

## Radar target detection simulation

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### Abstract:

Standard radar detection process requires that the sensor output is compared to a predetermined threshold. The threshold is selected based on a-priori knowledge available and/or certain assumptions. However, any knowledge and/or assumptions become inadequate due to the presence of multiple targets with varying signal return and usually non stationary background. Thus, any predetermined threshold may result in either increased false alarm rate or increased track loss. Even approaches where the threshold is adaptively varied will not perform well in situations when the signal return from the target of interest is too low compared to the average level of the background. Track-before-detect techniques eliminate the need for a detection threshold and provide detecting and tracking targets with lower signal-to-noise ratios than standard methods. However, although track-before-detect techniques eliminate the need for detection threshold at sensor's signal processing stage, they often use tuning thresholds at the output of the filtering stage. This paper presents a computerized simulation model for target detection process. Moreover, the proposed model method is based on the target motion models, the output of the detection process can easily be employed for maneuvering target tracking.

Keywords : Radar ,target ,simulation threshold , signal-to-noise ratio .

### I. INTRODUCTION

Radar target detection is affected by many factors. These factors are divided into two types. Type one is related to the Radar system design (Transmitter, Receiver, Antenna). The second type of factors is related to the target geometry characteristics. The target geometry affects extensively the radar target detection. This is called the radar cross-section area (RCS) and denoted by the symbol sigma ( $\sigma$ ). The higher the value of sigma the higher is the possibility of the target detection. This fact leads to steady techniques for the reduction of the radar cross section area to the minimum in order to make the target undetectable by radar. By theory if sigma value becomes zero, the radar will not be able to detect it. There are two techniques related to the radar cross section reduction area reduction or minimization. The first technique deals with active cancellation of the echo returned from the target. The second technique is the passive cancellation technique. This paper sheds the light on the radar target detection.

### II. THE RADAR RANGE EQUATION

Radar is an electromagnetic system for the detection and location of objects. It operates by transmitting a particular type of waveform, a pulse-modulated sine wave for example, and detects the nature of the echo signal. The radar equation relates the range of radar to the characteristics of the transmitter, receiver, antenna, target, and environment. It is useful not just as a means for

determining the maximum distance from the radar to the target, but it can serve both as a tool for understanding radar operation and as a basis for radar design. The simple form of the radar range equation derivation is:

If the transmitter power  $P_t$  is radiated by an isotropic, the power density at a distance ( $R$ ) from the radar is equal to the radiated power divided by the surface area  $4\pi R^2$  of an imaginary sphere of radius  $R$ , or :

$$\text{Power density} = \frac{P_t}{4\pi R^2} \dots\dots\dots (1)$$

The power ( $P_r$ ) returning to the receiving antenna is given by the Radar equation:

$$P_r = \frac{P_t G_t A_r \sigma F^4}{(4\pi)^2 R_t^2 R_r^2}$$

Where;

$G_t$  = gain of the transmitting antenna

$A_r$  = effective aperture (area) of the receiving antenna

$\sigma$  = radar cross section, or scattering coefficient, of the target

$F$  = pattern propagation factor

$R_t$  = distance from the transmitter to the target

$R_r$  = distance from the target to the receiver.

In the common case where the transmitter and the receiver are at the same location, ( $R_t = R_r$ ) and the term ( $R_t^2 R_r^2$ ) can be replaced by ( $R^4$ ), where  $R$  is

the range. For vacuum without interference ( $F = 1$ ) . The propagation factor accounts for the effects of multipath and shadowing and depends on the details of the environment. In a real-world situation, pathloss effects should also be considered .This yields to :

$$p_r = \frac{PtGtAr\sigma}{(4\pi)^2 R^4} \dots\dots\dots (2)$$

Equation (2) shows that the received power declines as the fourth power of the range, which means that the reflected power from distant targets is very, very small.

The distance to the target (range) is determined by measuring the time taken for the radar signal to travel to the target and back. The direction, or angular position (azimuth) , of the target may be determined from the direction of arrival of the reflected wave-front. The usual method of measuring the direction of arrival is with narrow antenna beams.

If relative motion exists between target and radar, the shift in the carrier frequency of the reflected wave (Doppler Effect) is a measure of the target's relative (radial) velocity and may be used to distinguish moving targets from stationary objects. In radars which continuously track the movement of a target, a continuous indication of the rate of change of target position is also available. The name radar reflects the emphasis placed by the early experimenters on a device to detect the presence of a target and measure its range. Radar is a contraction of the words radio detection and ranging. It was first developed as a detection device to warn of the approach of hostile aircraft and for directing anti-aircraft weapons. Although a well-designed modern radar can usually extract more information from the target signal than merely range, the measurement of range is still one of radar's most important functions. The most common radar waveform is a train of narrow, rectangular-shape pulses modulating a sine wave carrier.

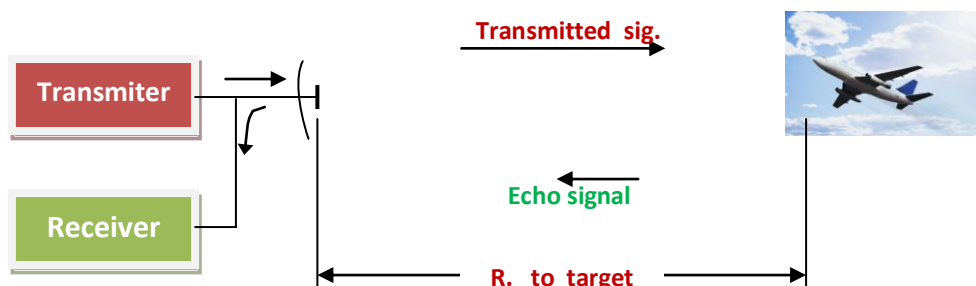


Figure (1) Basic principle of radar

Once a signal is radiated into space by radar, sufficient time must elapse to allow all echo signal to return to the radar before the next pulse is transmitted. The rate at which pulses may be transmitted, therefore, is determined by the longest range at which targets are expected. If the time between pulses is too short, an echo signal from a long-range might arrive after the transmission of the next pulse and be mistakenly associated with that pulse rather than the actual pulse transmitted earlier. This can result in an incorrect or ambiguous measurement of the range. Echoes that arrive after the transmission of the next pulse are called second-time-around echoes. Such an echo would appear to be

at closer range than actual and its range measurement could be misleading if it were not known to be a second-time-around echo. The range beyond which targets appear as second-time-around echoes is the maximum unambiguous range, ( $R_{un}$ ) and is given by equation (3):

$$R_{un} = \frac{cT_p}{2} = \frac{c}{2f_p} \dots\dots\dots (3)$$

Where;  
 $c$  = speed of light  $3 \cdot 10^8$  m/s.  
 $f_p$  = Pulse repetition frequency c/s (Hertz).

The operation of pulse radar may be described with the aid block diagram shown in figure (2):

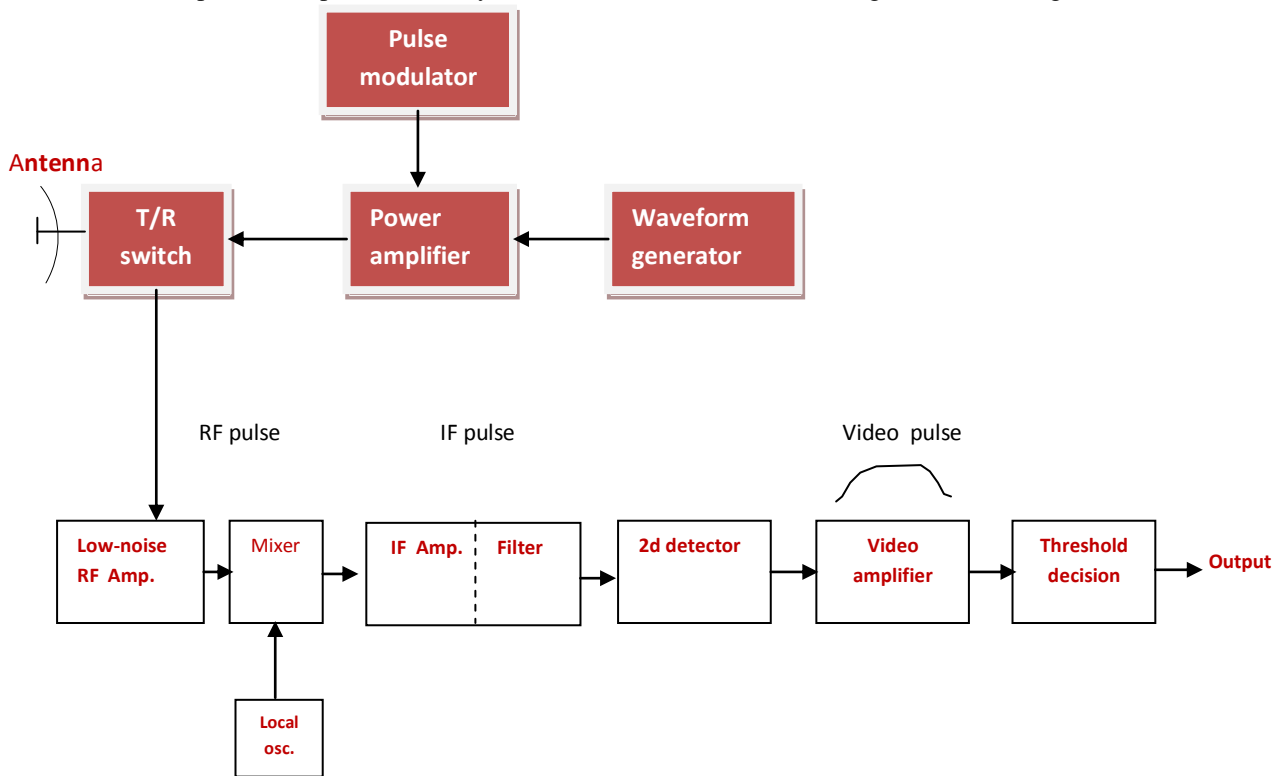


Figure (2) block diagram of conventional pulse radar With a super heterodyne receiver

### III. THE SYSTEM DESIGN

The proposed main block diagram is based on parallel port interface in order to guide the signal from keypad to the program to show the different cases in the program. The proposed block diagram shown in figure (3).

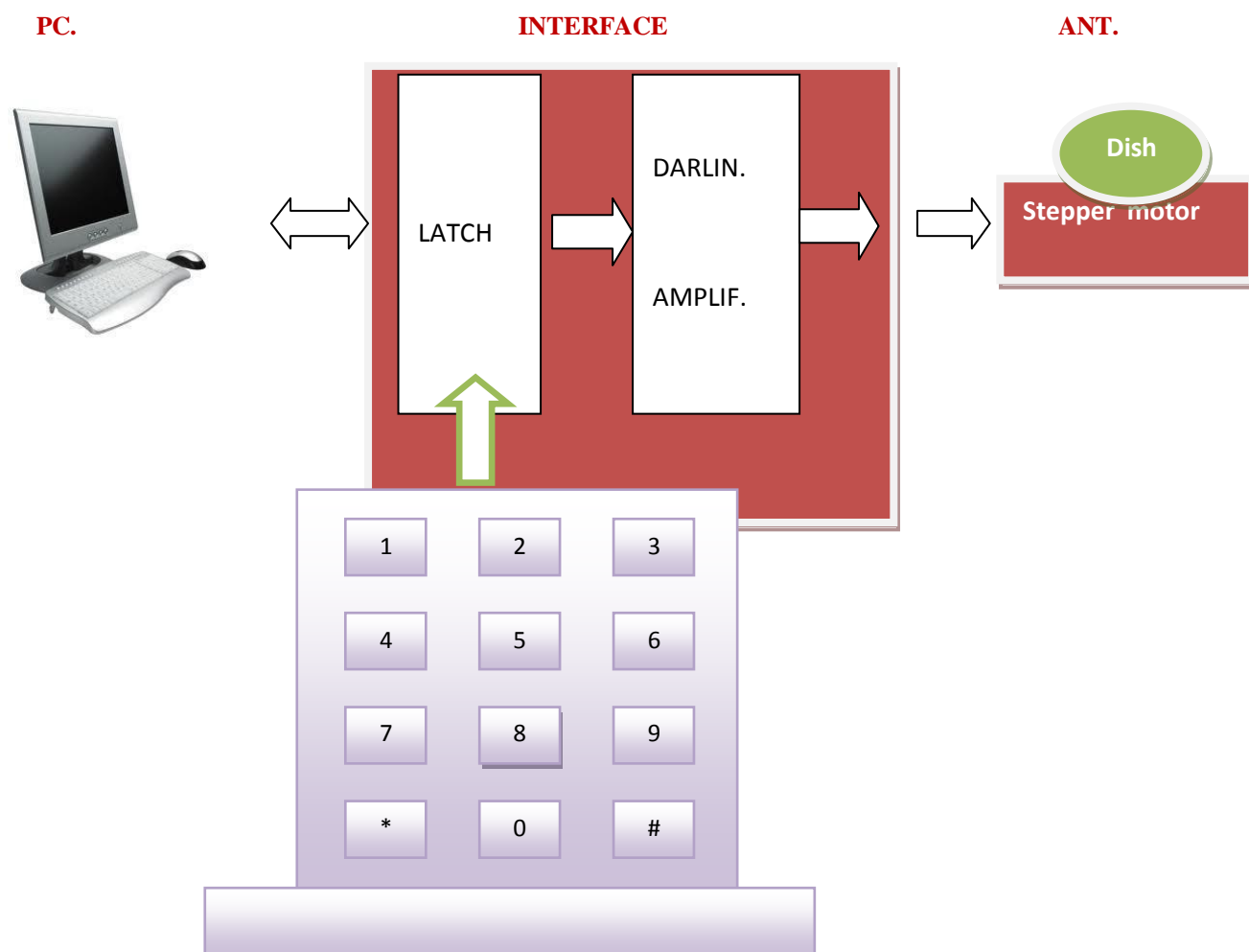


Figure (3) block diagram of the system design.

### Hardware component

The hardware components for computer interface circuit are :

**Breadboard:**

breadboard (protoboard) is a construction base for a one-of-a-kind electronic circuit, a prototype. Because the solderless breadboard does not require soldering, it is reusable, and thus can be used for temporary prototypes and experimenting with circuit design more easily. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

**IC SN74373:**

It is used as a buffer to store data .The IC contains eight D Flip flops.

**3x4 matrix keypad:**

This device is use to generate target, the output of keypad is an input to an (IC SN74373).

**D-25 Connector:**

This component is used to interface the computer to the electronic circuit. Figure(5) shows the pin outs of the female d-25 connector.

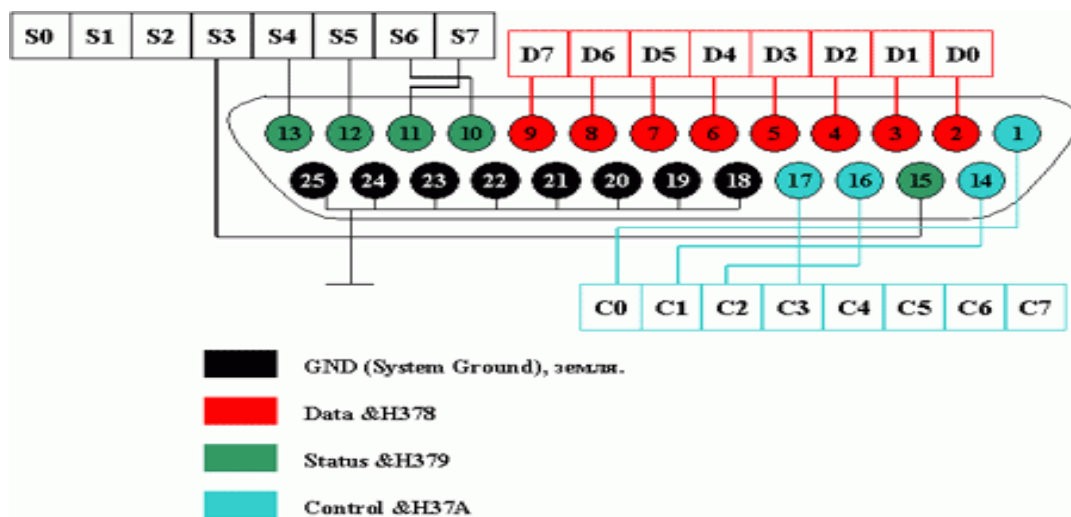


Figure (5) The female d-25 connector

**Lab link cable:**

The lab link cable is connected to the computer for processing and display the output.

**IV. ALGORITHM**

The proposed computer simulation algorithm is based on supplying the computer with the data about the targets (Range and Azimuth) from the matrix keypad .Many scenarios on target detection and display on the screen of the computer will be considered..These scenarios consider the generation of two targets and nine levels of noise overlapping the echo from the target .The noise levels affect the targets detection and display on the plane position indicator (PPI) of the radar. Running the program in the computer will indicate the effects of the imposed noise levels on the targets detection and display. Turbo C++ programming language is used in programming the computer The algorithm is :

Start

Initialization :

Screen design :

- Declare graphic mode programming.
- Clear all the screen.
- Design a plane position indicator (PPI) in the screen of the computer.
- Put the scanner in the plane position indicator (PPI) to (0 Degree).

Antenna control :

- Clear all outputs from the parallel port of the computer.
- Orient the stepper motor(i.e antenna) towards the Geographical north (0 Degree).
- Give instructions to the PPI scanner and the stepper motor to rotate in synchronization.

Targets generation:

- Generate two moving targets from the matrix keypad.
- Declare initial noise level = 1.
- Call detect and display subroutine
- If the keypad input = \* ) , then go to end.

--- Go to initialization.

End

.Detect and display :

Noise level:

- If the (noise levels = 10 ) , then go to return.
- Increment noise level from the keypad (noise level = noise level +1).
- Display target on the PPI screen of the computer.
- Perform a delay proportional to the speed of the target.
- Go to noise level.

Return.

## V. RESULTS

Table (1) below shows the results obtained from the generation of two targets in addition to applying nine noise levels . when applying the algorithm in paragraph (IV) above , we notice the effects of imposing the noise levels on the targets detection. The signal to noise ratio gets reduced. The calculated reduction of targets detection (blip brightness on the PPI) is equal about (5 % ) for each increment in the noise level .

Table (1) The results obtained for two targets in addition to applying nine noise levels

Noise level in (m Volt)	Target-1 (Range )in Km.	Target-1 (Azimuth) in degrees	Blip brightness (%)
Noise level-1 (10 m Volt)	300 Km.	45 Degree	90 %
Noise level-2 (20 m Volt)	295 Km.	50 Degree	85.5 %
Noise level-3 (30 m Volt)	290 Km.	55 Degree	81 %
Noise level-4 (40 m Volt)	285 Km.	60 Degree	77 %
Noise level-5 (50 m Volt)	280 Km.	65 Degree	73,5 %
Noise level-6 (60 m Volt)	275 Km	70 Degree	70 %
Noise level-7 (70 m Volt)	270 Km	75 Degree	66.5 %
Noise level-8 (80 m Volt)	265 Km	80 Degree	63 %
Noise level-9 (90 m Volt)	260 Km	85 Degree	60 %

**Note :** The same results hold for target number two.

## VI. CONCLUSION

The functionality of the design and simulation is to simulate the radar screen in the personal computer (pc) monitor using turbo C++ program. Targets are generated by using an external matrix keypad. The generated targets are send via the computer interface circuit to be displayed in computer screen. ,So the computer monitor will automatically turn to be radar monitor simulator (PPI). the interface design clearly discusses the handshaking between the design and personal computer. The program is written in Turbo C++ language (which is the most usage language in these application) to simulate the radar screen operation.

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