SS300U
SS300ULG

User Manual and Installation Guide

K-Band Ultra Low Speed Doppler Speed Sensor
Built Types:
SS300U-DFT, SS300U-OFD
SS300ULG-DFT, SS300ULG-OFD
SS300ULG-BHP

Rev 2, October 10th 2014

SS300U and SS300ULG in Weatherproof Enclosure

SS300U and SS300ULG Open Frame Version
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Any modification or use other than specified in this manual will strictly void the certification to operate the device.

This device carries FCC modular approval and as such is labeled with FCC ID TIASS300. If this label is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed SS300 module. This exterior label can use wording such as the following: “Contains Transmitter Module FCC ID: TIASS300” or “Contains FCC ID: TIASS300.” Any similar wording that expresses the same meaning may be used.
Warning: SS300U-OFD and SS300ULG-OFD radar is supplied in an open frame format with exposed antenna and electronics and thus is a static sensitive device. Please use static precautions when handling. Warranty does not cover damage caused by inadequate ESD procedures and practices.
Note: Specifications may change without notice.
Note: Not liable for typographical errors or omissions.
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INTRODUCTION

Congratulations on your purchase of the Houston Radar directional Doppler Speed Sensor SS300U/SS300ULG. This state of the art 24GHz K-band ultra-low speed range microwave Doppler radar is specifically designed for the license free battery operated speed measurement and monitoring market.

Utilizing high performance, ultra low power DSP (Digital Signal Processing) technology and microwave components based on a planar patch array antenna with integrated low power PHEMT oscillator, you will find that this high quality product meets your exacting standards for performance and reliability.

Some of the highlights of this product include:
- Complete speed output Doppler radar with digital processing
- Ultra low speed range of 0.25 mph to 16 mph (0.4 km/h to 25 km/h) or 0.13 to 11.2 mph (0.213 km/h to 18 km/h)
- Up to 3 places of decimal resolution available on speed output
- Best in class low power usage of only 9 mA at 12VDC (0.1 Watt)
- Unprecedented small size to allow incorporation into virtually any location
- Advanced DSP based algorithm yields consistent performance and speed detection
- Typically 90+ m (300+ feet) of pickup distance for incoming vehicles on open and level road.
- SS300ULG optimized for close up detection of trains, conveyor belts and other industrial applications.
- One RS232 and two ‘open collector’ vehicle detection trigger outputs
- Radar internal software is upgradeable in the field via RS232 PC interface.
- User configurable IIR filter and decimated speed output.
- All radar configuration parameters can be set by user via RS232 serial port.
- Extensive built-in self test.

INSTALLATION

Mounting:
SS300U-OFD is supplied in an “open frame” format. It requires a weatherproof enclosure before it may be used outdoors. Alternatively it may be mounted as a component in another product that already has a weatherproof enclosure.
The SS300U-OFD should be mounted such that the connector points left or right as shown in the picture on the front page.

The SS300U-DFT is supplied in a weatherproof encapsulated enclosure with a pigtail connection. This unit may be mounted outside without any further protection from the
environment. The SS300U-DFT should be mounted such that the text “Houston Radar” on the face of the unit is horizontal.

The unit may be rotated 90 degrees from the suggested optimal mounting. However, in this case, the detection range may be reduced by about 25%.

Direction Pointing:

The SS00 is directional in nature. It may be configured to detect and measure the speed of incoming or outgoing objects. It then rejects objects moving in the opposite direction. Direction of detection is configured via a bit in the MO variable in the radar or via the GUI.

For optimal performance:

- Radar should be mounted as suggested in the section titled “Mounting” earlier
- Radar should be pointed into the direction of the oncoming traffic/target to be detected.
- Radar should be placed along the side of the road or moving object to minimize the angle of the oncoming object to the radar.
- The radar may pickup rotating fans. Avoid pointing it at fans or compressors.
- For traffic applications radar should be mounted at least 3 feet high from the road for optimal performance and at least 5 feet off the ground for maximum pickup distance.
- For Industrial applications, particularly where targets are close to the face of the radar, we suggest the SS300ULG.

Recommended Enclosure for the SS300U-OFD:

The SS300U-OFD radar needs to be enclosed in a weatherproof enclosure for outside use. The following needs to be observed for optimal performance:

1. The front face of the radar (with the golden pads) is the antenna and is the face that must point into traffic.
2. Any cover or window in front of the unit MUST be at least ¼” away from the face.
3. Do NOT spray any conformal (or other) coating, paint or other substance on the antenna.
4. The optimum material to use as a front window is Lexan (Polycarbonate) plastic.
5. The optimum thickness of the polycarbonate window is half wavelength at 24.125Ghz or about 3.5 to 3.7mm (0.137” to 0.146”) thick.
a. Alternatively a thin window of any plastic material may be used. The maximum thickness in this case should be no more than 1 mm (40 mils).

b. Standard 0.25” thick Lexan should be avoided as it has particularly high reflection coefficient due to this specific thickness.

6. Other plastic materials may be used as a front window, but the optimum thickness will vary with the material’s dielectric constant. Please contact us for details.

Alternatively, you may consider weatherproof version SS300U-DFT that is available from Houston Radar.

Hookup:

*Power Input:*

The SS300U radar features wide operating input voltage range of 5.5V-18V. In a typical application it may be powered from a nominal 12V DC source and will feature best in class operational power consumption of 9mA (average). There is no other radar in the world that even comes close to this ultra-low power usage. Competing products may consume up to 20 times more power.

This ultra low operational power translates directly into a longer battery life or gives you an option to power the unit from smaller batteries and smaller solar panels.

Note: The radar employs aggressive power saving measures that include turning off parts of the circuit that are not being used at any instant. To get a true measure of the power usage of the circuit use a multi-meter that has an averaging function and does not suffer from autoranging during measurements. Otherwise you will get current readings that fluctuate from 4 mA to 18 mA.

Note: when the under-voltage lockout (UVL) feature is activated, the operating voltage range is reduced to 8.5V-18V and dropping the input voltage to 4.5V-6.5V will put the radar into a sleep mode where it will update the internal clock. UVL mode is the default from the factory in radars shipped from Dec 3rd 2010 and may be disabled by a bit in MD variable (see later section).

Your power supply to the radar must be capable of supplying up to 40mA of current for up to 5 seconds at a time (startup current is higher as the radar is initializing its internal systems).

*Serial Connection:*

The SS300U features an RS232 interface that is used to output speed and configure the unit as explained later in this document.
The RS232 interface is factory set to default to “cable detect” mode and will power the interface chip down to save power if the radar RX line is not connected. Cable detect mode may be disabled and the interface may be forced ON via a bit in the “MD” variable.

**Measured Speed Output:**

The SS300U will send out the measured speed via the ASCII interface as a 3 digit speed with an optional direction indicator. The format is:

```
[?,+][nnn].[ddd][\r,\n]
```

The format of the speed output can be adjusted to any combination of:
- “?”: Optional prefix sent when 000 selected to be sent when no vehicles are detected
- “+”: Optional prefix sent when nnn speed is sent for incoming vehicles
- “nnn”: Three digit ascii speed in the units selected via the UN variable
- “.ddd”: Programmable number of digits (0-3) after decimal point
- “[\r]”: Carriage Return character, optional line ending
- “[\n]”: Line Feed character, optional line ending

At least one or both of the line endings must be selected with ASCII format. No line ending is not an option. Please see serial port configuration section for details on how to select the above format.

Alternatively, the radar may be set to output a single byte speed in binary format. No line termination is issued when format is set to binary.

**Setting Detection Sensitivity via the ASCII Interface:**

In addition to the supplied Windows configuration program, the radar also allows to program sensitivity through legacy commands.

Over the serial interface, send in ASCII the following commands:

Sensitivity:nn\n
Sensitivity?!n

The first command will set the detection sensitivity to "nn" where nn is from 10 to 99 and is a percentage of the maximum detection range.

If sensitivity was set correctly, the unit replies with

```
OK\n```

The second command will report sensitivity.

Note 1: All settings, including sensitivity, are written to FLASH memory and are non-volatile. **DO NOT** update settings on a periodic basis, e.g. every second or every minute. Only change settings when the user needs it. The FLASH memory has a limited number of write cycles and will wear out with excessive (>10,000) number of writes. On the other hand, setting the variable to the same value repeatedly is **OK** because the radar recognizes that the variable has not changed and does not update it in FLASH.
Note 2: Legacy commands are deprecated and are not recommended. Please use configuration variables to set and get all parameters. All configuration variables may be accessed via simple ASCII interface. It is described in greater detail in our ASCII interface application note. Please contact Houston Radar for this document.
Wire Signal Descriptions:

<table>
<thead>
<tr>
<th>Connector Pin #</th>
<th>Signal Name</th>
<th>Direction (wrt Radar)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>PWR</td>
<td>Radar GND (battery “–” terminal)</td>
</tr>
<tr>
<td>2</td>
<td>N/C</td>
<td>N/C</td>
<td>Do not connect</td>
</tr>
<tr>
<td>3</td>
<td>I/O0</td>
<td>I/O</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>4</td>
<td>I/O1</td>
<td>I/O</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>5</td>
<td>I/O2</td>
<td>I/O</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>6</td>
<td>I/O3</td>
<td>I/O</td>
<td>Reserved for future use</td>
</tr>
<tr>
<td>7</td>
<td>Trig O/P 1</td>
<td>Output</td>
<td>“Open Drain Output 1”. See Note 1.</td>
</tr>
<tr>
<td>8</td>
<td>Trig O/P 2</td>
<td>Output</td>
<td>“Open Drain Output 2”. See Note 1.</td>
</tr>
<tr>
<td>9</td>
<td>RS232 TX</td>
<td>Output</td>
<td>RS232 Transmit Signal from radar</td>
</tr>
<tr>
<td>10</td>
<td>RS232 RX</td>
<td>Input</td>
<td>RS232 Receive Signal into radar</td>
</tr>
<tr>
<td>11</td>
<td>VCC</td>
<td>PWR</td>
<td>+5.5 to +18VDC Power Supply</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>PWR</td>
<td>Radar GND (battery “-“ terminal)</td>
</tr>
</tbody>
</table>

Note 1: See Appendix A for detailed description on how to hookup an external device to be triggered when radar detects incoming objects. Incorrect hookup may result in the output devices being destroyed and will not be covered under warranty.

The SS300U features two low impedance outputs that can trigger/turn on an external display/device to bring it out of power saving mode when a vehicle is detected. Both outputs are under radar software control and the typical functionality is to turn both on together when a vehicle is detected. However, if you need different functionality please contact us.

When a vehicle is detected and the speed is above the “LO” speed limit and below the “HI” speed limit, both these pins are pulled down to GND and held low as long as a vehicle is tracked. These pins are released as soon as the radar detects no further traffic. This logic may be inverted via a bit in the IO variable. See later section.

These are “open drain” (AKA open collector) outputs capable of sinking 130 mA each. You must limit the current externally to ensure that no more than 130 mA goes into each pin when they turn on. They may be connected in parallel to double the sink capacity to 260 mA.

The device providing this functionality on the radar board is the ON-Semi “NUD3124” relay driver. Please refer to the datasheet for this device on detailed operating characteristics for these trigger outputs.
USE

Turn on the power to the SS300U to make it operational. No other action is required. The radar will activate OUT 1 and OUT 2 open drain outputs whenever it detects an object that is above the programmed lower speed limit (the “LO” value) and below the programmed high limit (the “HI” value). The default limits are set at 0 and 16 at the factory. The units (e.g. kph, mph, fps, mps) are determined by UN variable.

The radar will also keep sending out the speed in user selected ASCII format over the serial interface while an incoming vehicle is tracked.

Connect radar to PC RS232 serial port and use provided Windows configuration software to program the high speed limit (“HI” variable). The radar de-asserts the trigger outputs above this limit. If you do not wish an upper detection limit, set this value to 99. This will ensure that the upper limit is never reached regardless if the units are set to MPH or KPH.

Set the “LO” variable to set the lower detection speed limit. The outputs will be de-asserted for vehicles below this speed limit. The lowest value this may be set is 0 MPH (0KPH).

Green LED flashes at 1/3 Hz (12.5% duty cycle) rate when radar is running giving a visual OK signal. In the SS300U-OFD version green LED may be installed on the back depending on the requested build option.
Configuring the Unit:
The unit’s internal parameters may be configured after connecting the radar’s RS232 port to a PC’s RS232 serial COM port and using the Houston Radar configuration program’s “Connect To Radar” screen as described here.

The following internal “variables” may be set. Their functions are described below.

These are common to the SS300U and SS300ULG.

<table>
<thead>
<tr>
<th>SS300U and SS300ULG Radar Configuration Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS</td>
<td>Sets the RS232 serial port’s baud rate and output format. Do not change this value unless you understand the implications.</td>
</tr>
</tbody>
</table>
| UN                                                    | **Lower Byte**: Sets the internal speed units of the radar. All LO, SP, HI, SI speeds are interpreted to be in this units.  
0 = MPH  
2 = FPS (Feet per second)  
1 = KPH  
3 = MPS (Meters per second)  
**Upper Byte**: Sets number of digits after decimal point. |
| LO                                                    | Low speed cutoff. Vehicles are not detected below this speed. Minimum value is 2. Should be set to be less than HI. Speeds above this limit trigger the O/P1 and O/P2 outputs and sends ASCII speeds. Note: If the Rotary switch is enabled (See MO bitmask), then the actual Cutoff speed = (LO + Rotary Switch Setting * SI) |
| HI                                                    | High speed cutoff. Vehicles are not detected above this speed. Maximum value is 159. Should be set higher than LO speed. |
| SP                                                    | Flashing speed limit. Any speed higher than this value “flashes” the trigger output at 50% duty cycle. To “flash” the ASCII speed, 000 are interspersed in the “nnn” speed output on the serial port. Set to HI value to never “flash” the speed output. |
| ST                                                    | Target detection sensitivity. Valid values are from 10 to 99 and are a percentage of max range. So a value of 50 would yield about 150 feet detection. **Note: This is not a range setting but detection sensitivity. Thus if large vehicles are being detected at 400 feet, a value of 50 will reduce detection range for them to approximately 200 feet.** |
| SF                                                    | 1 = Select Fastest Target if multiple targets are detected  
0 = Select Strongest Target if multiple targets are detected |

Radar Configuration Variables Continued:

<table>
<thead>
<tr>
<th>SS300U and SS300ULG Radar Configuration Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MO</td>
<td>Radar mode bitmask. Bits are as follows:</td>
</tr>
<tr>
<td>Bit 0:</td>
<td>SI3 ASCII command compat flag. Contact us for more details.</td>
</tr>
<tr>
<td>-------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Bit 1:</td>
<td>Enable ASCII console output on RS232 serial port</td>
</tr>
<tr>
<td>Bit 2 to 6:</td>
<td>Reserved in SS300U radar</td>
</tr>
<tr>
<td>Bit 7:</td>
<td>Enable Rotary Switch on SS300U Break out IO board.</td>
</tr>
<tr>
<td>Bit 8:</td>
<td>Disable power optimized mode. RF ON all the time.</td>
</tr>
<tr>
<td>Bit 9 to 11:</td>
<td>Reserved</td>
</tr>
<tr>
<td>Bit 12:</td>
<td>Detection direction. 0 = only incoming, 1 = only outgoing (see note 1).</td>
</tr>
<tr>
<td>Bit 13:</td>
<td>Gang the effective LO/SP/Hi speeds to external Rotary switch. Contact us for details if you wish to change the above speed limits in the field by turning a rotary switch rather than connecting a PC.</td>
</tr>
</tbody>
</table>

**SI**
- Speed Increment of the rotary switch on the optional break out board.
- Effective low speed cutoff in radar = (LO + Rotary Switch Setting * SI)

**HT**
- Output Hold Time in seconds. Once the output is triggered, it is held for this amount of seconds from the last trigger source before going inactive. Note: Only the digital output is held. The ASCII speed output is not held. The ASCII speed output goes to 000 as soon as target is no longer tracked.

**IO**
- Radar IO configuration bitmask. Bits are as follows:
  - Bit 0: Reserved
  - Bit 1: Set: IO 1 Active high. Clear: IO 1 active low.
  - Bit 2 to 7: Reserved
  - Bit 8: Reserved.
  - Bit 10 to 15: Reserved

**Configuration Variable Notes:**

**Note 1:** Bit 12 of the MO variable sets direction of detection. This functionality is available in firmware versions v115 and higher release date Jan 21st 2010. Older radars may be upgraded to this version. Please contact Houston Radar for a firmware update.

**The following variables are available in the SS300ULG only.**

<table>
<thead>
<tr>
<th>SS300ULG Radar Configuration Variable Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>FFT averaging filter time constant in milliseconds Can be set from 10ms to 65,000ms. Smooths the output. Use this filter instead of an external running average on the speed output for better results.</td>
</tr>
<tr>
<td>DM</td>
<td>Output decimation value in number of batch cycles. Each calculation batch is 81ms. So a value of 1 will output a new speed</td>
</tr>
<tr>
<td>value every 81ms. A value of 5 will output a new speed every 5th cycle or every 0.405 seconds.</td>
<td></td>
</tr>
</tbody>
</table>
Setting Variables in the Radar:

1. Install the provided Houston Radar Advanced Stats Analyzer (or Houston Radar Configuration) Windows program on a Windows 2000, XP, Vista or Win 7 computer. 32 and 64 bit computers are supported.
2. Connect the radar RS232 port to the PC’s RS232 serial port. If the PC does not have a serial port you may buy a USB serial converter dongle (from BestBuy, Radioshack or any Internet store).
3. Power up the radar. Ensure the green LED on the front (side or back as the case may be) flashes every 3 seconds.
4. Start the Houston Radar Stats Configuration tool program
5. Click on Start->Connect to Radar…
6. Click on “Connect” button.
7. Ensure you see a “Radar found on COM” message. The COM # will depend on your computer
8. Click on OK. Now you are ready to configure the radar.
9. Click over to the “Radar Setup” tab page to configure the radar.
10. To set variable values direction, you may do so via Advanced->Radar Configuration->Set a Radar Variable…
Set Serial Baud Rate:

The supplied Windows configuration program can auto detect the baud rate of the radar serial port. However if you wish to communicate with the radar from your electronics, the radar serial port may be configured to different baud rates.

<table>
<thead>
<tr>
<th>Baud Rate (bps)</th>
<th># Data Bits</th>
<th># Stop Bits</th>
<th>Parity</th>
<th>“RS” variable value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>7</td>
<td>1</td>
<td>Even</td>
<td>10</td>
</tr>
<tr>
<td>1200</td>
<td>7</td>
<td>1</td>
<td>Odd</td>
<td>11</td>
</tr>
<tr>
<td>1200</td>
<td>7</td>
<td>1</td>
<td>None</td>
<td>12</td>
</tr>
<tr>
<td>1200</td>
<td>8</td>
<td>1</td>
<td>None</td>
<td>13</td>
</tr>
<tr>
<td>2400</td>
<td>7</td>
<td>1</td>
<td>Even</td>
<td>20</td>
</tr>
<tr>
<td>2400</td>
<td>7</td>
<td>1</td>
<td>Odd</td>
<td>21</td>
</tr>
<tr>
<td>2400</td>
<td>7</td>
<td>1</td>
<td>None</td>
<td>22</td>
</tr>
<tr>
<td>2400</td>
<td>8</td>
<td>1</td>
<td>None</td>
<td>23</td>
</tr>
<tr>
<td>9600</td>
<td>7</td>
<td>1</td>
<td>Even</td>
<td>30</td>
</tr>
<tr>
<td>9600</td>
<td>7</td>
<td>1</td>
<td>Odd</td>
<td>31</td>
</tr>
<tr>
<td>9600</td>
<td>7</td>
<td>1</td>
<td>None</td>
<td>32</td>
</tr>
<tr>
<td>9600</td>
<td>8</td>
<td>1</td>
<td>None</td>
<td>33</td>
</tr>
<tr>
<td>115200</td>
<td>7</td>
<td>1</td>
<td>Even</td>
<td>40</td>
</tr>
<tr>
<td>115200</td>
<td>7</td>
<td>1</td>
<td>Odd</td>
<td>41</td>
</tr>
<tr>
<td>115200</td>
<td>7</td>
<td>1</td>
<td>None</td>
<td>42</td>
</tr>
<tr>
<td>115200</td>
<td>8</td>
<td>1</td>
<td>None</td>
<td>43</td>
</tr>
<tr>
<td>19200</td>
<td>7</td>
<td>1</td>
<td>Even</td>
<td>50</td>
</tr>
<tr>
<td>19200</td>
<td>7</td>
<td>1</td>
<td>Odd</td>
<td>51</td>
</tr>
<tr>
<td>19200</td>
<td>7</td>
<td>1</td>
<td>None</td>
<td>52</td>
</tr>
<tr>
<td>19200</td>
<td>8</td>
<td>1</td>
<td>None</td>
<td>53</td>
</tr>
</tbody>
</table>

Note: Many ASCII output formats are available including options to send out repeating “heartbeat” zero’s when no vehicles are detect etc. and may be selected via an Excel configuration tool. Please contact us for this tool.
SS300U SPECIFICATIONS

General
Operating Band  K-Band
Frequency  24.125 GHz ±50Mhz (US), 24.200Ghz on request
RF Power Output  5mW
Antenna Beam Pattern  45deg x 38 deg
Polarization  Linear
Supply Voltage  5.5V DC to 18V DC
Reverse Battery  Protected
Nominal Current Draw  9 mA avg. (+/-1ma,) (@+12V DC)
Operating Temp.  -22°F to +185°F
(-30°C to +85°C). Electronics designed and tested to –40C.
Weatherproof  Yes (SS300U-DFT build option). Open frame also available.
IR Remote Programmable  No

Approvals

Data Interfaces
Serial Communication  RS232
Data Rate  Baud Rates from 1200 to 115200 baud
Data & Pwr Connector  SS300U-OFD:Molex “C Grid SL” male shrouded 12 pin RA part #70553-0011
SS300U-DFT:Molex “C Grid SL” female 12 pin (mate to above #)

Mechanical
Weight  approx 33 grams (1.16 oz)
Dimensions  2.1”x1.75”x0.6” (LxWxD) 52 x 46 x 16mm
Cable Exit  SS300U-OFD: Side via right angle connector
SS300U-DFT: Encapsulated cable from back
Mounting  Four #2-56 standoff’s embedded on module

Specifications continued on next page …
Performance
Measurement Limits
SS300U 0.25mph to 16mph
SS300ULG 0.13mph to 11.2mph
Resolution ±0.006 mph
Accuracy ±0.5% of reading + 0.1mph

Detection Range
SS300U Typically 90+ m (300+ feet) for compact vehicles on open and level road with radar mounted 1.5 m (5 feet) high and pointed straight into oncoming traffic. 150+ m (500+ feet) for larger trucks, lorries and vehicles with inherently large radar cross-section. May vary with installation and road conditions. Detection range specified is typical for speeds between 3kph and 21kph (2 to 13mph). It tapers off below and above this speed range. At the low end of the speed range (0.5mph (0.8kph), the detection range is about 34+ m (110+ feet).

SS300ULG Varies based on target. Contact us for more details.
Appendix A: Hooking up to the trigger outputs on the radar

The SS300U radar features two “open drain” outputs. The device used for this purpose is the On Semiconductor relay driver NUD3124. The output configuration of this device is shown below (from the On Semi datasheet).

The two outputs O/P1 and O/P2 are brought out on the radar connector pins (see IO connector pin out in manual for connector pin numbers).

This device can sink 130mA of DC current at up to 28VDC.

However, these are low impedance outputs, which means that you must externally limit the maximum current that will flow into these outputs to 150mA at the worst-case head voltage. They may be parallel together to increase this value to 300mA.

There are two ways to ensure this:

1. Connect an output device that is rated to draw no more than 150mA at your supply voltage (+Vhead). This device can be powered up to 28VDC. For example, this can be a 12 or 24VDC relay coil rated at more than 150 mA coil current or

2. Connect an external resistor in series with the output load and the O/P1 or O/P2 pins. The value of this external resistor should be calculated as follows (ohms law):
   \[ R \text{ (in K Ohms)} = \frac{V_{\text{head}} - V_{\text{load drop}}}{150} \]

![Diagram of output configurations](image-url)
Connecting the load to the High power and trigger outputs:
You may directly connect your high power DC load + & - to J5. The load is activated via fuse F1 when the output is triggered.
You may directly connect a <150mA relay coil or other low power load to the J4 & J6 connectors. The + load terminals are always wired to VCC. The (-) terminals are connected to GND when a vehicle is detected and the output triggered. J5 is always triggered at the same time as J6.
Optional Breakout IO Board Connections:
(Isolated Solid-State Relay version, AC or DC capable)