AGD315-205 and AGD315-207

RADAR USERS MANUAL

1 INTRODUCTION

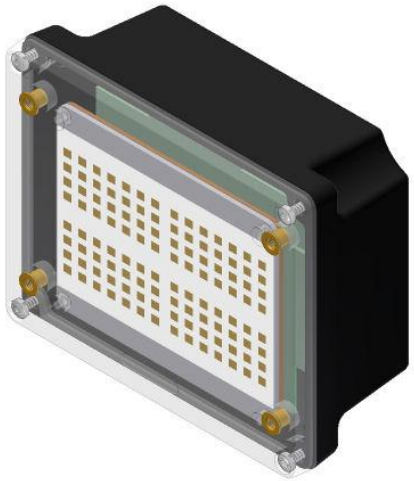
These instructions detail the use and operation of the AGD315-205 and -207 radars. This radar has been specifically designed for the accurate measurement of the speed and range of passing vehicles when mounted at the side of the road for enforcement purposes. The radar is designed to work in conjunction with an AGD340 radar plus 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 and range measurement. The connection to the radar is via a 1 metre cable with multi-pin connector, and mounting is provided by fixings on the housing.

The AGD315-205 is a 24.2GHz frequency modulated continuous wave (FMCW) radar whereas the AGD315-207 is a 24.125GHz (24.075GHz-24.175GHz) radar which are capable of measuring range and speed. 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 and range at a frame rate of 40 readings per second via an advanced digitising and tracking technique to a resolution of approximately 1 mph and 2 metres.

Details of each vehicle speed measurement are passed to the host system via a high speed serial communications interface.

Changes or modifications to this equipment, not expressly approved by AGD Systems Ltd, may void the user's authority to operate this equipment



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AGD Systems Limited
White Lion House, Gloucester Road, Staverton, Cheltenham, Gloucestershire, GL51 0TF UK
☎ +44 (0) 1452 854212 www.agd-systems.com
F: +44 (0) 1452 854213 E: info@agd-systems.com

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2 DOCUMENT REVISION

Issue	Amendment Details	Date of Issue	By
1	Initial Draft	23/12/2009	NK
2	DCR3006 – added section relating to test and calibration procedures. Figures and Tables identified using auto-numbered captions.	14/06/2010	SCH

3 FMCW OVERVIEW

3.1 Basic Operating Principles of FMCW Radar

In an FMCW radar such as the AGD315-205/207, the following basic operating principles are applied:

- The transmit signal is frequency modulated, normally by a linear modulation (a chirp)
- The modulation of the received signal is compared to the modulation of the transmitted signal to determine time delay and therefore range
- velocity is determined by range differentiation or Doppler processing

Consider a signal transmitted from the radar at time t=0 and with frequency f_{start}. When this signal strikes a target, the signal will be reflected back and received by the radar at a time $t=t_{delayed}$. During the time of flight of the reflected signal. the transmit frequency will have increased to a new frequency $f_{delayed}$, where $f_{delayed}$ is given by the chirp rate and amplitude.

Hence at any instance in time after $t_{delayed}$, there is a difference in frequency between the transmitted and received frequencies. This frequency difference is proportional to the time of flight for the received signal, and since the radar signal travels at the speed of light (a constant), the time of flight is also proportional to the range of the target which reflected the radar signal.

In an FMCW system, the transmit and receive signals are compared using an RF Mixer. The mixer is driven by the transmit and receive signals, and the mixer output is the difference between the two input signals. The output signal is referred to as the intermediate frequency (IF).

If the IF is sampled into an analogue to digital converter (ADC) at fixed time intervals during a single excursion of the frequency modulation (one period of the chirp) and the resultant digital signal is viewed in the frequency domain, a number of different frequencies will be seen, where each frequency corresponds to a target at a particular range.

If data from a number of successive chirps is gathered and processed, speed and range for individual targets can be determined.

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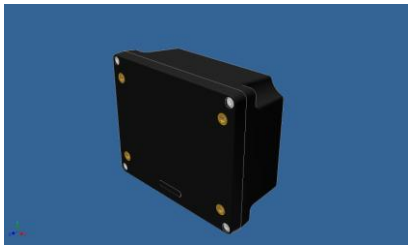
4 SPECIFICATIONS

Radar General			
Items	**Specification**		**Notes**
Housing	Black UV stabilised polycarbonate		Fine spark finish  
Radar Weight	0.80 Kg		Including 1 metre lead and connector
External Dimensions	160mm(W) x 130mm(H) x 60mm(D)		
Mounting Fixings	4 x M4 threaded inserts M16 cable gland		
Sealing	IP66		
Radar Connection	9 pin Bulgin Bucanneer (male) attached to end of 1 metre lead		Bulgin PX0728/P See section 9 for more information
Radar Labelling	Manufacturer's Label		
LED	Red status indicator LED Blue 'Bluetooth' indicator LED		
Radar Power Connection			
Parameter	**Specified**	**Tolerance**	**Notes**
Supply Voltage	24V dc	9-30V	
Current	263mA	10%	At 12Vdc
Radar Data Connection			
Parameter	**Specified**		**Notes**
4 wire RS 422			See extra notes on data connection and BAUD command.

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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	Quarter wave resonator	
Receiver	Homodyne I Q down converter	
Radome	Black UV stabilised polycarbonate	
Radar Transmission		
Parameter	**Specified**	**Notes**
Radar Centre Frequency	24.200 GHz UK/EU/AS/NZS 24.125GHz USA	
Modulation Bandwidth	80MHz	
Operating Frequency Band	24.150 - 24.250GHz (UK/EU/AS/NZS) 24.075 – 24.175GHz (USAVersion)	Modulation bandwidth of ~80MHz plus temperature stability guard bands (+/- 10MHz)
Fundamental Frequency Power	<20dBm EIRP	
Fundamental Frequency Field Strength	<1000mV/m	@3m
Frequency Temperature Stability	Typically < 1 MHz/°C	Uncompensated
Polarisation	Plane polarised with E-Field vertical	
Horizontal Beamwidth	7 degrees	

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Vertical Beamwidth	28 degrees	
Spurious	< 1μW EIRP (25 to 22000MHz)	
Emission Code	80M0FXN	ITU Designation
Antenna Sidelobe Suppression	>15dB	
Radar Detection		
Parameter	**Specified**	**Notes**
FFT size	256 point	
Tracking window	Not Applicable	
Image Rejection	Not Applicable	
Measurement rate	40 Hz	The number of speed \ range measurements made per second
Technical Performance Specifications		
Radio Specifications	ETS300.440, AS/NZS4268 FCC 47CFR15.245	

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5 SYSTEM HARDWARE OVERVIEW

A simplified block diagram of the AGD315-205/207 is shown below:

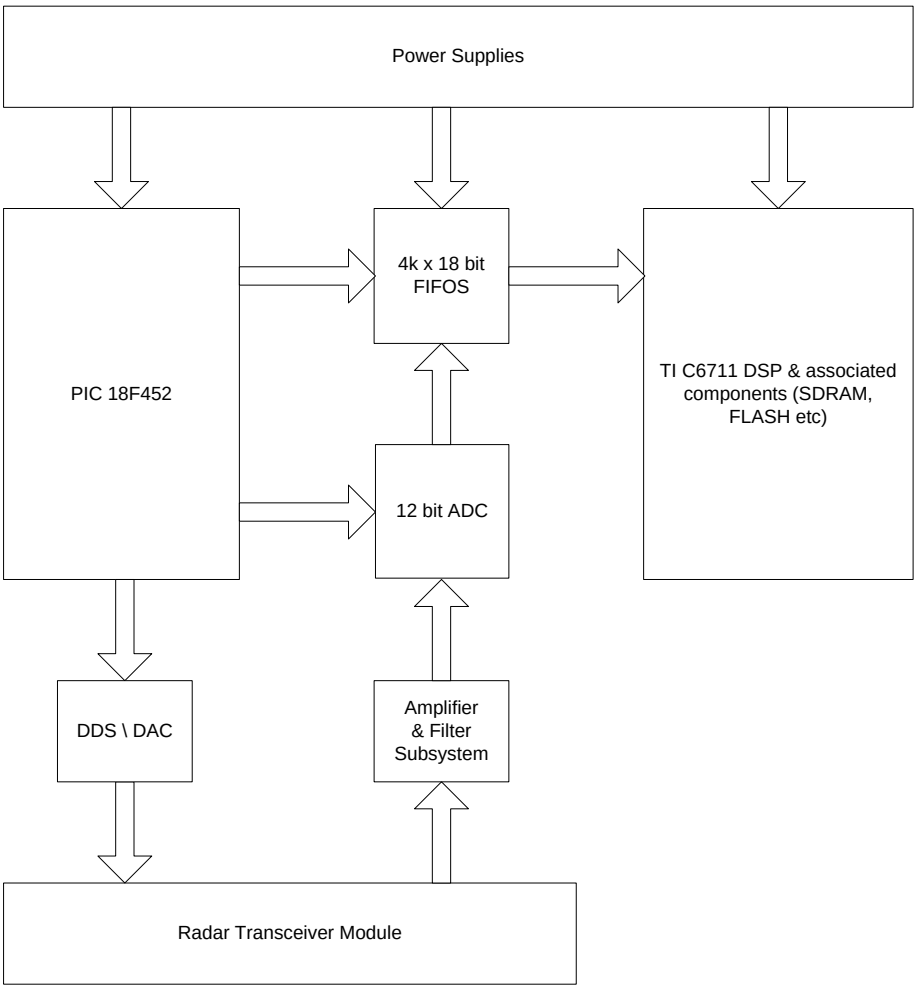

Figure 1 System Hardware Overview

5.1.1 Serial interface, RS422

A UART interface is provided using RS422 voltage levels, over a 4 wire (full duplex) interface. The default baud rate for this interface is 115200. This may be changed using the BAUD command to speeds of up to 921600. The BAUD command will store the baud rate into non volatile memory of the radar ready for the next time the radar boots.

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

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

Table 1 Default UART Settings

The RS422 provides the primary output of the radar in the form of ASCII messages. These messages provide speed and range information.

5.1.2 LED's

No LED's are visible from the outside of the unit. A number of internal LED's are provided for test and debug purposes.

5.1.3 Temperature Sensor

A digital temperature sensor has been installed on the digitiser board. This allows the processor to monitor environmental conditions. The temperature of the radar may be requested using the TEMP command.

5.1.4 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.

5.2 Power supply board CB-180

The radar is powered using a DC voltage in the range of 9 to 30 volts. 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.

5.2.1 Input Protection

A one shot anti-surge (T) fuse with a 630mA rating has been installed to protect against electrical short circuit fault conditions.

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6 MESSAGE FORMATS

6.1 Standard Messages

In normal operation, the radar produces a single standard message of the following form

```
<frame number>,<radar mode>,<detection direction>,
<cosine correction>:<debug info>#<target information><CR>
```

A sample message sequence from a typical roadside test is shown below:

```
0001917903,R,A,22: #T0:A,29,11,11.7,70.3
0001917904,R,A,22: #T0:A,29,11,11.7,60.4
0001917905,R,A,22: #T0:A,29,11,11.7,65.5
0001917906,R,A,22: #T0:A,29,12,12.8,61.0
0001917907,R,A,22: #T0:A,29,12,12.8,66.1
0001917908,R,A,22: #T0:A,28,12,12.8,68.4
0001917909,R,A,22: #T0:A,28,13,13.8,65.5
0001917910,R,A,22: #T0:A,28,12,12.8,67.3
0001917911,R,A,22: #T0:A,27,13,13.8,63.0
0001917912,R,A,22: #T0:A,28,13,13.8,71.2
```

The fields in each message are described in the table below:

Field Descriptor	Explanation	Comments
Frame number	Increments every frame	Reset if detector is rebooted
Radar Mode	R – ranging mode	Factory set by AGD
Detection direction	Advance, Recede, Bidirectional	See section 8 – radar usage
Cosine correction	Mounting angle to the road	
Debug into	Between : and !	AGD use only
Target Information	Target number, Direction, Range bin, Doppler Bin, Speed, Power Level	Range bin = 2 metres Doppler bin = ~1 mph Speed includes cosine correction and is in either mph or kph

Table 2 Message Descriptors

Notes:

- Speed – vehicle speed will be modified by the cosine of the dominant detector mounting angle. Use the **`*AD<space><angle><cr>`** command to set the mounting angle of the detector relative to the road surface, and use **`UNITS<space>MPH<cr>`** or **`UNITS<space>KPH<cr>`** to set the measurement units.
- The fundamental unit of speed measurement is the Doppler bin, which is approximately equal to 1mph, so the speed resolution of the radar cannot be any better than this, no matter what units are selected.

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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 System Integration

The AGD315-205/207 has been designed to be used in conjunction with the AGD340 and a host system. It is the responsibility of the supplier of the host system to ensure that data fusion \ correlation of the speed and range data from the AGD315-205/207 and speed data from the AGD340 is done in such a manner as to be 'fit for purpose'.

7.3 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 **Error! Reference source not found.**. The angle is also reported in all output 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.

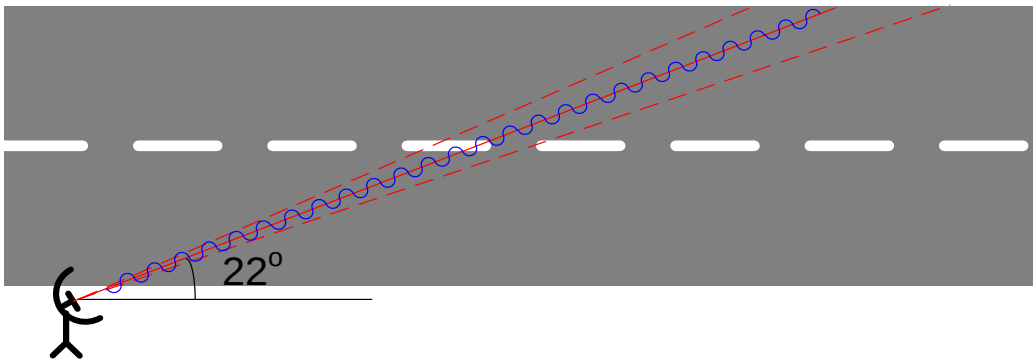

Figure 2 Radar Mounting Angle

The radar transmits a radio beam across the road that has a horizontal beam width of ~7 degrees. The vertical beam width of the radar beam is relatively large at 28degrees 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.

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7.4 Maximum Speed Measurement

Normally, the radar can detect targets travelling in both directions simultaneously (if required) at speeds of up to 128mph. The radar can resolve the speed to the nearest Doppler bin, which is approximately equal to 1mph.

In some situations, it may be required that the radar measure higher target speeds than 128mph. It is possible to configure the radar to measure targets up to 255mph, but with the caveat that the radar must be set into either advance or recede mode (not bidirectional), and targets travelling in the wrong direction at sufficient speed will generate erroneous speed readings which appear to have come from the required direction.

For example, if the radar is set into advance mode, and the command **`*RV<space>150<cr>`** is sent to the radar, the following behaviour will be seen:

Vehicle Speed (mph)	Vehicle Direction	Radar Operation
0 – 10	Approach	Vehicle not detected, speed is below the low speed cutoff
10 – 150	Approach	Vehicle detected, speed and direction measured correctly, message sent
150+	Approach	Vehicle not detected, speed is above upper limit set by *RV
0 – 10	Recede	Vehicle not detected, speed is below the low speed cutoff
10-105	Recede	Vehicle detected, speed and direction measured correctly, no message
105+	Recede	Vehicle detected, speed and direction measured incorrectly, message sent

Table 3 Maximum Speed Behaviour

So, the *RV command is used to set the maximum speed measurable in the required direction. Under most situations, the erroneous speed measured can be filtered out because the range measurement will be incorrect.

One situation where the range cannot be used to filter out erroneous targets is for a vehicle driving the wrong way down the road at excessive speed (for example, a vehicle driving the wrong way down a dual carriageway or motorway). However, two radars deployed at the same position, one set to approach and one set to recede, both with the same *RV setting could be used under these circumstances, which would give the capability to measure up to ±255mph (255mmph approach with one radar, 255mph recede with the other). Under most normal situations however, a single radar will the capability for ±128mph should be sufficient.

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8 CABLE CONNECTIONS

The AGD315-205/207 connections are shown in the table below:

Pin No.	Wire Colour	Function	Power Off	Power On - No Detect	Power On - Detect
1	Orange \ White	24v ac or 12-24v dc			
2	White \ Orange	24v ac or 0v dc			
3	Green	Earth / Ground			
4	Blue \ White	Detector RS422 Y			
5	Brown \ White	Relay Common			
6	White \ Brown	Relay Contact	N/C	N/O	N/C
7	White \ Blue	Detector RS422 Z			
8	White \ Green	Detector RS422 B			
9	Green \ White	Detector RS422 A			

Table 4 Cable Connections

9 TEST & CALIBRATION

9.1 Overview

The AGD315-205207 is subjected to rigorous build, calibration and test procedures. These procedures are designed to provide a simple set of pass and fail criteria for production operatives to ensure standardisation in the delivered product, isolate faults so they can be identified and fixed prior to unit shipment, and to weed out infant mortality failures in components.

9.2 Configuration Of User Settings

Once a unit has been calibrated, a number of specified settings are adjusted, and further tests are carried out to ensure the unit is operating within acceptable limits (please refer to Figure 3 overleaf). Table 5 summarises the user settings which are adjusted, showing the tests carried out, and the pass \ fail criteria applied to each test.

Test	Description	Pass \ Fail Limits	Comments
11	Check for correct operation of RS422	Receive OK Transmit OK	At 115200 baud
12	Check serial number via RS422 port	Same as serial number set previously	Serial number cannot be adjusted via RS422 for security
13	Message OK	Frame rate 40FPS Cosine set to 22º	Message should start automatically on power up

Table 5 User Settings

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Figure 3 shows the process by which the user settings are configured:

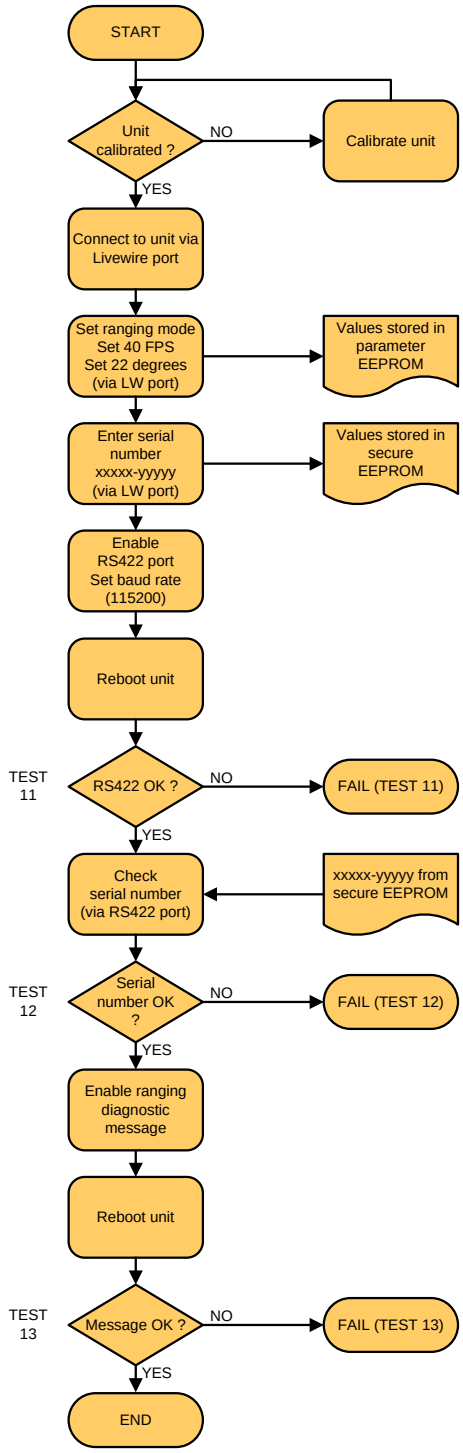

Figure 3 Configuration Of User Settings

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