to special order)
MDS	-110dBM short pulse, -114dBM	-110dBM short pulse, -114dBM	-110dBM short pulse, -114dBM	-110dBM short pulse, -114dBM
Dynamic range	>100dB	>100dB	>100dB	>100dB

* SFC: 3 layer sandwich foam core; SLF: solid laminate fibreglass; TMG: thin membrane geodesic

X-band radars	
Model	**DWSR-2001X**
Transmitter type	magnetron
Antenna diameters	2.4m
Half power beam width	1.0deg
Feed	Orthogonal polarimetric waveguide horn
Sidelobe level	<-25dB within 12 deg
Radome	SLF 3.7m
Frequency	8.5-9.6GHz
Peak power	200kW
Pulse widths	0.5-1.0us
Receiver location	Above elevation (below elevation to special order)
MDS	-108dBm short pulse, -110dBm
Dynamic range	>100dB

* SFC: 3 layer sandwich foam core; SLF: solid laminate fibreglass; TMG: thin membrane geodesic

4. Conclusions

At the time of this report, there are about half a dozen C-band dual polarization radars operating in Europe by National Meteorological Services. The polarimetric parameters available are: Z, Z_{DR}, Φ_{DP}, ρ_{HV}, and LDR, although some radars only provide Z and Z_{DR}. Most radars are transmitting simultaneously the H and the V waves, and do not provide LDR simultaneously with the other dual-polarization variables. However, special scans can be set aside for the acquisition of LDR. It should also be noted that transmission slant at 45˚ results in a sensitivity loss of the reflectivity measurement of about 2 to 3dB, which may be of significance at longer range particularly for NWP assimilation.

Some radars operate with their receiver located in the control room (like the Météo-France's Trappes radar) and some located on the radar pedestal (like the UK Met Office's Thurnham radar). The benefits of this latter configuration are unquestionable i.e. simplification of waveguide system, lower waveguide signal loss, removal of rotating joint modulation, reduce the cost of the radar. As this type of design matures we can expected that the receiver's/signal processor's overall size will reduce with all the attendant benefits i.e. lower weight, easier serviceability, lower power consumption, lower heat generation. On the down side there are concerned that this arrangement could lead to reliability problems, in particular with the signal processor, but to date this has not been an issue on the Met Office system.

The main issue with operational dual polarization radars that has been highlight during the course of OPERA2, is regarding the (alleged) impact of the radome on the dual-polarization variables. As report in WD_2006_05, the analysis of Z_{DR} and Φ_{DP0} as functions of the azimuth have revealed wave-like features with a number of periods that correspond to the number of peels from two different orange-peel arrangement radomes. As the disturbances are stationary, it thought that empirical corrections can be determined and applied. There is another school of thought that does not recommend empirical solution but rather the use of quasi random radome; however, it should be noted that there are at present no report of practical experiments to support this recommendation.