AGD340

RADAR USER MANUAL AND OPERATING INSTRUCTIONS

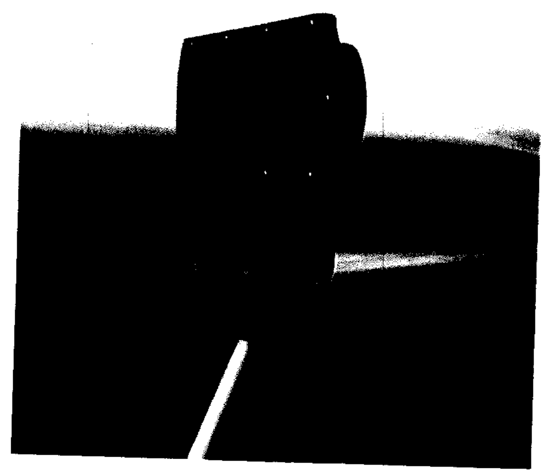
1 INTRODUCTION

These instructions detail the use and operation of the AGD340 radar. This radar has been specifically designed for the accurate measurement of the speeds of passing vehicles when mounted at the side of the road for enforcement purposes. The radar is designed to work in conjunction with a host, photographic based, enforcement system. The host system may be mobile or fixed location in nature.

The radar is supplied in a black plastic enclosure which incorporates all the radar circuitry and processing circuitry to perform the speed measurement function. The connection to the radar is via two integral connectors and mounting is provided by different fixing facilities on the housing which are dependent on the radar's deployment in application. In addition LED outputs are provided which provide a visual indication of the radar's status.

The AGD340 is a 24GHz continuous wave radar which measures speed by the Doppler Effect. The radar's integral planar antenna forms a narrow beam which is sited at a predetermined angle across the road. When vehicles pass through the beam the radar accurately measures the speed at approximately 195 readings per second via an advanced digitising and tracking technique to a resolution of 0.1Km/hr.

Details of each vehicle speed measurement are passed to the host system via a high speed serial communications interface. The radar also incorporates a number of self-checking and verification processes for measurement integrity.



Contents

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2 DOCUMENT REVISION

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A	Initial Draft	5/4/07	PRW
1	First Issue	16/6/08	PRW

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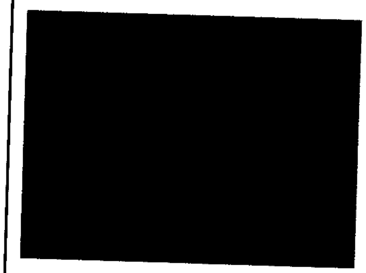
3 SPECIFICATIONS

Radar General		
Items	**Specification**	**Notes**
Housing	Black UV stabilised polycarbonate	Fine spark finish  
Radar Weight	0.80 Kg	No mounting cables, connectors or brackets
External Dimensions	288mm(W) x 112mm(H) x 50mm(D)	
Mounting Fixings	1x M10 female thread on lower face. 8 x 5mm clearance on front flange	
Sealing	IP66	
Radar Connection	3 pin male bulkhead power connector 10 pin male bulkhead data connector	Bulgin PX0410/03S/5560 Bulgin PX0410/08S/6065
Radar Labeling	Manufacturers Label Calibration Label	
LED	Red status indicator LED	
Operating Temperature	-25^{o}C to +60^{o}C	

Radar Power Connection			
Parameter	**Specified**	**Tolerance**	**Notes**
Supply Voltage	24V dc	9-30V	Should not be powered from a vehicle when the vehicles engine is running, otherwise damage to the radar may occur.
Current	100mA		At 24Vdc

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Radar Data Connection		
Parameter	**Specified**	**Notes**
4 wire RS 485		See extra notes on data connection and BAUD command.
25KHz signal	Buffered reference signal frequency	

Environmental Performance		
Test	**Severity**	**Specification**
Cold	(-20°C Operational)	IEC 68-2-1 Test Ab
Dry Heat	+60°C Operational	IEC 68-2-2 Test Bb
Damp Heat	Cyclic 48Hrs 25°C to 40°C 95%RH	IEC 68-2-30 Test Db
Free Fall	Each top rear corner & each top rear face. 1000mm free fall to concrete.	IEC 68-2-32 Test Ed
Drop and Topple	All faces & corners 100mm drop	IEC 68-2-31 Test Ec
Shock	4000m/S^2, 2mS Duration	IEC 68-2-27 Test Ea
Random Vibration	0.02g^2/ Hz (10-50Hz) 0.01g^2/ Hz (50-150Hz) 0.002g^2/ Hz (150-500Hz) Overall RMS 1.58g 3Hrs on X,Y,Z axes	IEC 68-2-34 Test Fd
Sinusoidal Vibration	5-7Hz ± 1.5mm 7-35Hz ± 10m/S^2	IEC 68-2-6 Test Fc
Bump	1000 in X,Y,Z axes 100m/S^2,16mS	IEC 68-2-29 TestEb
Immersion	Preconditioned to +30°C over ambient before 12Hrs Immersion.	IEC 68-2-18 Test R

Radar Transceiver		
Component	**Specification**	**Notes**
Antenna	Planar patch array	
Transmitter	Dieletric resonator oscillator, DRO	
Receiver	Homodyne I Q down converter	
Radome	Black UV stabilised polycarbonate	

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Radar Transmission		
Parameter	**Specified**	**Notes**
Fundamental Power	<20dBm EIRP	FCC = 727.8mV/m @3m
Operational Frequency	24.100GHz ± 25MHz	
Frequency Temperature Stability	Typically < 100 kHz/°C	
Polarisation	Plane polarised with E-Field horizontal	
Horizontal Beamwidth	4.5 degrees	See Figure 26 and Figure 27
Vertical Beamwidth	15 degrees	See Figure 26
Spurious	< 1μW EIRP (25 to 22000MHz)	
Emission Code	1H00N0NXN	ITU Designation
Radar Detection		
Parameter	**Specified**	**Notes**
FFT size	1024 point	
Tracking window	3Km/hr	
Image Rejection	>20dB	
Measurement rate	195 Hz	The number of speed measurements made per second
Technical Performance Specifications		
Radio Specification	ETSI EN300 440-1	
Radio EMC Specification	ETSI EN301 489-1	

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4 SYSTEM HARDWARE OVERVIEW

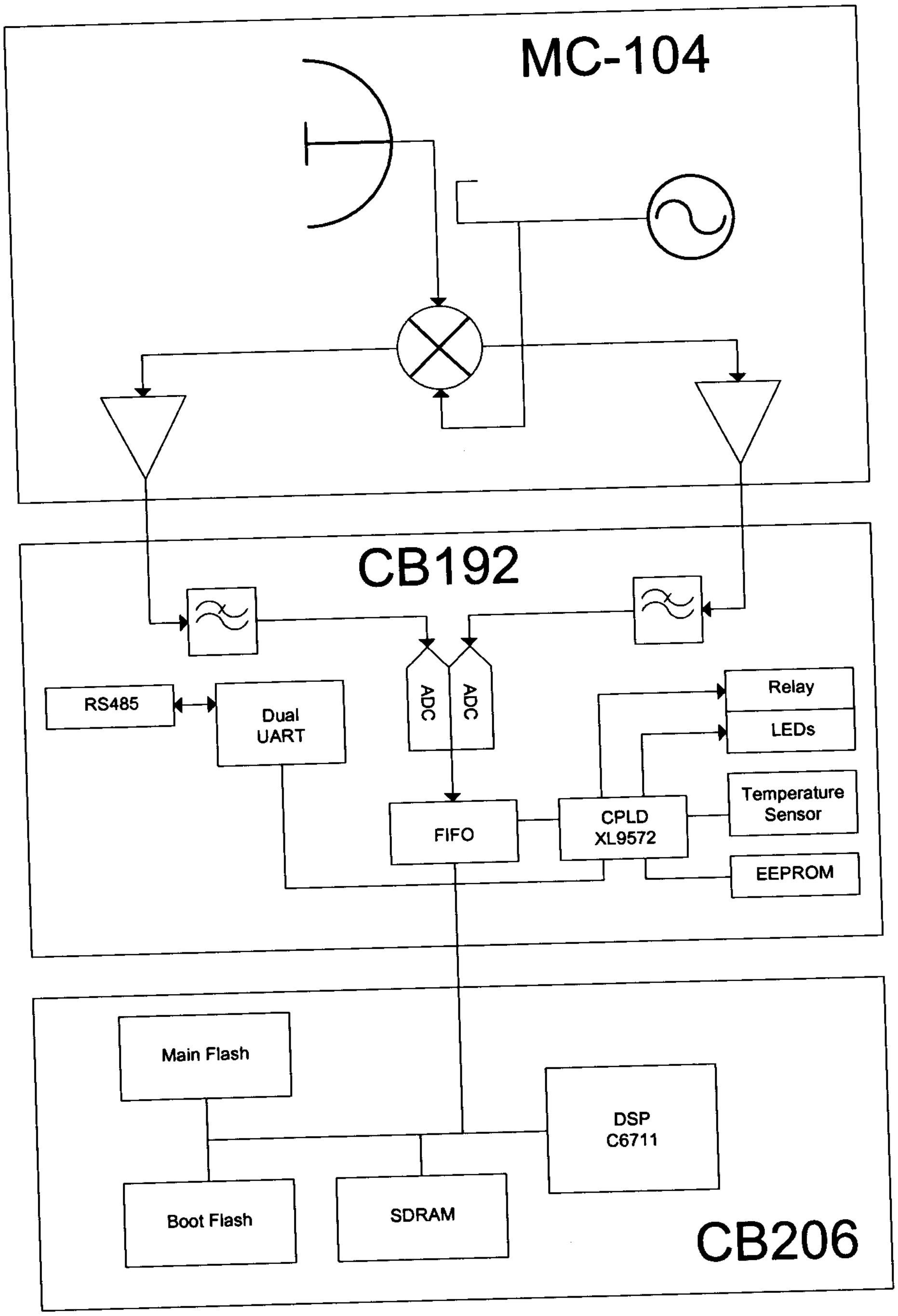

Figure 1 System Hardware Overview

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4.1.1 Serial interface, RS485

A UART interface is provided using RS485 voltage levels. The default baud rate for this interface is 115200. This however maybe changed using the BAUD command to speeds of up to 926000. The BAUD command will store the baud rate into non volatile memory of the radar ready for the next time the radar boots. When the radar first boots it will always use a baud rate of 115200 to report the radar firmware version and the baud rate that will be used. It then switches to the new baud rate and again reports the radar firmware version.

The serial interface default setup during normal operation is shown in Table 1.

Parameter	Value
Baud Rate	115200
Data bits	8
Parity Bits	None
Stop Bits	1
Flow control	None

Table 1 Default UART Settings

The RS485 provides the primary output of the radar in the form of ASCII messages. These messages provide speed, beam entry and beam exit information.

4.1.2 LEDs

The externally visible LED is used to indicate the radar status, see Table 2.

LED On Time (Seconds)	LED Off Time (Seconds)	Radar Condition
3	0.5	Normal Operation
0.5	0.5	Error condition

Table 2 LED Status

Three internal LEDs are used to indicate a target detect. The LED that is illuminated is dependent on the direction the target is travelling relative to the radar and whether it is a double sideband target like a tuning fork.

4.1.3 Temperature Sensor

A digital temperature sensor has been installed on the digitiser board. The temperature of the radar may be requested using the TEMP command.

4.1.4 Non Volatile Memory

An EEPROM is installed on the board to provide non volatile memory. The primary use of this EEPROM is to store configuration and calibration data.

4.2 Power supply

The radar is powered using a DC voltage in the range of 9 to 30volts. The radar is polarity protected using a diode. The radar can take a very large current doing power up that is of the order of amps. However, this current only lasts for ~1ms and should not affect most applications.

The radar should not be powered from a vehicle when the vehicles engine is running, otherwise damage to the radar may occur.

4.2.1 Input Protection

A thermal fuse with a 630mA rating has been installed to protect against electrical short circuit fault conditions.

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5 SOFTWARE FUNCTIONALITY

5.1 Overview

The AGD340 radar is a real time radar that continuously samples the input. The radar uses a real time operating system that is continuously performing a number of tasks simultaneously using a time multiplexing method.

5.2 Tasks

The radar has a number of key tasks that are performed in parallel.

- Watch Dog Task
  This task has the lowest priority so that if any other task locks up for any reason this task will not be run. If this task is not run then the radar will reset itself automatically after ~0.5 seconds. This task is also used to provide the heartbeat functionality where a message is sent over the RS485 approximately every 10 seconds

- Detection Task
  This task performs the detection of targets. This task waits for the ADC to complete a block of data collection and then performs the necessary signal processing.

- RS485 Handling Task
  This task processes data received on the RS485 connection. It processes commands sent to the radar and provides appropriate responses.

- Configuration Update Task
  The configuration task updates the radar configuration data once every minute. The main purpose of this task is to update the lifetime figures for the radar.

5.2.1 Detection Task

This task performs the main functionality of the radar to detect speeding vehicles using digitised data from the microwave module.

5.2.2 Target Tracking

The radar FFT target information is split into approaching, receding and double sideband targets.

The target tracking function only tracks a single target at a time so when operating in dual direction mode the function is called twice, once for each direction. If the double sideband target detection is turned on the target tracking function is called again and passed the double sideband target list.

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6 MESSAGE FORMATS

6.1 Standard Messages

The radar in normal operation produces four standard messages. Each message type is identified by the MT field, see Figure 2. The four message types are:

01	Beam entry message
02	Valid detect message
03	No detect message
04	Beam exit message

The numbers above the boxes in Figure 2 indicate how many bytes are used for each field.

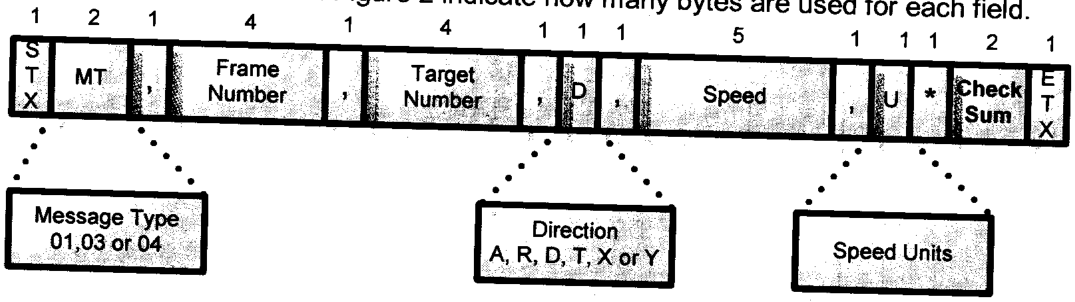

Figure 2 Format for 01, 03 & 04 messages

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Name	Size/ Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'01'=Beam Entry '03'=No Detect '04'=Beam exit	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Target Number	4	XXXX	Target identification number in hexadecimal format
,	1	','	Comma
Direction	1	'A'=Approaching Target 'R'=Receding Target 'D'=Double sideband target 'T'=Simulated Test Target 'X'=Simulated approaching target 'Y'=Simulated receding target	Direction the target is travelling.
,	1	','	Comma
Speed	5	'DDD.D'	Target speed to one decimal place in decimal format
,	1	','	
U	1	'M'=MPH 'K'=KPH	The speed units used for the measurement
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 3 Format for 01, 03 &04 messages

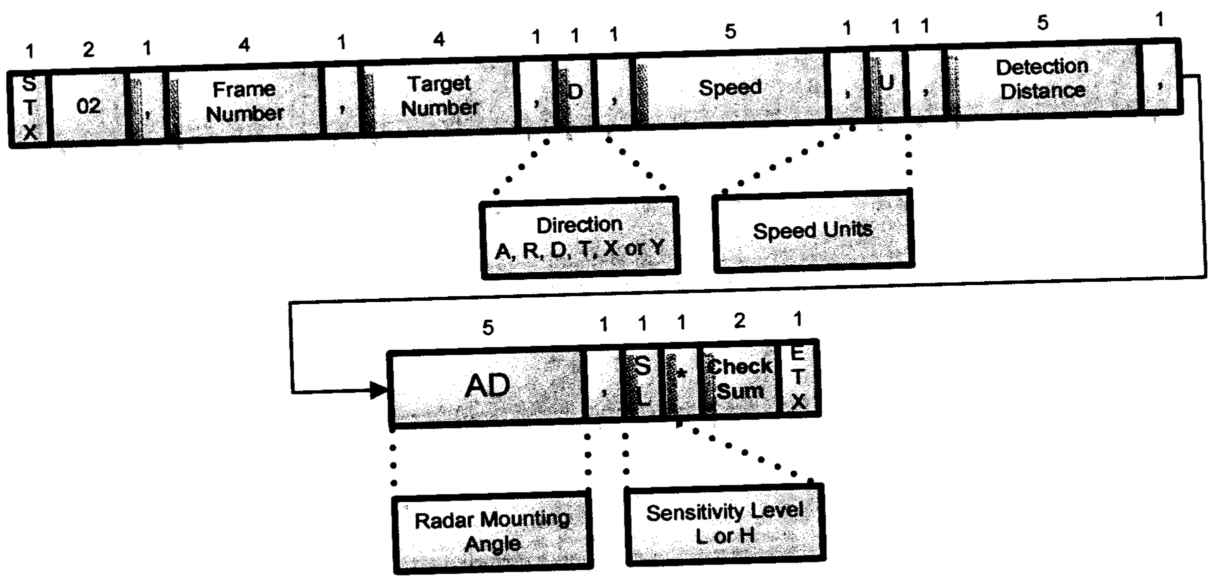

Figure 3 Format for 02 message

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Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'02'=Valid detect	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Target Number	4	XXXX	Target identification number in hexadecimal format
,	1	','	Comma
Direction	1	'A'=Approaching Target 'R'=Receding Target 'D'=Double sideband target 'T'=Simulated Test Target 'X'=Simulated approaching target 'Y'=Simulated receding target	Direction the target is travelling.
,	1	','	Comma
Speed	5	'DDD.D'	Target speed to one decimal place in decimal format
,	1	','	
U	1	'M'=MPH 'K'=KPH	The speed units used for the measurement
,	1	','	
Detection Distance	5	'DDD.D'	The distance a target has travelled during detection in metres
,	1	','	
AD	5	'DDD.D'	Radar mounting angle in degress to an accuracy of one decimal place in decimal format. This is the angle the radar uses to calculate the speed of a target
,	1	','	
SL	1	'L'=Low 'H'=High	Sensitivity level the radar is set to
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 4 Valid Detect Message Format

The radar counts time in frames. The time the message is sent is stored in the frame number field in hexadecimal format.

Each new target detected is given a new target number that is stored in the field target number in hexadecimal format.

The direction field can either be A for approaching or R for receding. When the radar is operating in double sideband detect mode the direction can also be D to indicate a double sideband target detection.

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The speed of the target is given to 1 decimal place. The units used are supplied in the U field. K signifies KPH while M indicates MPH.

The check sum value is calculated by performing an XOR on all the characters starting with the first byte of the MT field and up to but not including the checksum characters. The checksum is output as a 2 character hexadecimal number.

6.2 Diagnostic Messages

These messages are not produced as standard and are normally disabled. The *DM command has to be sent to the radar to enable them.

6.2.1 D0 Message

The D0 messages are enabled by using the *DM command. When followed with a 1 the D0 messages are enabled and disabled by following with a 0, e.g.

*DM 1	Turn D0 messages on
*DM 0	Turn D0 messages off

The D0 message format is shown in Figure 4.

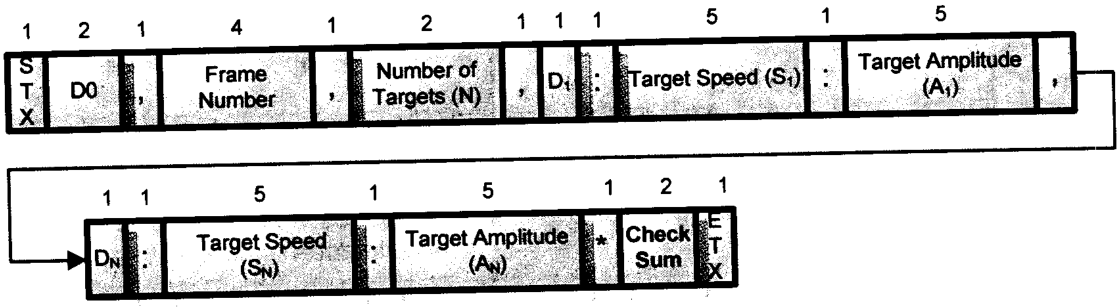

Figure 4 D0 Message

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Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'D0'=Debug message	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Number of targets	4	XXXX	Number of targets being reported
,	1	','	Comma
D_1	1	'A'=Approaching Target 'R'=Receding Target 'D'=Double sideband target 'X'=Simulated approaching target 'Y'=Simulated receding target	Direction the 1st target is travelling.
:	1	':'	Colon separator
Target Speed S_1	5	'DDD.D'	Target speed in KPH to one decimal place in decimal format of 1st target
:	1	':'	Colon separator
Target Amplitude A_1	5	'DDD.D'	Amplitude of 1st target in dB
,	1	','	Comma
.	.		.
D_n	1	'A'=Approaching Target 'R'=Receding Target 'D'=Double sideband target	Direction the nth target is travelling.
:	1	':'	Colon separator
Target Speed S_n	5	'DDD.D'	Target speed in KPH to one decimal place in decimal format of nth target
:	1	':'	Colon separator
Target Amplitude A_n	5	'DDD.D'	Amplitude of nth target in dB
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 5 Diagnostic Message format

The D0 messages contain the output of the target detection function. The D0 message lists all the potential targets the radar has detected for the mode the radar is working in. When the radar is operating in this mode large amounts of data need to be transferred over the RS485 interface. D0 messages during a target detect will typically be produced at a rate of 195 per second. Therefore a baud rate of at least 115200 is required to support this mode of operation.

D0 messages contain a lot of information about the track history of a target as it travels through the beam. The D0 messages could be used to provide extra evidence about any particular speeding offence. For instance Figure 5 shows a typical D0 sequence for a vehicle, see Figure 6, approaching the radar.

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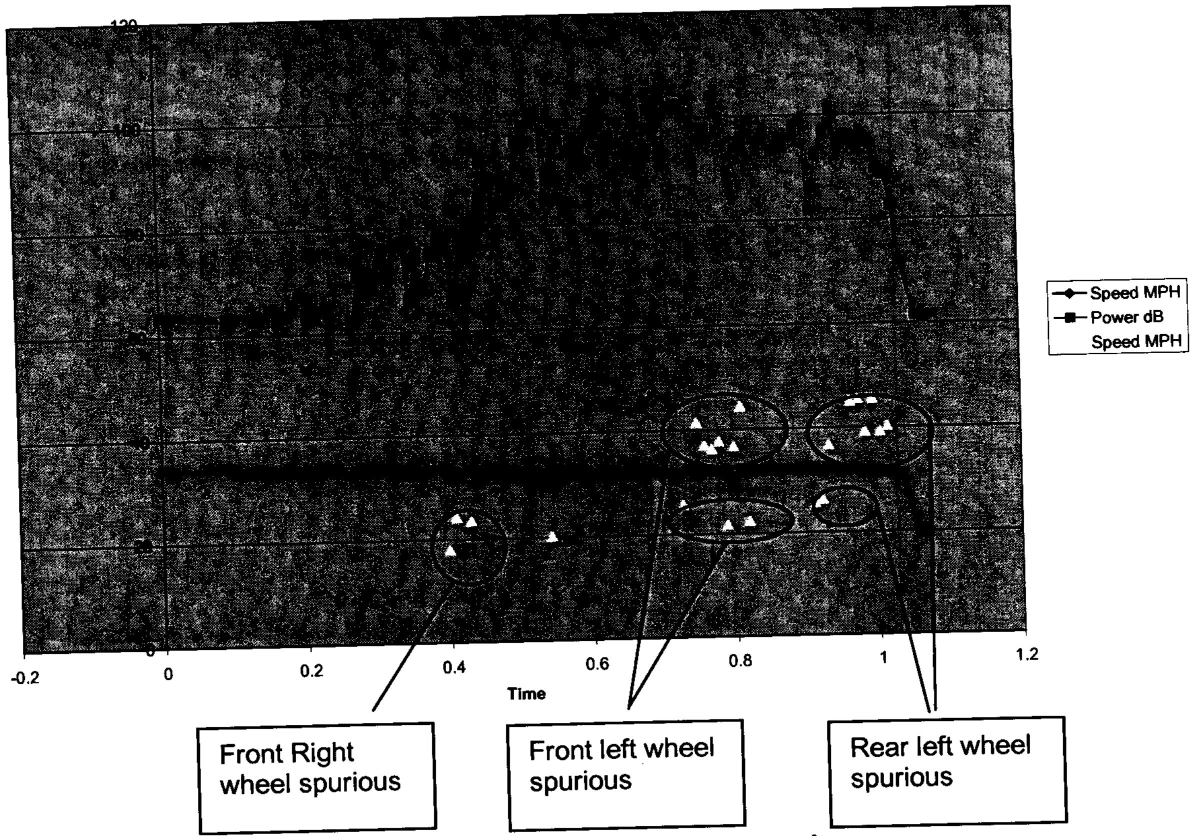

Figure 5 Typical D0 data plotted

Figure 6 D0 Example Target

As can be seen from Figure 5 the vehicle speed can easily be picked out from any spurious signals caused by the wheels of the vehicle. The wheels of a vehicle can produce spurious speeds which can vary between 0 and twice the actual speed of the vehicle.

However because the wheel spurious signals are not consistent a track is never formed on them. The speed reported by the radar in the valid detect and beam exit messages will be the one associated with the largest magnitude detected.

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6.3 Status Messages

6.3.1 C0 Message

The C0 message is produced in response to the CHECK-ADC command. The message format is shown in Figure 7.

1	2	1	4	1	4	1	4	1	2	1
STX	C0	,	Frame Number	,	I DC Offset	,	Q DC Offset	*	Check Sum	ETX

Figure 7 C0 Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C0'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
I DC Offset	4	XXXX	I Channel DC Offset in hexadecimal format
,	1	','	Comma
Q DC Offset	4	XXXX	Q Channel DC Offset in hexadecimal format
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 6 C0 Message Format

6.3.2 C1 Mounting Angle Message

This message is sent in response to a #AD command. The message reports the mounting angle the radar is using to calculate the speed of vehicles. The message format is shown in Figure 8.

1	2	1	4	1	5	1	2	1
STX	C1	,	Frame Number	,	Radar Mounting Angle	*	Check Sum	ETX

Figure 8 C1 Mounting Angle Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C1'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Radar Mounting Angle	5	DD.DD	Radar mounting angle in degrees
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

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Table 7 C1 Message Format

6.3.3 C2 Radar Enquiry Message

This message is sent in response to a #AGD command. The message reports the radar type and firmware version. The message format is shown in Figure 9.

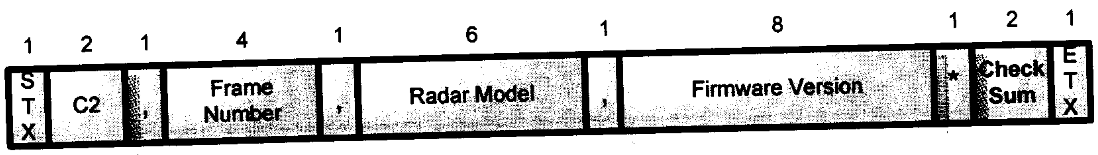

Figure 9 CF Radar Enquiry Message

Name	Size Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C2'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Radar Model	6	AGD340	Radar type
,	1	','	Comma
Firmware Version	8	'MI-DDD-A'	Firmware version
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 8 Radar Enquiry Message

6.3.4 C3 DDS Mode Message

This message is sent in response to a #DDS command. The message format is shown in Figure 10.

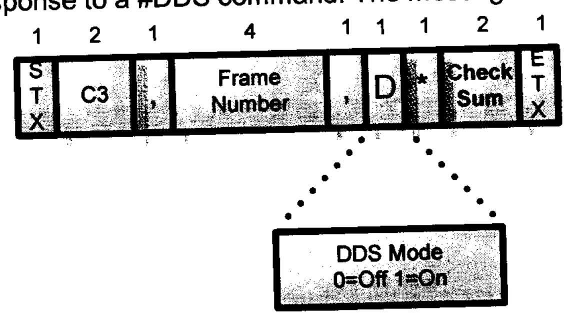

Figure 10 DDS Mode Message

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Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C3'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
DDS mode	1	'0' = Off '1' = On	DDS mode
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 9 DDS Mode Message

6.3.5 C4 Direction Mode Message

This message is sent in response to a #DIR command.

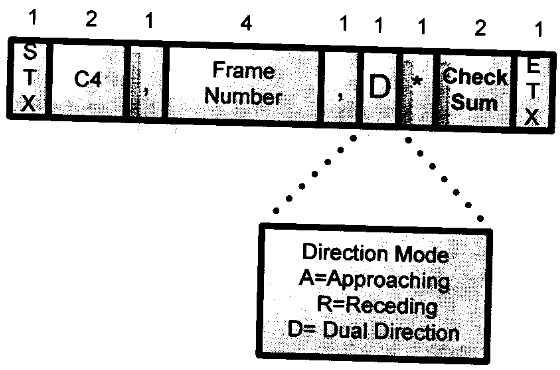

Figure 11 Direction Mode Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C4'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Direction mode	1	'A' = Approaching 'R' = Receding 'D' = Dual Direction	Direction mode of radar
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 10 Direction Mode Message

6.3.6 C5 Debug Mode Message

This message is sent in response to a #DM command. The message format is shown in Figure 12.

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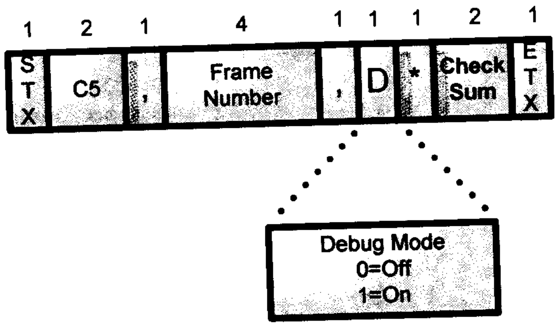

Figure 12 Debug Mode Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C5'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Direction mode	1	'0' = Off '1' = On	Debug mode of radar
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 11 Debug Mode Message

6.3.7 C6 Frequency Error Message

This message is sent in response to a #FE command. The message reports the ADC sampling frequency measured by the processor and the ADC sampling frequency error. The message format is shown in Figure 13.

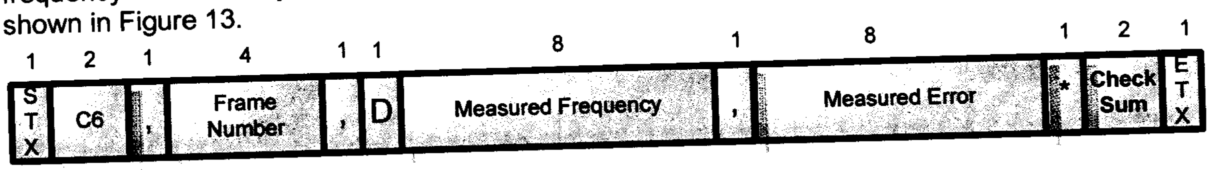

Figure 13 Frequency Error Message

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Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C6'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Measured Frequency	8	DDDDD.DD	Measured ADC sampling frequency in decimal
,	1	','	Comma
Measured Error	8	DDDDDDDD	ADC frequency error in parts per million
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 12 Frequency Error Message

6.3.8 C7 Low Speed Threshold Message

This message is sent in response to a #LS command. The message reports the low speed threshold being used by the radar and the units the radar is using. The message format is shown in Figure 14.

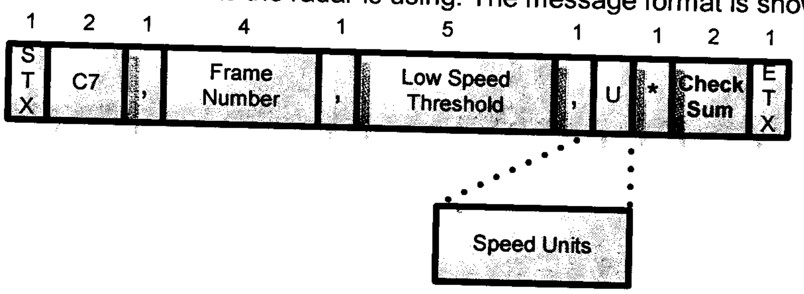

Figure 14 Low Speed Threshold Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C7'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Low Speed Threshold	5	DDDDD	
,	1	','	Comma
Speed Units	1	'K'=KPH 'M'=MPH	Speed units being used
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 13 Low Speed Threshold Message

6.3.9 C8 Sensitivity Level Message

This message is sent in response to a #SL command. The message format is shown in Figure 15.

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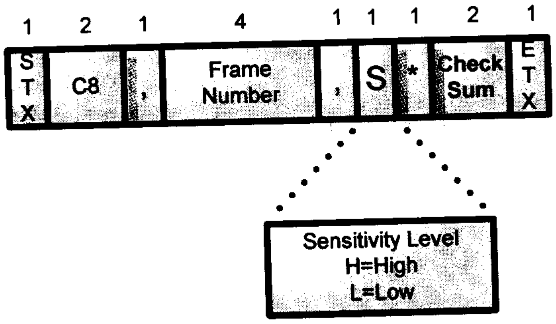

Figure 15 Sensitivity Level Message

Name	Size/Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C8'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
S	1	'H' = High 'L' = Low	Radar sensitivity level
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 14 Sensitivity Level Message

6.3.10 C9 Speed Units Message

This message is sent in response to #SU command. The message format is shown in Figure 16.

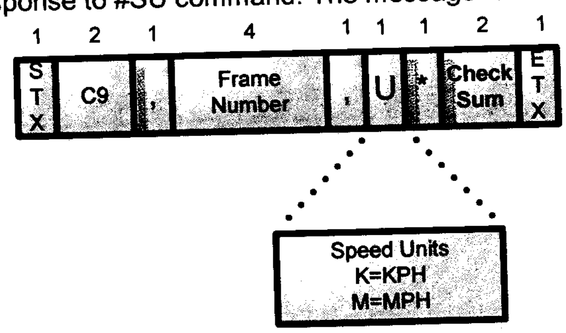

Figure 16 Speed Units Message

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Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'C9'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Speed Units	1	'M' = MPH 'K' = KPH	Speed units being used by radar
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 15 Speed Units Message

6.3.11 CA Temperature Message

This message is sent in response to a #TEMP command. The message reports the temperature of the radar as measured by a sensor on the digitiser board. The message format is shown in Figure 17.

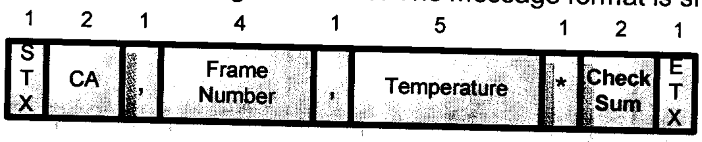

Figure 17 Temperature Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'CA'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Temperature	5	DD.DD	Radar temperature in degrees Celsius
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 16 Temperature Message

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6.3.12 CB Firmware Version Message

This message is sent in response to a #VER command. The message format is shown in Figure 18.

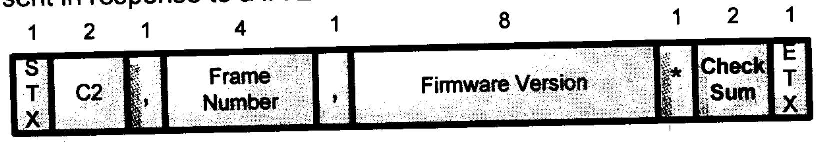

Figure 18 Firmware Version Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'CB'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
,	1	','	Comma
Firmware Version	8	'MI-DDD-A'	Firmware version
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 17 Firmware Version Message

6.3.13 CF Heartbeat Message

This is the heart beat message. This message is sent approximately every 10 seconds. The message format is shown in Figure 19.

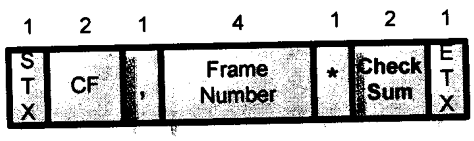

Figure 19 CF Heartbeat Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'CF'	Message Type
,	1	','	Comma
Frame Number	4	XXXX	Frame number in hexadecimal format
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 18 CF Heartbeat Message Format

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6.4 Error Messages

6.4.1 E0 Message

The E0 message is used to report errors detected in the radar. The format of this message is shown in Figure 20.

1	2	1	2	1	2	1	N	1	2	1
STX	E0	,	Error No.	,	Text Length N	,	ASCII Text Description	*	Check Sum	ETX

Figure 20 E0 Error Message

Name	Size / Bytes	Value	Notes
STX	1	2	Start of message byte
MT	2	'E0'	Message Type
,	1	','	Comma
Error Number	2	XX	2 digit error number in hexadecimal format
,	1	','	Comma
Text Length, N	2	XX	2 digit hexadecimal number indicating the length of the text description
,	1	','	Comma
Text Description	N	"Some text string"	Text string of length N
*	1	'*'	Asterisk
Check Sum	2	'XX'	Check sum in hexadecimal format
ETX	1	3	End of message byte

Table 19 Error Message Format

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7 RADAR USAGE

7.1 Introduction

For best detection performance the radar must be setup correctly. Failure to do so can result in inaccurate or false detections.

7.2 Radar Mounting Angle

Radars are supplied factory programmed to be used for a specific mounting angle, usually to 22 degrees. This angle is the angle the radar points across the road from the direction of the road, see Figure 21. The angle a radar is setup for is printed on the top side of the radar. The angle is also reported in valid detect messages and the command *AD may be used to determine it. This angle is used by the radar to adjust the speed the radar measures to the actual target speed and therefore it is important the radar is setup with the correct angle. If the radar is setup with an angle that is less than the mounting angle then the radar will measure speeds that are larger than the vehicles true speed, while if the angle is greater than the mounting angle the radar will measure speeds that are less than the vehicles true speed.

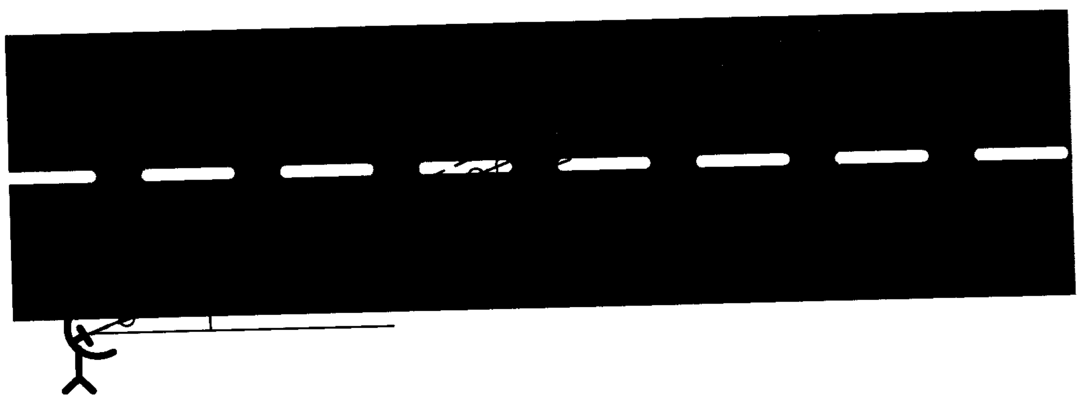

Figure 21 Radar Mounting Angle

The radar transmits a radio beam across the road that has a horizontal beam width of ~5 degrees. The vertical beam width of the radar beam is relatively large at 15degrees so although the radar should be made level this is not crucial for correct operation. For a fixed camera installation often the radar is mounted relatively high (~3m) and in this case it is desirable to point the radar more down towards the ground. In this application careful consideration of the radar beam and its shape is required to ensure that all the lanes of the road are covered.

7.3 Sensitivity Level

The radar has two sensitivity levels to allow it to operate in most situations. The sensitivity level is adjusted using the *SL command. If the radar is being used to monitor only two lanes of a road then the low sensitivity level should be chosen. This is particularly important in an urban environment where the radar may pick up reflections and falsely trigger the camera that will take a picture of a non-existent or incorrect vehicle. This is illustrated in Figure 22 where the radar has triggered the camera because it has detected a speeding car from its reflected signal off a building. By setting the sensitivity level of the radar to low this weak reflected signal is often not detected.

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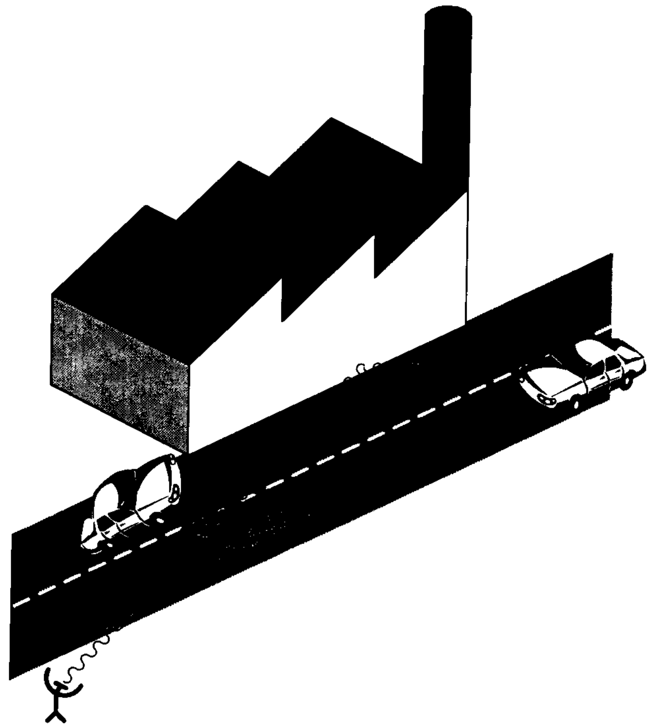

Figure 22 High sensitivity false detections in an urban environment

To reduce further the possibility of detecting reflections the radar should not be pointed at any large vertical flat surfaces which may reflect the radars transmissions. This is particularly true if the surface is metal.

When the radar is monitoring 3 or more lanes the high sensitivity mode of the radar maybe used. The radar, even in low sensitivity mode, will detect most vehicles on a four lane road but some targets with small radar signal returns may not be detected in the far lanes e.g. motorcycles.

7.4 Dual Direction Mode

The radar can be set in a mode to detect speeding vehicles travelling in both directions. Each direction is tracked independently. In this mode the vehicle travelling on the opposite side of the road may not be detected correctly because the signal is blocked by a vehicle nearer to the radar. It is therefore recommended that the radar is setup to detected vehicles on the far side of the road using beam entry messages and nearby targets using the beam exit messages. Figure 23 shows what can happen in an incorrect setup. In an incorrect setup the vehicle in the far lane is detected correctly and a beam entry message is sent. This message would not be used to take a photo though as the rear number plate can not be seen yet. However moments later a car travelling in a lane nearer to the radar blocks the signal from the far vehicle and so the radar sends a beam exit message and the system would then take a photo. However the far vehicle is not in view and therefore no conviction can be made. In the correct setup though as soon as the radar detects the speeding far vehicle a beam entry message is sent and a photo is taken. Moments later the near vehicle blocks the signal from the far target and a premature beam exit message is sent but a photo has already been taken and a safe conviction may be made.

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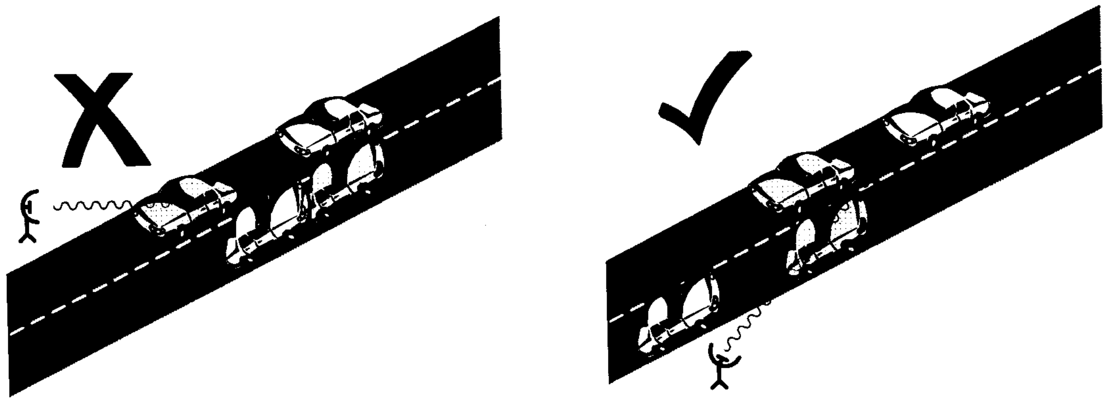
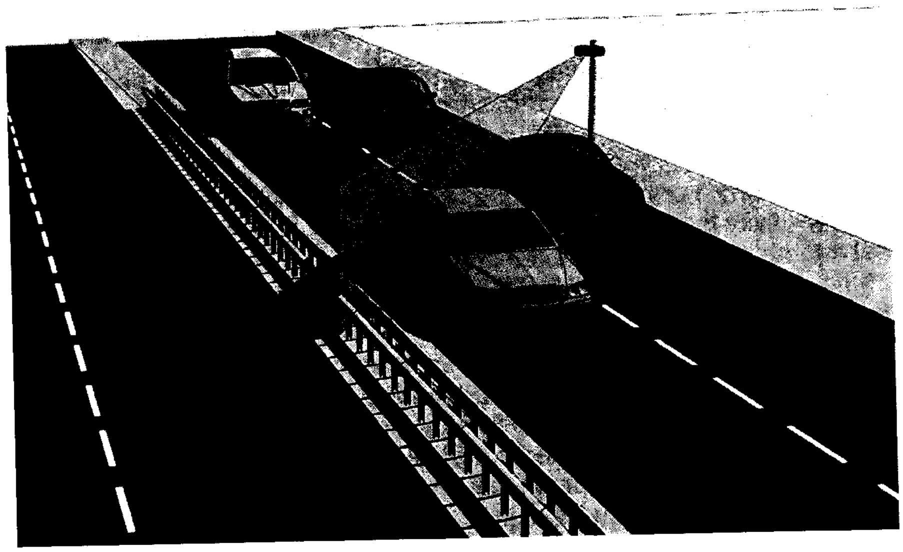


Figure 23 Dual direction detection



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Appendix A - Radar Commands

A.1 *AGD or #AGD*

Reports the name of the radar and its firmware version.

Example

AGD
AGD340 Speed Enforcement Radar
Firmware Version MI-096-A

#AGD
[STX]C2,0003A651,AGD340,MI-096-A*08[ETX]

A.2 **AD or #AD*

Used to enquire the radar's mounting angle setting, that is used to calculate the speed of a target.

*AD	Reports the mounting angle used by the radar in degrees.

Example

*AD
22.00

#AD
[STX]C1,0000F9EC,22.00*0F[ETX]

A.3 *BAUD*

Used to enquire/modify the baud rate used by the RS485 interface of the radar.

When the radar first boots the baud rate that is used will be reported over the RS485 interface at a baud rate of 115200. Therefore if the baud rate of the radar is not known simply use a tool like HyperTerminal and set the baud rate to 115200 to find out the baud rate of the radar. A typical output from the radar when powered up and viewed with HyperTerminal set to a baud rate of 115200 is shown below.

User configuration successfully loaded
AGD340 Speed Enforcement Radar
Firmware Version MI-083-L1
Baud rate = 921600

The usage of the BAUD command is shown below

BAUD	Reports the baud rate being used by the radar
BAUD x	Sets the baud rate of the radar to x. When the baud rate has been set using this command the next time the radar is rebooted this is the baud rate that will be used.

A.4 *CHECK-ADC*

Measures the DC offset values of the I and Q ADC channels and reports this in a C0 message. This command is useful to perform a simple check of the analogue stages of the radar. In normal

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circumstances the values returned for the I and Q offsets should be in the range 8000h ± 100. Note these values are in hex. A typical radar response is shown below

CHECK-ADC
[STX]C0,00001773,0000805E,00007FD4,*22[ETX]

A.5 *DDS or #DDS

This command turns on double sideband target reporting mode. This mode of operation of the radar will report double sideband targets which are usually simulated targets such as a tuning fork. Another common double sideband target is fluorescent lights.

The usage of *DDS command is shown below

*DDS 0	Turn double sideband detection off
*DDS 1	Turn double sideband detection on

The #DDS command is similar but also responds with a C3 message.

A.6 DIRECTION or #DIR

Used to enquire/modify the direction mode of the radar.

DIRECTION	Report the direction mode being used
DIRECTION A	Approaching targets mode
DIRECTION R	Receding targets mode
DIRECTION D	Dual direction mode

#DIR is used in a similar way but a C4 message is sent in response.

A.7 *DM or #DM

Used to enquire/modify the diagnostic mode of the radar.

*DM	Reports the diagnostic mode being used.
*DM 0	Turn diagnostic mode off
*DM 1	Turn diagnostic mode on

In diagnostic mode the radar produces D0 messages that can be used to provide supporting evidence for an offence. However, this requires a significant baud rate to be used for reliable operation. Normally a baud rate of 115200 is sufficient.

#DM is similar but also responds with a C5 message.

A.8 *FE, #FE or FREQ_ERROR

This command reports the results of the latest frequency error measurement. A typical response is shown below

*FE
49984.54Hz
-11ppm
200.00MHz
Passed

The first frequency reported is the measured ADC clock rate. The next line reports the measured error in parts per million. Next the assumed frequency of the processor clock is reported.

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#FE is used in a similar way but the radar responds with a C6 message.

A.9 *FFD

This command loads the factory set defaults from the EEPROM. This command can be used to set the configuration to a known good state.

A.10 *HELP or ?

This command is used to produce a list of the user commands. The command does not provide information on factory commands.

A.11 LIFE

Reports life time statistics of the radar. A typical response is shown below.

```
LIFE
Time on                 = 1226Minutes
Number of boots         = 66
Valid Target detects    = 489
```

A.12 *LS or #LS

Used to enquire/modify the low speed threshold velocity of the radar. Target speeds detected below this are not reported. This command must be passed a value of 20KPH or greater.

*LS	Reports the present low speed threshold velocity in the presently set speed units.
*LS x	Sets the low speed threshold velocity to x. The units of x are in the presently set speed units (See *SU).

#LS is similar but responds with a C7 message.

A.13 REBOOT

Performs a software reboot of the radar.

A.14 SELF-TEST

This command is used to activate the radars hardware self test circuitry. The hardware can simulate both a receding target and an approaching target. When activated the radar will turn the simulation hardware on and analysis the returning messages. If the radar measures an incorrect speed during this test or the wrong direction the radar will shut down the ADC. The usage of the SELF_TEST command is as follows

SELF-TEST A	Simulate an approaching target
SELF-TEST R	Simulate a receding target

The self test functionality is also called during bootup.

A.15 *SL or #SL

This command is used to set the sensitivity level of the radar.
The usage of the *SL command is shown below

*SL	Enquire radar sensitivity level
*SL L	Set low sensitivity level. Suitable for monitoring across up to two lanes
*SL H	Set high sensitivity level. Suitable for monitoring across up to four lanes

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The #SL is similar but responds with a C8 message.

A.16 *SU, UNITS or #SU

These commands are used to enquire/modify the speed units used by the radar. Valid units are:

M	Miles per hour MPH
K	Kilometres per hour KPH

The usage of the command is shown below

*SU	Enquire radar speed units
*SU M	Set MPH as the radar speed units
*SU K	Set KPH as the radar speed units

The #SU is similar but responds with a C9 message.

A.17 *TGT

This command tells the radar to simulate a target detect sequence. A typical response is shown below.

```
[STX]01,00024CA5,00000001,A,100.0,K*22[STX]
[STX]02,00000341,00000001,T,120.0,K,003.4,022.0,H*52[ETX]
[STX]04,00024CB9,00000001,A,120.0,K*2A[ETX]
```

The direction field of the simulated target will be T so that it can not be mistaken for a real target. The beam entry message will always have a target speed of 100KPH and the following messages will always contain a speed of 120KPH. No D0 messages are simulated in this target simulation.

A.18 TEMP or #TEMP

Reports the temperature of the radar in degrees Celsius. A typical response is shown below.

```
TEMP
32.88
```

#TEMP is similar but responds with a CA message.

A.19 VERSION or #VER

Reports the firmware version of the radar.

The #VER reports the software version in a CB message.

A.20 *VN

This command reports the security numbers of the DSP board. These are unique to each DSP board and can not be adjusted. A typical output is shown below

```
[STX]F0,18541854,2D392D42,3AF33AF3,55955595*50[ETX]
```


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Appendix B - Connectors

B.1 *Data Connector*

Pin No.	Signal Name	Note
1	A (RX +)	4 Wire RS485
2	B (RX -)	
3	Z (TX-)	
4	Y (TX+)	
5	NC	
6	Reference Oscillator	24992.54Hz ±50PPM
7	0V	Ground
8	spare	

Table 20 Data Connector

B.2 *Power Connector*

Pin No.	Signal Name	Note
L	+ve Supply	9 to 30V DC
N	-ve Supply	0V or Ground
E	Earth	

Table 21 Power Connector

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Appendix C - RADAR SELF TEST FEATURES

C.1 *25KHz Reference Signal*

The radar uses an analogue to digital converter, ADC, to digitise the received signals. The ADC clock source is derived from a crystal on the digitiser board that is also used for the UART. The crystal used has a frequency of 14.7456MHz. This is divided down by the CPLD by 295 to give an ADC clock frequency of 49985.08475Hz. The signal used for the ADC has a very small duty ratio that means it is difficult to measure the signals period using an oscilloscope. Therefore for measurement purposes the ADC clock is made into a square wave which requires a further division by two to give a frequency of 24992.54Hz. This signal is provided on the data connector of the radar.

To measure the reference signal output a frequency counter maybe used. The radar constantly monitors the sampling frequency by comparing how long the radar takes to collect data samples by using the processors crystal as a reference, which is independent from the ADC clock source. Measurements are compared approximately every second and if two successive measurements show a large enough error then the radar will send an error message and shut down the ADC converter. This in turn means the frame counter will longer increase in the heartbeat message. The measurement of the ADC clock frequency can be accessed at any time by using the #FE or *FE commands.

C.2 *IQ Monitoring*

The internal connectors J1 and J2 can be used to monitor the in phase and quadrature signals from the microwave front end. The radar has to be opened to access these connectors and should therefore only be performed at calibration time. If using an oscilloscope to observe these signals it should be configured as a high impedance probe. Using a 50Ohm probe to monitor these signals will distort the measurements.

C.3 *IQ Injection*

The internal connectors J1 and J2 can be used to inject I and Q signals into the radar. A low impedance source should be used to provide the signals with a magnitude of up to 5V peak to peak.

C.4 *Hardware Simulated Target*

The radar has a built in hardware based target simulator. This is used during boot up to simulate an approaching and then a receding target. If an error is detected in the simulated target's speed then the radar will send an error message and turn off the ADC clock rending the radar inactive. The radar can be made to perform a simulated target test at any time by sending a SELF-TEST command. Again if an error is detected in the targets speed the radar will stop. To distinguish real targets from simulated targets the radar inserts an X or a Y in the direction fields of all related messages produced. During simulation the microwave front end is turned off to avoid any possible interference with the simulation.

The CPLD on the digitiser board generates the signals used for the simulated target. These signals are generated using the logic shown in Figure 24. The input signals to the logic are:

- DIR
  This input selects the direction the simulated circuit will simulate. This signal is controlled by the C6711 processor.
- CS
  This input selects whether the outputs are active. This signal is controlled by the C6711 processor.
- CLK
  This signal is taken from the ADC sample clock and is the circuits input clock.

The purpose of this logic is to generate two square waves, I and Q, with a frequency that is one sixteenth of the ADC sample frequency (ie 49985.08475 / 16 = 3124.07Hz) and out of phase by 90°. This effectively provides a

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simulation of the expected signals from the microwave module when it can see a Doppler target. The DIR signal controls whether the Q channel lags or leads by 90° and therefore controls the effective direction the simulated target is travelling.

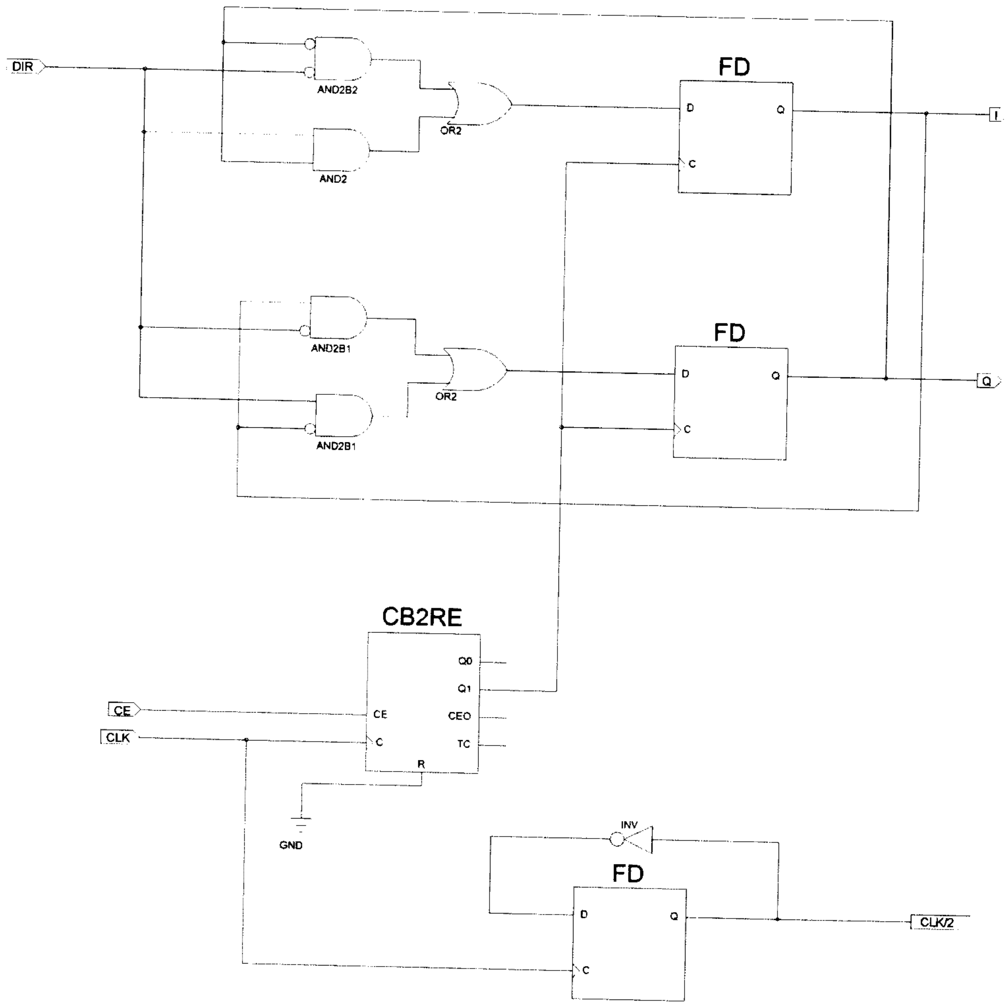

Figure 24 CPLD Target Simulator

The I and Q signals from the CPLD are then filtered before being applied to the –ve input of the digitisers board input operation amplifiers. The filter reduces the harmonic content of the I and Q signals to a level which the radar can cope with.

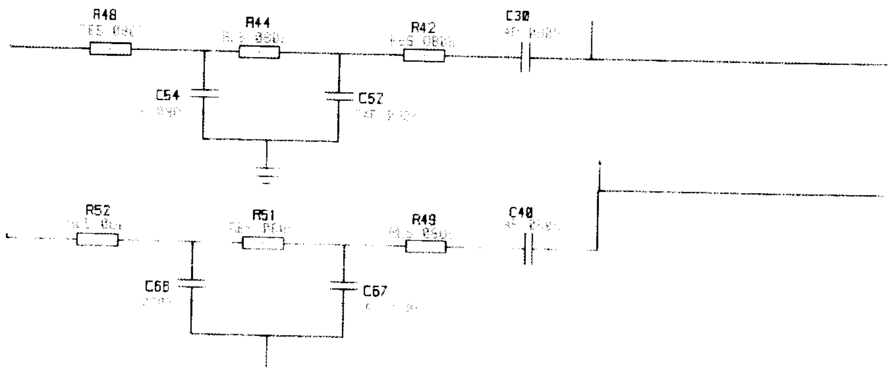

Figure 25 Target Simulator Filter

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Appendix D - RADAR Certification

D.1 *Radar Certification Overview*

It is essential for the AGD340 law enforcement radar to be certified every 12 months, ensuring the radar is within the design specification limits and traceable to known standards.

During manufacture of the radar an automated calibration and test rig is used to control all of the required test equipment and generate an initial 4 page calibration certificate/report.

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Appendix E - Antenna Field Patterns

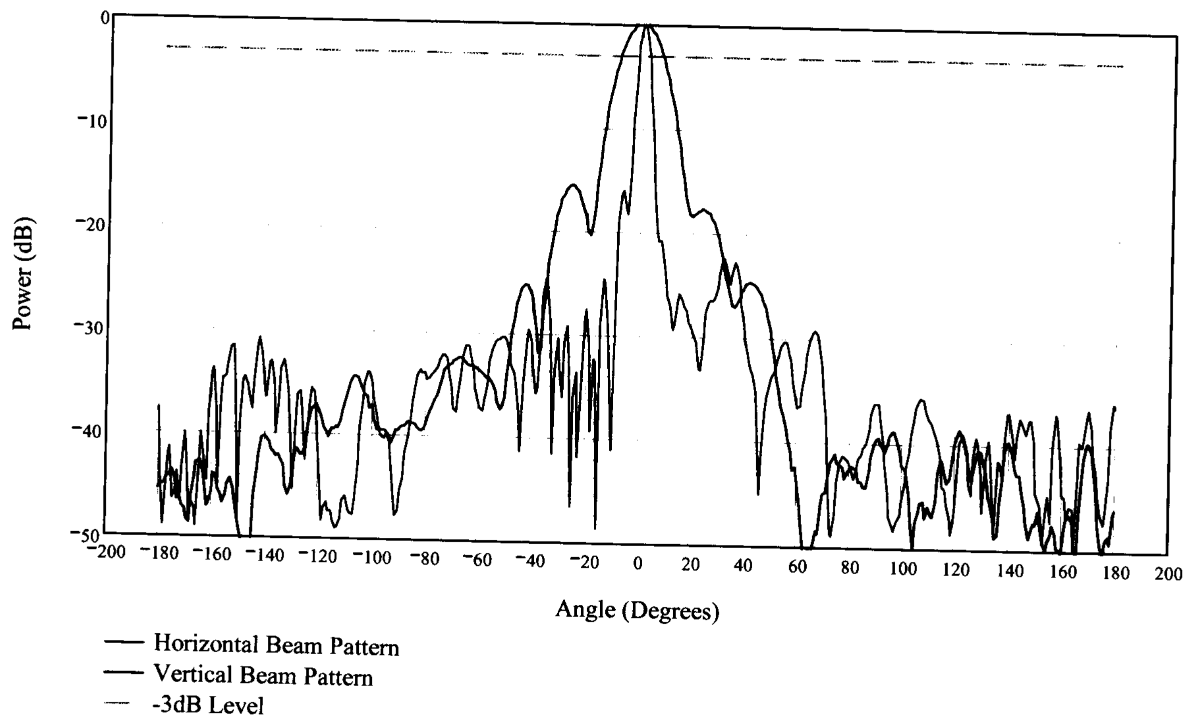

Figure 26 AGD340 Antenna Field Patterns

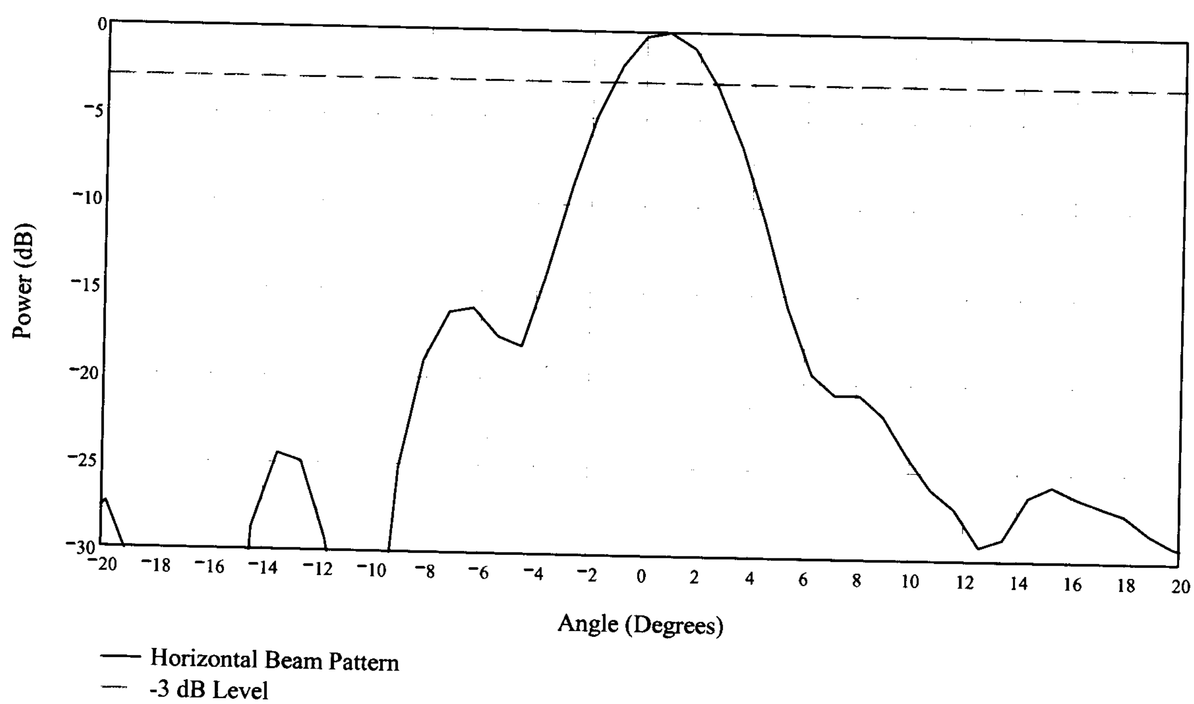

Figure 27 AGD340 Horizontal Beam Pattern

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