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Acknowledgments

xi

Chapter 1 Introduction

1

References

6

Chapter 2 History

7

References

18

Chapter 3 Principles of Operation

21

3.1 The secondary surveillance radar system

21

3.2 Antenna characteristics

21

3.3 Interrogation signals

23

3.4 Reply signals

24

3.5 System problems

26

3.6 Monopulse

31

3.7 Specifications and standards

34

3.8 Typical ground equipment performance specification

35

References

37

Chapter 4 Ground Antenna Systems

39

4.1 Horizontal characteristics

39

4.1.1 Interrogate (sum) beam

40

4.1.2 Control beam

40

4.1.3 Difference beam

42

4.2 Vertical characteristics

44

4.2.1 Vertical tilt angle

47

4.2.2 Gain at high angles

47

4.2.3 Changes in the horizontal characteristics with elevation

48

4.3 Backlobe

49

4.4 Radio frequency switch

51

4.5 Rotating joint

52

4.6 Radio frequency cables

54

4.7 Colocating with primary radar

55

4.7.1 Top mounting

55

4.7.2 Back mounting

56

4.7.3 Back-to-back mounting

57

4.7.4 Integrated feed systems

57

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10 9 8 7 6 5 4 3 2 1

4.8 Radomes	58
References	65
Chapter 5 Interrogators	67
5.1 Mode generator	67
5.1.1 Mode interlace programs	67
5.1.2 Transmitter pulse specifications	68
5.1.3 Interrogator repetition frequency	69
5.1.4 Use of a radio frequency switch	69
5.1.5 Triggers for external use	70
5.2 Transmitter	71
5.2.1 Frequency control	71
5.2.2 Modulation	72
5.2.3 Power output stage	73
5.2.4 Transmitter sideband spectrum and output filtering	79
5.3 Standard receiver	80
5.3.1 Receiver sensitivity	80
5.3.2 Receiver bandwidth	81
5.3.3 Pulse detection	84
5.3.4 Gain-time control	87
5.3.5 Receiver sidelobe suppression	88
5.4 Monopulse receivers	90
5.4.1 Principles	90
5.4.2 Amplitude processing	99
5.4.3 Phase processing	103
5.4.4 Typical results	106
References	106
Chapter 6 Sliding Window Plot Extraction	109
6.1 Reply decoder	110
6.1.1 Pulse detection	110
6.1.2 Bracket detection	111
6.1.3 Code extraction	113
6.1.4 Special military replies	113
6.1.5 Mode determination and range measurement	114
6.2 Defruiting	114
6.3 Target detection and position measurement	115
6.4 Shortcomings of the sliding window plot extractor	117
Chapter 7 Monopulse Plot Extraction	119
7.1 Summary	119

7.2 Reply processing	122
7.2.1 Interrogation mode detection	123
7.2.2 Pulse leading edge detection	123
7.2.3 Pulse trailing edge detection	124
7.2.4 Bracket detection	126
7.2.5 Code pulse position timing	126
7.2.6 Definition of garbling replies and interleaved replies	126
7.2.7 Phantom replies	127
7.2.8 Special military replies	127
7.2.9 Mode S preamble detection	128
7.2.10 Pulse sampling	129
7.2.11 Reply reference selection	130
7.2.12 Reply decoding	130
7.2.13 Low amplitude pulses	134
7.2.14 Monopulse azimuth data	135
7.2.15 C2-SPI phantom detection and rejection	136
7.3 Reply-to-reply processing	136
7.3.1 Initial processing	136
7.3.2 Reply-to-reply correlation	139
7.3.3 Raw target report declaration	141
7.4 Surveillance processing	142
7.4.1 Summary	142
7.4.2 Discrete code correlation	143
7.4.3 General association	143
7.4.4 General correlation	146
7.4.5 Track initiation	147
7.4.6 Target report update	147
7.4.7 Typical performance results	149
7.4.8 Track update	151
7.4.9 Track coasting and dropping	153
7.5 False target processing	155
7.5.1 Initial conditions	156
7.5.2 False target tests	156
7.5.3 Track status	159
7.5.4 Determination of reflecting surfaces	160
7.6 Plot combination with primary radar target reports	161
References	163
Chapter 8 Transponders	165
8.1 Transponder specification documents	165
8.1.1 Receiver sensitivity	166
8.1.2 Reply delay and jitter	167
8.1.3 Reply suppression	167

8.1.4 Reply transmitter power	167
8.1.5 Random trigger rate	168
8.1.6 Replies to Mode C interrogations	168
8.1.7 Dual-antenna installations	168
8.2 Airborne antenna patterns	170
8.3 Conformance to specifications	170
8.3.1 Reply frequency	171
8.3.2 Transmitter power and receiver sensitivity	171
8.3.3 Pulse widths	171
8.3.4 Reply pulse errors	175
8.3.5 Suppression characteristics	175
8.3.6 Reply delay	176
8.4 Need for transponder performance reporting	177
References	178
Chapter 9 Multipath and Interference	179
9.1 Multipath	180
9.1.1 Multipath signals in the same vertical plane	180
9.1.2 Small horizontal angle between multipath signals	190
9.1.3 Large horizontal angle between multipath signals	199
9.1.4 Example using an improved antenna	202
9.2 Types of interference	205
9.2.1 Unwanted signals	205
9.2.2 Loss of wanted signals	209
References	211
Chapter 10 System Design	213
10.1 The radar equation as applied to secondary surveillance radar	213
10.2 Uplink and downlink power budgets	218
10.2.1 Uplink	219
10.2.2 Downlink	220
10.3 Reply and detection probabilities	222
10.3.1 Transponder reply probability	222
10.3.2 Detection probability	222
10.4 Transmitter pulse repetition frequency	223
10.5 Bearing accuracy	224
10.5.1 Sliding window	224
10.5.2 Monopulse	226
10.6 Antenna height	233
10.7 Cross-coupling between primary radar and secondary surveillance radar	234
References	235

Chapter 11 Performance Measurement and Monitoring	237
11.1 Performance measurement	237
11.1.1 Target detection	237
11.1.2 Track jitter	238
11.2 Performance monitoring	243
11.2.1 Site monitor	243
11.2.2 Fault detection and isolation	244
11.2.3 Antenna pattern measurement	246
11.3 Model of the secondary surveillance radar environment	246
References	250
Chapter 12 Mode S	251
12.1 Reason for development	251
12.2 Interrogation formats	252
12.3 Reply format	257
12.4 Parity and address	258
12.5 Interrogation types	261
12.5.1 Surveillance interrogation	261
12.5.2 Comm-A interrogation	264
12.5.3 Comm-C interrogation	264
12.5.4 All-call interrogation	265
12.5.5 Broadcast interrogation	266
12.6 Reply types	267
12.6.1 Surveillance reply	268
12.6.2 Comm-B reply	269
12.6.3 Comm-D reply	271
12.6.4 All-call replies	272
12.7 Applications of the data link	273
12.8 The open systems interconnection model	274
References	275
Chapter 13 Traffic Advisory and Collision Avoidance System	277
13.1 Identification of intruding aircraft	278
13.1.1 Whisper-shout interrogation	278
13.1.2 Directional interrogation	279
13.1.3 Mode C All-call interrogation	279
13.2 Track initiation and maintenance	280
13.3 Threat traffic and resolution advisories	280
13.4 Coordination with ground air traffic control	282
13.5 Sensitivity level control	283
13.6 TCAS III	285

Secondary Surveillance Radar

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7

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21

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21

3.3 Interrogation signals

23

3.4 Reply signals

24

3.5 System problems

26

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31

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34

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35

References

37

Chapter 4 Ground Antenna Systems

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4.1 Horizontal characteristics

39

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40

4.1.2 Control beam

40

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42

4.2 Vertical characteristics

44

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47

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47

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48

4.3 Backlobe

49

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51

4.5 Rotating joint

52

4.6 Radio frequency cables

54

4.7 Colocating with primary radar

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55

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56

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5.1.2 Transmitter pulse specifications	68
5.1.3 Interrogator repetition frequency	69
5.1.4 Use of a radio frequency switch	69
5.1.5 Triggers for external use	70
5.2 Transmitter	71
5.2.1 Frequency control	71
5.2.2 Modulation	72
5.2.3 Power output stage	73
5.2.4 Transmitter sideband spectrum and output filtering	79
5.3 Standard receiver	80
5.3.1 Receiver sensitivity	80
5.3.2 Receiver bandwidth	81
5.3.3 Pulse detection	84
5.3.4 Gain-time control	87
5.3.5 Receiver sidelobe suppression	88
5.4 Monopulse receivers	90
5.4.1 Principles	90
5.4.2 Amplitude processing	99
5.4.3 Phase processing	103
5.4.4 Typical results	106
References	106
Chapter 6 Sliding Window Plot Extraction	109
6.1 Reply decoder	110
6.1.1 Pulse detection	110
6.1.2 Bracket detection	111
6.1.3 Code extraction	113
6.1.4 Special military replies	113
6.1.5 Mode determination and range measurement	114
6.2 Defruiting	114
6.3 Target detection and position measurement	115
6.4 Shortcomings of the sliding window plot extractor	117
Chapter 7 Monopulse Plot Extraction	119
7.1 Summary	119

7.2 Reply processing	122
7.2.1 Interrogation mode detection	123
7.2.2 Pulse leading edge detection	123
7.2.3 Pulse trailing edge detection	124
7.2.4 Bracket detection	126
7.2.5 Code pulse position timing	126
7.2.6 Definition of garbling replies and interleaved replies	126
7.2.7 Phantom replies	127
7.2.8 Special military replies	127
7.2.9 Mode S preamble detection	128
7.2.10 Pulse sampling	129
7.2.11 Reply reference selection	130
7.2.12 Reply decoding	130
7.2.13 Low amplitude pulses	134
7.2.14 Monopulse azimuth data	135
7.2.15 C2-SPI phantom detection and rejection	136
7.3 Reply-to-reply processing	136
7.3.1 Initial processing	136
7.3.2 Reply-to-reply correlation	139
7.3.3 Raw target report declaration	141
7.4 Surveillance processing	142
7.4.1 Summary	142
7.4.2 Discrete code correlation	143
7.4.3 General association	143
7.4.4 General correlation	146
7.4.5 Track initiation	147
7.4.6 Target report update	147
7.4.7 Typical performance results	149
7.4.8 Track update	151
7.4.9 Track coasting and dropping	153
7.5 False target processing	155
7.5.1 Initial conditions	156
7.5.2 False target tests	156
7.5.3 Track status	159
7.5.4 Determination of reflecting surfaces	160
7.6 Plot combination with primary radar target reports	161
References	163
Chapter 8 Transponders	165
8.1 Transponder specification documents	165
8.1.1 Receiver sensitivity	166
8.1.2 Reply delay and jitter	167
8.1.3 Reply suppression	167

8.1.4 Reply transmitter power	167
8.1.5 Random trigger rate	168
8.1.6 Replies to Mode C interrogations	168
8.1.7 Dual-antenna installations	168
8.2 Airborne antenna patterns	170
8.3 Conformance to specifications	170
8.3.1 Reply frequency	171
8.3.2 Transmitter power and receiver sensitivity	171
8.3.3 Pulse widths	171
8.3.4 Reply pulse errors	175
8.3.5 Suppression characteristics	175
8.3.6 Reply delay	176
8.4 Need for transponder performance reporting	177
References	178
Chapter 9 Multipath and Interference	179
9.1 Multipath	180
9.1.1 Multipath signals in the same vertical plane	180
9.1.2 Small horizontal angle between multipath signals	190
9.1.3 Large horizontal angle between multipath signals	199
9.1.4 Example using an improved antenna	202
9.2 Types of interference	205
9.2.1 Unwanted signals	205
9.2.2 Loss of wanted signals	209
References	211
Chapter 10 System Design	213
10.1 The radar equation as applied to secondary surveillance radar	213
10.2 Uplink and downlink power budgets	218
10.2.1 Uplink	219
10.2.2 Downlink	220
10.3 Reply and detection probabilities	222
10.3.1 Transponder reply probability	222
10.3.2 Detection probability	222
10.4 Transmitter pulse repetition frequency	223
10.5 Bearing accuracy	224
10.5.1 Sliding window	224
10.5.2 Monopulse	226
10.6 Antenna height	233
10.7 Cross-coupling between primary radar and secondary surveillance radar	234
References	235

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11.1 Performance measurement	237
11.1.1 Target detection	237
11.1.2 Track jitter	238
11.2 Performance monitoring	243
11.2.1 Site monitor	243
11.2.2 Fault detection and isolation	244
11.2.3 Antenna pattern measurement	246
11.3 Model of the secondary surveillance radar environment	246
References	250
Chapter 12 Mode S	251
12.1 Reason for development	251
12.2 Interrogation formats	252
12.3 Reply format	257
12.4 Parity and address	258
12.5 Interrogation types	261
12.5.1 Surveillance interrogation	261
12.5.2 Comm-A interrogation	264
12.5.3 Comm-C interrogation	264
12.5.4 All-call interrogation	265
12.5.5 Broadcast interrogation	266
12.6 Reply types	267
12.6.1 Surveillance reply	268
12.6.2 Comm-B reply	269
12.6.3 Comm-D reply	271
12.6.4 All-call replies	272
12.7 Applications of the data link	273
12.8 The open systems interconnection model	274
References	275
Chapter 13 Traffic Advisory and Collision Avoidance System	277
13.1 Identification of intruding aircraft	278
13.1.1 Whisper-shout interrogation	278
13.1.2 Directional interrogation	279
13.1.3 Mode C All-call interrogation	279
13.2 Track initiation and maintenance	280
13.3 Threat traffic and resolution advisories	280
13.4 Coordination with ground air traffic control	282
13.5 Sensitivity level control	283
13.6 TCAS III	285

References	285
Glossary of terms	287
Index	295

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Chapter 1

Introduction

Civil aviation is concerned with the safe and expeditious movement of people and freight from one point on the globe's surface to some other desired point. The responsibility for this safe passage is that of the pilots of the aircraft involved. In this responsibility they are assisted by ground-based systems and personnel. Safety is maintained by assuring adequate separation of aircraft, and to this end appropriate procedures and recommended practices have been devised by the International Civil Aviation Organization (ICAO). Many countries provide an air traffic control (ATC) service in at least part of their airspace. Pilots are required to file flight plans before their departure so that their intentions are understood and their flight can be integrated with other air traffic.

The degree of separation required for aircraft is influenced by the quality and accuracy of the position data available. In sparsely populated areas external aids to the pilot can be few and far between and separations of as much as 30 min of travel can be set for aircraft on the same course. These procedural separations are very generous since they are dependent on the aircraft's own navigation accuracy and allowance must be made for possible errors in navigation. However, they are inappropriate in areas of dense traffic, and the use of ground radar is required in order to handle demands on airspace without prejudicing safety.

The word "radar", which is an acronym of RAdio Detection And Ranging is usually taken to mean what is more accurately called primary radar. In primary radar a high power pulse of radio frequency energy is transmitted from a rotating antenna and if this strikes the body of an aircraft then a small amount of that energy is reflected back towards the rotating antenna. The skill of the primary radar design engineer is directed to the detection of this small amount of reflected energy. When an aircraft has been detected in this way its range can be determined by measuring the elapsed time between the transmission and subsequent reception of the reflection since the speed of a radio wave is known. The aircraft's bearing is indicated by the direction of the antenna at the time that the aircraft is detected.

Like any system, primary radar has its good and bad points. The major good point is that, for its operation, it does not require anything special of the aircraft other than that it presents a reasonable radar-reflecting surface. The bad points are that primary radar also obtains returns from rain, from the ground and even from birds, and these extraneous returns make it difficult to distinguish between real aircraft and the background clutter. Many special techniques have been developed to overcome these problems with some considerable success. However, primary radar is unable to distinguish one

aircraft from another similar aircraft and in most cases cannot determine height to sufficient accuracy.

Secondary radar overcomes these difficulties. Secondary radar, more precisely secondary surveillance radar (SSR), requires each aircraft to carry on board a special transmitter-receiver equipment known as a transponder. An SSR ground station transmits pulses of radio frequency energy from a rotating antenna in the same way as for primary radar except at a very much lower power level. Only sufficient power to overcome the one-way path loss to the transponder is required compared with the two-way path loss for primary radar. SSR transmits pulses of a few hundred watts in power compared with a few hundreds or thousands of kilowatts in the case of primary radar. Upon reception of the ground-station signal, the transponder transmits a reply on a different frequency. The use of a separate frequency prevents the reply from being confused with possible returns from rain, birds or terrain. The aircraft range and bearing are determined from the time delay and antenna direction in the same way as for primary radar.

The main advantage of SSR is that it can obtain extra information from the aircraft. The availability of the on-board SSR equipment allows a rudimentary data link to be added to the radar function. The ground SSR station codes its transmission by emitting pairs of pulses of different spacing. At the same time as determining the aircraft's range and bearing the ground station can also ask the aircraft "Who are you?" or "What is your altitude?". The response of the airborne transponder is in the form of a multiple-pulse reply carrying as data either its identity number or its flight level. The ability of SSR to obtain this additional information about the aircraft is of immense value to the air traffic controller on the ground. As a result SSR is becoming the major sensor for ATC.

Other advantages of SSR include the ability to obtain long-range cover (over 200 nautical miles if required) at lower cost, as SSR is only a fraction of the cost of an equivalent primary radar. The latter fact is producing a trend to the use of SSR only at *en route* sites away from major airports.

The SSR ground equipment comprises a rotating antenna, a tower with antenna-turning equipment, a transmitter-receiver, which is usually called an interrogator, and a reply-signal processor known as a plot extractor or digitizer. The ground station transmits to the aircraft on a frequency of 1030 MHz and receives the aircraft's response on a frequency of 1090 MHz. Figure 1.1 shows a typical SSR antenna, in this case mounted on a collocated primary radar antenna with which it shares the tower and turning gear. The SSR interrogator and a plot extractor are normally installed in an equipment room, and examples are shown in Fig. 1.2. The plot extractor converts the reply data into a target report for each aircraft and sends these reports via land lines to ATC centers. The target report data are displayed to the air traffic controller in the form of a map-like presentation. The display shows the position of each aircraft, with either its SSR identity number or its associated

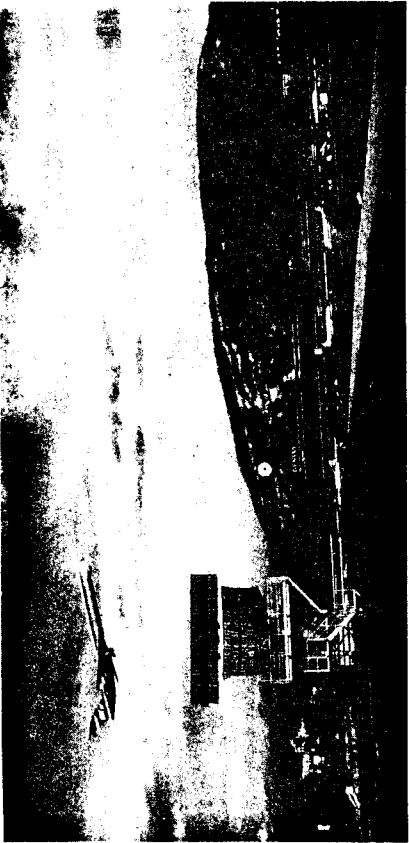


Fig. 1.1 SSR antenna (Cossor type CRSS12) mounted on a primary radar antenna (TI type ASR8) at Geneva airport.

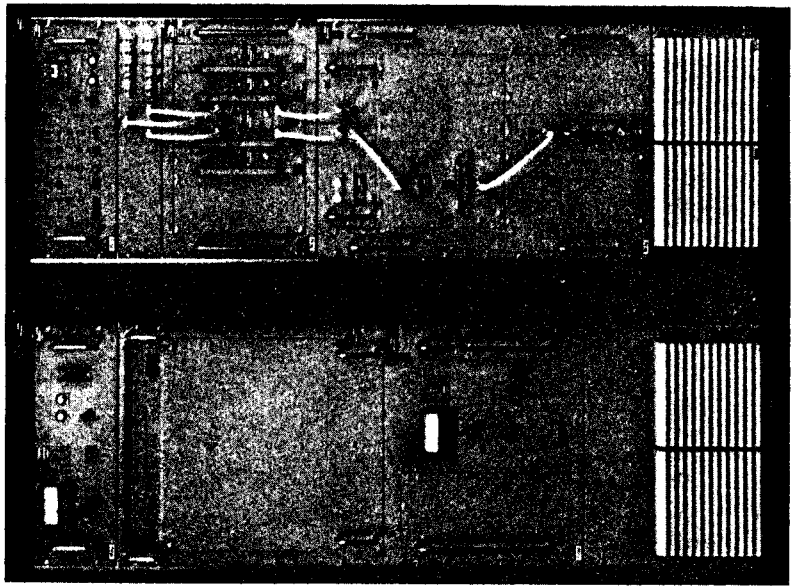


Fig. 1.2 Typical interrogator (right) and plot extractor (left) (Cossor types 9610 and 9620 respectively).

