V1.00

1. Introduction

AP96 series K-Band miniature microwave module is a Doppler transceiver with built-in features such as low current HEMT oscillator, single balance mixer and bi-static microstrip patch antenna arrays. It is ideal for applications in automatic access, security, lighting control and speed measurement.

Its lightweight, miniature size and slim profile offer the flexibility to OEM manufacturers in making trendy and slim final products.

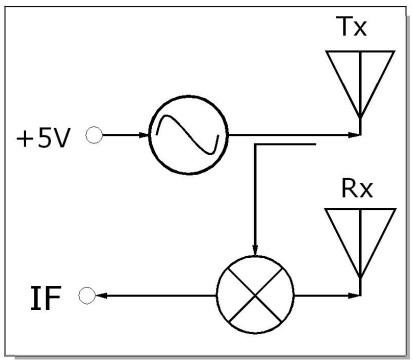

Figure 1: Block Diagram

2. User Interface

A 3-way 2.54mm pin header is used for user interface. The pin header (shown in figure 2 below) connects the terminals (+V_s, IF, GND) to the amplifier circuits. Any mounting methods deemed suitable may be used, but the mounting parts should not touch the +V_s and IF lines and should not be too near to the patch antennas.

Any pressure or stress to the chassis of the module must be avoided at all, as it may result in change of module performance.

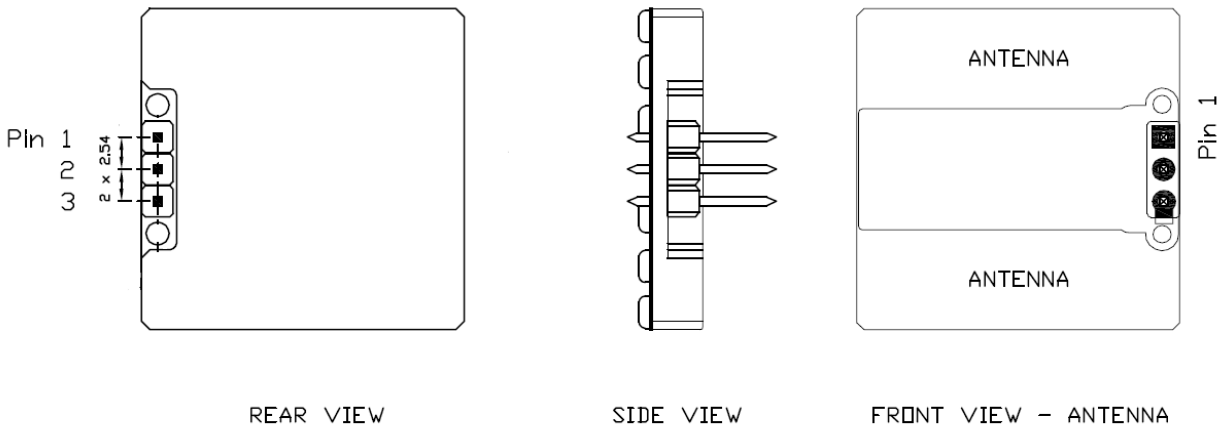

Figure 2: User interface pin definition: 1: V_{in}, 2: IF, 3: GND

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3. Power Supply

AP9 series module operates at +5 Vdc for Continious wave (CW) operation. There are also modules (e.g. AP96-3) designed to operate at +3 Vdc.

The module can be powered by $+V_s$ low duty cycle pulsed trains of up to 2KHz repetition frequency for lower power consumption. Sample & Hold circuit at the IF output is required for pulse operation.

4. Before Powering Up

Connect the power supply, ground and amplifier circuitry to the designated terminals. Designation of the connection terminals are printed on the PCB as shown in diagram (right).

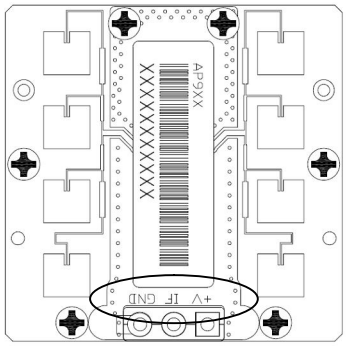


Figure 3: Terminals designation

CAUTION:

Plugging-in the module into an active power supply may not itself cause any damage, but any accidental short to ground during this process may cause component damage in the module.

It is therefore recommended that power supply to be SWITCHED OFF first before connecting the modules.

5. Transmit Frequency

The transmitting frequencies (ISM band) and EIRP (Effective Isotropic Radiated Power) of various modules are factory-set and are not user-adjustable. Table 1 shows the EIRP and transmitting frequencies of the various AP9 series modules.

Local radio communication authority regulates the use of transmitting devices. Though user license may be exempted, type approval of equipment or other regulation compliance may be required.

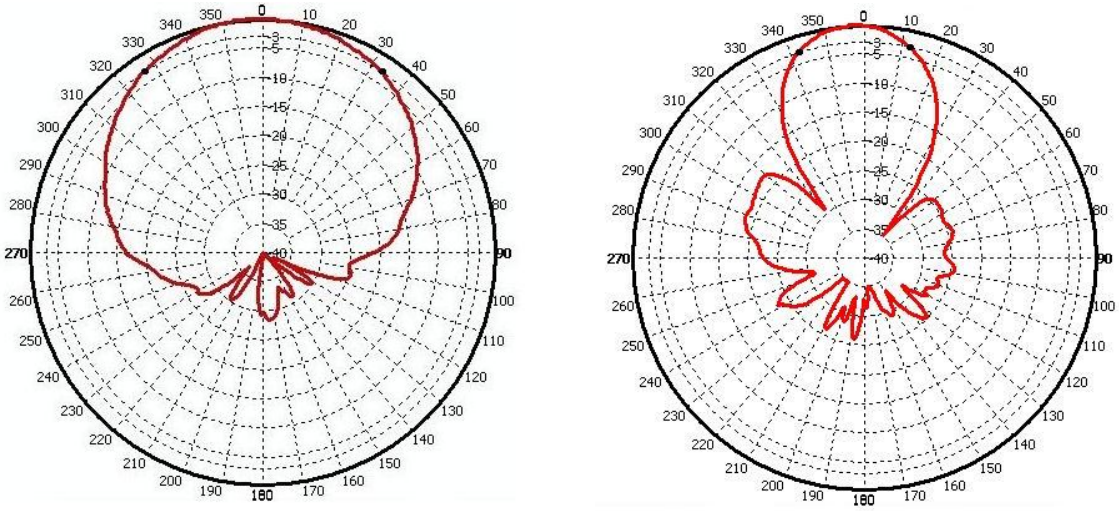
Model	EIRP (TYP.)	Frequency Setting
AP96	15 dBm	24.000 - 24.250 GHz
AP96-US	15 dBm	24.075 – 24.175 GHz
AP96-3	15 dBm	24.000 - 24.250 GHz

Table 1: Transmitting frequency for AP9 series

Please refer to Annex 1 for more information on transmitting signal.

6. Radiation Pattern

The module is to be mounted with the antenna patches facing to the desired detection zone. The user needs to choose the correct orientation of the module to obtain the desired coverage. The radiation patterns of the antenna and their half power beam width (HPBW) are as shown in the diagram below.



Azimuth **Elevation**

Figure 4: Beam pattern of AP9 series sensor modules

7. Output Signals

Doppler shift - Doppler signal appears at IF terminal when movement is detected. The magnitude of the Doppler signal is proportional to the reflection of transmitted energy and is typically in the range of microvolts (μV). A high-gain low-frequency amplifier is usually connected to the IF terminal in order to amplify the Doppler shift to a processable level. The frequency of Doppler shift is proportional to velocity of motion. Typical human walking generates Doppler shift below 100 Hz. Doppler frequency can be calculated by Doppler equation in Annex 2.

The Received Signal Strength (RSS) is the voltage measured at the IF output, when the module is subjected to a motion. Reflection of a human body is dependent on the size of the body, clothing, apparels and other environmental factors. RSS measured for different human bodies may vary by as much as 50%.

Circuit designer must take note of the typical Received Signal Strength (RSS) specified in technical data sheet, when designing the amplifier. Sensitivity deviation between modules has to be considered when setting amplifier gain or alarm threshold. On-production gain adjustment may be necessary if a narrow window for triggering threshold is required.

Noise - The noise specified in the technical data sheet is the noise measured in an Anechoic chamber, that shields the unit-under-test from external interference, as well as reflection from surfaces. Hence, the figure is only presenting the noise generated by the internal circuit itself.

In actual applications, besides noise generated from internal electronic circuit, other noises may be picked up from surrounding, or other part of the electronic circuit. Special attention has to be given to the interference pick-up from fluorescent light, as the 100/120 Hz noise is closed to the Doppler frequency generated by human movement. On and off switching of certain devices (relay, LED, motor, etc.) may generate high magnitude of transient noise at the IF terminal. Careful PCB layout and time-masking is necessary to prevent false triggering.

DC Level - DC level (0.01 to 0.2 Vdc) exists at the IF terminal and its polarity can be positive and negative. Its magnitude may vary over temperature. AC coupling is recommended for IF terminal connection.

8. Placing the module in enclosure

If AP9 series module needs to be housed in an enclosure, it is important to ensure that the performance of the module is not significantly degraded by the presence of enclosure.

The recommended material for the enclosure is plastic (such as ABS), as microwave can penetrate through the material without significant loss. For comparison purpose, a metal results in full reflection while water results in high absorption of the microwave. It is therefore important not to use any metallic material as the enclosure.

It is recommended that the cover placed in front of the module antenna is of flat panel, so that the beamwidth of the antenna is not significantly distorted. The thickness of the cover, h_1 and the spacing between the antenna and the cover, h_2 should be ideally half-wavelength of the microwave signal.

In this case, for AP9 series module whose transmission frequency is ~24GHz, the recommended h_1 and h_2 are 3-4mm and 6mm.

A half wavelength of a 24 GHz in the air is about 6mm. However, the half wavelength of the signal in other medium depends on the dielectric constant of the material. In the case of ABS which has a dielectric constant of between 2.5 to 3.5, the half wavelength of the signal is 3 – 4 mm.

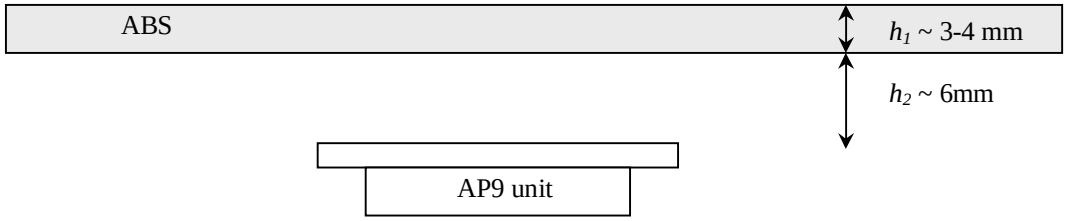


Figure 5: Recommended thickness and clearance for ABS placed in front of AP9 sensor

9. Radiation Safety

Microwave radiation from the module is well below established safety standards for general public environment, like ANSI C95.1-1991 of USA and NRPB-G11 of United Kingdom.

10. Handling

The module has been fully tested to specifications. Upon opening, tighten or loosen the chassis will cause performance deterioration.

The module is an electrostatic-sensitive device (ESD). Precautions must be observed for handling and storage of the modules.

10. Product Support

Please contact our product support engineers in the factory for technical assistance whenever necessary.

Product Support (Microwave Sensors)
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This device complies with part 15 of 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.

Any changes or modifications to ST Electronics equipment not expressly approved by ST Electronics could void the user authority to operate the equipment.

The system integrated the radio should have label indicated the FCC ID of approved Radio.
Such as putting a label on system as below: CONTAIN FCC ID: VECAP96-US

Warning : The radio does not allow to be installed and operated with other radio simultaneously when integrated in host system.
Installed in such configuration may subject to additional FCC testing and equipment authorization.

Annex 1: Transmission of RF

1. Though same frequency is allocated in some countries, national regulations may specify different EIRP, spurious emission or other requirements.
2. ETS EN300 440 is the recommended harmonized standard for European Community, member country may adopt their own national regulation. The AP96 series transceivers meet the requirement of EN300 440
3. The AP96-US model is designed to meet the FCC standard part 15.245 and is aimed for use in the America.
4. The regulations are subjected to change from time to time, please contact appropriate authorities for full and up-to-dated information.
5. Useful websites:

Agency	Website
The Code of Federal Regulations, USA	http://www.access.gpo.gov/cgi-bin/cfrassemble.cgi?title=199847
The European Radiocommunication Office	http://www.ero.dk/
The Radiocommunications Agency , UK	http://www.radio.gov.uk/
Federal Communications Commission	http://www.fcc.gov/

Annex 2: Doppler Equation

$$F_d = 2V\left(\frac{F_t}{c}\right)\text{Cos}\theta$$

Where

F_d = Doppler frequency
V = Velocity of the target
F_t = Transmit frequency
c = Speed of light (3 X 10^8m/sec)
θ = The angle between the target moving direction and the axis of the module.

If a target is moving straight toward or away from AP96 (F_t = 24.125 GHz). The formula is simplified to:

F_d = 44.7V (Velocity in km/hour) or 71.9*V* (*V* in mile per hour)

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