In video #40, I compared ultrasonic distance sensors, and in video #97 I compared PIR sensors. Both can be used to detect movement, and both use different physical principles. Today we will have a look at a new kid in the block: Radar sensors. This is one of the strangest devices which came across my desk. Small and some of them, dirt cheap. So, let’s explore, if they are also useful.

The invention of radar influenced the way world war two went, because it was possible to detect planes of the enemy and shoot them down. And since then, this technology made civil aviation as we know it possible, because it can detect movement of metallic surfaces over distance. Of course, the technology can also be used against us, for example if we are trapped while speeding…

Till a few month ago, radar devices were quite big and quite expensive. This is, because they work on high frequencies, and need a strong sender and a big antenna. This antenna sends a signal, usually only in one direction. In parallel, a receiver listens on the same frequency. If the signal hits a metallic surface, it is reflected back to the receiver. And if the surface moves, the reflected frequency is slightly different than the one sent out. This difference is proportional to the speed of the surface and the effect is called “doppler effect”. We all know this effect from police cars which pass by and sound different if they move towards or away from us.

So, the parts we need to build a radar are:

1. An antenna
2. A sender
3. A receiver
4. A Mixer to bring the signal to low frequency
5. And a system for analysis

And now came these small devices which are sold as “radar sensing devices”. They come in different shapes, but all look somehow similar: They consist of an IC, a transistor, some passive elements, and a “snake” like trace on the PCB. There are some investigations in how these devices work, but for me, this is still not completely clear.

What is obvious is, that the sender, the receiver, and the mixer all are integrated in one simple transistor. The antenna must be the trails on the PCB.

This is, what we can call: “Reduce to the max”. The IC is only low frequency and is used for analysis. It has nothing to do with the radar, and it is a very similar chip as used in the PIR sensors. Its main responsibility is to create the timing of the digital signal.

I leave a link in the description for more information about the working principle of these devices. But I have to admit, I still did not find a convincing explanation on how we can build a sender, a receiver, and a mixer into one transistor. If this works, it is really intelligent engineering!

Just a small remark about metal: Radar can not only detect metal. It also can detect water. This is used for example to create the rain maps on your smartphones. And humans consist mainly of water…

So, I bought a few of these devices available on the internet. And now, I want to answer some questions:

* Can we use them on 3.3 or 5 volts?
* How much current they draw?
* How long do they stay “ON” if they detected somebody?
* How big is the distance they can detect the movement of an adult human?
* What is the angle of detection?
* Do they “see” trough obstacles like glass, wood, or even walls?
* What additional features do they offer?
* Can I use more than one device in the same room? Or are there interferences?

And because they work on quite high frequencies, I want also to know if they disturb my Wi-Fi network.

First, we look at the contenders:

The RCWL-0516 is the cheapest device and it should work from 3.3 to 28 volts. It offers a connection for a LDR resistor to inhibit its function if the ambient light level is already high. I did not test this function. It also has a stabilized output of 3.3 volts and you influence its sensitivity and delay time by adding a resistor or a capacitor. A small remark: The 3.3 volt pin is an output. The Vcc pin is called Vin.

The next is the HW-MS03. It looks similar, and also has a similar size, but you cannot influence its behavior by adding components. You would have to replace them.

Next comes the XYC-WB-G1. It also has no possibilities to add components, and it has a JST 2.0 connector.

The WB3-12 seems to be built for a particular purpose: To be used in round lamps. To get this small footprint, they used two PCBs which are soldered together. It also seems to have the possibility to add an LDR. The sensitivity and the delay can be influenced by replacing two resistors. They are quite tiny, but accessible. This device also needs a pull-up resistor at the output. Otherwise it will not work.

The last in the crowd is the HFS-DC06. This device is bigger than the others. It has trim potentiometers to influence delay and sensitivity. And it has some sort of metal shielding. It is also the most expensive of all.

First, we tested the possible supply voltages. Despite the promises in the leaflets, most of the devices are not usable at 3.3 volt. They expose a particular behavior: If no movement is detected, the output switch forth and back between ON and OFF. The only module which works also on 3.3V is the HFS-DC06.

All modules claim to run up to 12 volts or higher. I did not test it, but because most of them have some sort of voltage regulators on board, and all only draw small currents, I can believe, that they work also on higher voltages.

Next, we measured the current needed during operation. Most of them only need 2-3 mA. Only the HFS-DC06 needs 14 to 22 mA. A quick comparison with PIR sensors shows, that these consume below 1 mA, and the ultrasonic sensors consume around 5 mA.

The time a sensor stays “ON” after triggering decides in which scenario we can use it. If we work with microcontrollers, we prefer a short on-time, because we want to define the timing with our software. If we want to use the sensor stand-alone, we usually need a longer on-time. Without changing or adding any parts on the sensors, two sensors stay on for about 5 seconds, and the other two stay on for 20 to 30 seconds. Again, the HFS-DC06 is different: It starts at 5 seconds and can be much longer, depending on the position of the trim potentiometer. We were not patient enough to test the longest possible delay.

Now comes the fun: How well do these devices detect movements of humans? For these tests, I had help from a neighbor. Because my house is quite small, and the weather outside is rainy, we decided to use a 4-meter distance. Anyway, in many situations, 4 meters is already too much.

All devices were able to detect even small movements of arms over a distance of 4 meters. Which is for me very astonishing, that such simple devices have this capability.

The only device which was clearly more sensitive was again the HFS-DC06. We did a short test, and were able to detect also movements over a distance of 8 meters. Of course, with the maximum sensitivity selected. BTW: Its sensitivity selection works fine and you can restrict the detection range down to about 1 meter.

PIR and ultrasonic detectors had a detection range of about +/- 30 degrees. How about these new devices? Radars, in general are very direction sensitive, because we want to detect also exactly, where the planes are. In order to test this, we turned the sensors by 180 degrees and did the same tests again. Interestingly, we did not see a difference in sensitivity. With the exception of the HFS-DC06. This device was not sensitive at all in the reverse direction.

So, we turned the sensors only 90 degrees. And, strange enough, they worked as good as before. The only exception, again, was the HFS-DC06. It only has an opening of about 180 degrees. The other devices are sensitive over 360 degrees. And, as we will see later, also up and down. So, they expose no directivity at all. Very interesting!

We all know, that radio waves also travel through walls. And because our radar sensors claim to work with radio waves, we have to test also this claim. So, the first test is if they travel through a glass window. We discovered, that glass is quite a strong insulator. Also on shorter distances, we were not able to detect movements behind glass.

Next, we tried the wooden table. For this experiment, I had to take the role of an “underdog” and go on my knees. Here, the devices had no problem to detect even very small movements. And the wood has a thickness of about 4 cm or 1.6 inches. Great!

5 mm or 0.2-inch Acrylic glass did also not hinder the sensitivity a lot. 15mm or 0.6-inch wood however, reduced the sensitivity about 25%.

So, all-in all this is a great new category of devices. Some of them claim to work on 5.8 GHz, others on 24 GHz. But the dimensions are not much different. So, these numbers are hard to believe for me. And I read somewhere, that they can work also on 2.4 GHz (which would only be a missing point in the 24 GHz number). And this would be very harmful for my Wi-Fi or Bluetooth devices. So, let’s check. My spectrum analyzer only covers up to 3 GHz. So, I cannot measure the 5.8 GHz Wi-Fi band. But at least, below 3 GHz none of the devices emitted energy. Except the XYC-WB-G1: It emits a small signal around 3 GHz. I did not found any information about this device, and even the picture on Aliexpress is different to the one I got. But still, the signal is not on 2.4 and quite small. So, no danger here.

The next question, of course: What happens, if I use more than one device in the same room? To test that, we powered all available devices on the table and did the sensitivity test. We did not discover any difference. So, they seem to somehow have no big influence on each other. Which, again, is a mystery for me. Even two of the very same make worked without any problems in a distance of 10 cm!

Summarized:

* These cheap and small sensors all work
* They can detect human movements in a distance of at last 4 meters
* Most of them work from 5 volts and up. Only one worked on 3.3 volts
* Sensitivity and delay time can be influenced by either trim potentiometers, added resistors or capacitors, or by replacing resistors or capacitors. The latter is not easy because the parts are very small.
* For the usage with microcontrollers, 5 second delay is the maximum. 20-30 seconds is useless.
* The devices work in all directions. Only one exception has a directionality
* These devices detect movement also through plastic, or wood. Even thin walls are no big obstacle.

All-in all my favorite is the RCWL-0516. It is simple and cheap, has a decent sensitivity and a short delay time. The only disadvantage: It cannot be used in 3.3 volt environments. If you need a lot of flexibility, the HFS-DC06 is the best choice. However, it is roughly 10 times more expensive. The others are somehow in-between.

I like these devices, also because they can be mounted inside a plastic box without any contact to the outside. An example for that is this 220-volt proximity sensor form Banggood. It is a completely closed plastic case, and it comes with dip switches to select sensitivity and delay. I mounted one of those for my remote desk in my lab. And it works very well.

I hope, this video was useful or at least interesting for you. If true, then like.

Bye