MDU2750L

APPLICATIONS

Microwave Solutions Ltd. design, manufacture, sell and support a full range of Microwave Doppler Motion Detector Units operating at X-Band (10GHz) and K-Band (24GHz) . These units can be incorporated into a wide range of sensors and are suitable for the following typical applications :

Intrusion Alarms (Room, Vehicle)	Collision Avoidance
Automatic Door Openers	Traffic Control
Speed Measurement	Presence Sensing
Energy Management	Home Automation

Motion Detector Units utilise the Doppler shift phenomenon to "sense" motion and are available in a variety of different formats

The MDU (Motion Detector Unit) is a miniature microwave Doppler radar sensor optimised for low power consumption, short range (<30 metres) and low cost. The circuit features a dielectric resonator stabilised FET oscillator, which provides stable operation over a broad temperature range in either CW or low duty cycle pulse mode and a balanced mixer for enhanced sensitivity and reliability.

The MDU emits a low level X Band microwave signal which is reflected from all objects within its coverage area. If any of the objects that the signal has bounced off are moving towards or away from the sensor, the frequency of the reflected signal received back by the sensor will be increased or decreased from that of the transmitted signal by the Doppler effect.

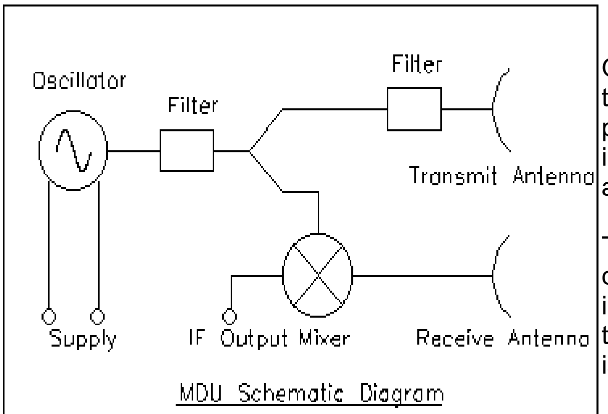
The MDU compares the transmitted and received frequencies and produces an output signal, the frequency of which is proportional to the velocity of the object. The amplitude of this signal is a complex function of the size and reflectivity of the object and its distance from the MDU, as well as the characteristics of the MDU. See "Radar Range Equation" for a discussion of range.

Signal processing circuitry (not provided with the unit) amplifies this signal and analyses its frequency spectrum. If the signal strength is above a threshold level, and has the required frequency spectrum an output signal can be generated.

In order to conserve power it is usual for the MDU to be pulsed on and off rapidly so that it is only transmitting for approximately 5% of the time. As well as reducing power consumption, this also reduces the average power transmitted. This does not reduce the ability of the MDU to detect moving objects.

CIRCUIT DESCRIPTION

The Microwave Solutions Ltd Motion Detector Unit contains a dielectric resonator stabilised microwave FET oscillator, providing a frequency and amplitude stable signal at the operating frequency of the unit. The power from this oscillator is filtered to remove harmonic and spurious signals and is then split into two approximately equal amplitude signals.



MDU Schematic Diagram

One of these signals is further filtered and feeds the transmit antennas of the unit, illuminating the volume to be protected. The other signal is routed to the local oscillator input of a balanced mixer providing the reference signal against which the Doppler return signal is compared.

The Doppler return signal, reflected from the target is collected by the receive antennas and coupled to the RF input of the balanced mixer, where it is compared with the transmitted signal. The Doppler frequency is extracted and is available at the IF output of the unit for signal processing.

Oscillator
The oscillator requires 5V ± 0.25 V applied to the +5 V terminal of the device. If the oscillator is powered continuously (CW mode) the current consumption is typically 50 mA. For low power consumption it is usual to operate the unit in pulsed mode,supplying the oscillator with 5 V pulses with a typical pulse width of 30µ seconds and repetition rate of 1 to 3 KHz. The duty cycle of 3 to 10% reduces the average current consumption to 1.5 to 5 mA

The peak value of the pulse voltage must lie between 4.75 and 5.25 V and the flatter the pulse top the better the detection capability of the MDU will be. Under these conditions pulse chirp will be less than 1 MHz.

Application of a peak voltage in excess of 5.25 V will degrade the reliability of the unit and may cause it to transmit RF power at frequencies outside the authorised bands.

RF Power Levels
The RF power levels radiated by the MDU are extremely low under all conditions, and many orders of magnitude below the maximum recommended levels in normal operating modes.

The maximum transmitted power is less than 15mW. This power is distributed within the coverage pattern of the MDU, and the maximum power density is 1mW/cm² at a distance of 5mm from the front face of the unit, reducing to 0.72µW/cm² at a distance of 1 metre.

Any equipment containing an MDU as the sole emitter of electromagnetic fields is therefore exempt from the testing requirements for human exposure to electromagnetic fields under the safety aspects of the R&TTE directive per EN 50371:2002

The emissions from the front face of the MDU are also below the recommended maximum permissable exposure levels specified in IEEE standard C95.1-1991. In fact under normal pulsed operating conditions, measured at a distance of 1 metre in front of the MDU, the emissions are a factor of 194,000 below the recommended maximum levels.

Balanced Mixer
The mixer in the MDU compares the frequency of the transmitted signal with that reflected back from targets in the coverage area. A balanced mixer configuration is used which provides superior matching and conversion loss compared with a single-ended mixer. This improves the sensitivity of the MDU, enhancing capture and reducing false alarms.

This configuration also means that the mixer diodes are protected to a large degree from static damage since each diode protects the other from excess reverse voltages. In addition it is relatively simple to design self-test circuitry which will verify that the mixer is operating correctly.

The mixer does not require an external DC return, however if it is desired to use a DC return (for self-test or other purposes) a value of between 1KW and 12KW is recommended. The IF output impedance of the mixer is approximately 400W.

A portion of the oscillator signal is fed to the LO (local oscillator) port of the mixer, and the return signal intercepted by the receive antenna is fed to the RF input. The magnitude of the IF output signal is proportional to the magnitude of the signal received at the RF input, and the frequency is proportional to the relative velocity of the target reflecting the received signal.

In a real life situation there are many signals received from many different targets moving at different velocities, so the total IF output is a spectrum of signals of varying frequency and amplitude.

In addition there is a DC component at the IF output, which is the vector sum of all signals reflected off static targets in the coverage area of the unit.

SYSTEM DESIGN

If the oscillator is powered continuously the IF output needs only to be amplified with a narrow band low frequency amplifier covering the Doppler frequency range of interest. The Doppler frequency, which is linearly proportional to relative velocity between the MDU and the moving target, is 70 Hz per metre per second (31 Hz per m.p.h.) for a microwave frequency of 10.525 GHz.

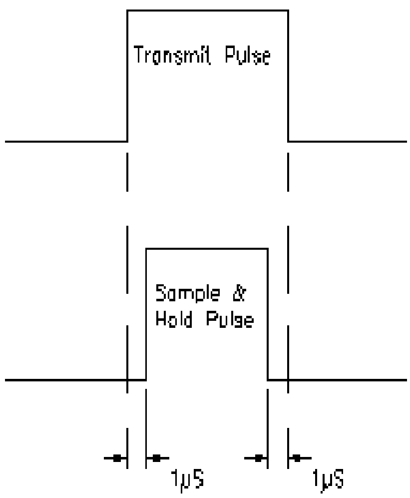
If the MDU is operating in an environment where fluorescent lights could be operating at the same time as the MDU, narrow band notch filtering will be required in the amplifier or in the subsequent signal processing to reduce the sensitivity of the unit to the moving plasma in the fluorescent tube.

The frequency of this notch filter needs to be centred on twice the mains supply frequency in the area of operation (100Hz for 50Hz supply or 120Hz for 60Hz supply).

Typical amplifier characteristics would be 70dB gain with a -3dB bandwidth of 3Hz to 80Hz, with a 60dB notch filter at twice the mains supply frequency.

If the MDU is operated in a pulsed mode as suggested in (3) above its sensitivity will be reduced in proportion to the duty cycle of pulsing.

This loss of sensitivity can largely be recovered using a sample and hold circuit between the IF output of the unit and the amplifier. The sample and hold circuit would typically consist of a FET series switch turned on when the oscillator is turned on, and a shunt capacitor which is then charged from the IF output of the unit. In practice any switching transients generated during the turn-on or turn-off of the oscillator can be eliminated from the IF output by in-setting the sample and hold pulse by approximately 1µs within the oscillator pulse.



Pulse Relationships

The video impedance of the IF output of the MDU is approximately 400W when the oscillator is running, and no DC return is required on the IF output.

A low DC level (<± 150mV) will be present on the IF output of the MDU whilst it is operating. Under pulsed operating conditions this will appear as a square wave on the IF output,the magnitude of which will vary with the mounting location of the unit and with static reflecting targets in its coverage area. This voltage is the vector sum of a large number of reflected signals from both within the MDU and the environment in which it is operating.

As long as this DC level is less than ± 150mV under all operating conditions the functional performance of the unit will be in specification. If external DC bias is applied to the IF output this should be such that the DC level does not fall outside these limits.

Coverage Pattern

The MDU uses separate transmit and receive antennas. As well as improving the sensitivity of the unit by providing isolation between transmit and receive paths this features also permits the shape of the coverage pattern to be optimised.

The coverage pattern of the standard unit is 72° horizontally and 36° vertically, with the connection tab facing downwards. This represents the angular coverage over which the sensitivity is at least 70% of the peak sensitivity directly in front of the MDU.

In practice, in an intruder alarm sensor, this equates to a horizontal coverage pattern of 90° so that a unit mounted in the corner of a rectangular room will give complete coverage along the walls without unprotected creep zones.

MECHANICAL

Mounting Arrangements

The MDU must be mounted firmly as movement relative to a fixed object within the coverage pattern will provide a Doppler output which could be detected as an intruder. Four mounting holes are provided in the corners of the MDU, which should be used to attach the unit firmly to the sensor. There should be no obstruction in front of the unit or within a 45° arc from the edges of the unit closer than 6mm from the face. Beyond this distance a plastic (ABS, polyethylene, PVC etc.) window can be mounted, through which the microwave signal will be transmitted. The thickness of this window will affect the sensitivity of the unit, although for the plastics mentioned above a 2mm thick window would be expected to reduce range by less than 10%.

Connections

The length of leads connecting the MDU to the signal processing circuitry must be minimised, to reduce pick up of electromagnetic interference. A maximum lead length of 1.5cm is recommended and screened leads are preferred. The housing of the unit can be grounded, but the electrical ground connection must be made through the GND tab. The unit is susceptible to static damage, so normal static handling procedures must be adopted when connecting or testing the units. In general, susceptibility to static damage is much reduced once the MDU is connected to the rest of the electronics.