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3D TARGET DETECTION USING STACKED HOLOGRAM

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Abstract: A very popular technique of 3D vision now-a-days is holography which has many advantages over the stereo-scopic 3D vision. The same technique can be implemented on RADAR to take high resolution 3D picture of the target and to track with very minute displacement. As this does not employ parallax method, so binocular antenna can be replaced by a single antenna. Again in this thesis another new concept, gated range, is implemented, i.e., the target can be detected within a certain range on spatial domain so that it can focus to the target and the clutter has no effect on it. Narrow virtual transmit pulses are synthesized by differencing long-duration, staggered pulse repetition interval (PRI) transmit pulses. PRI is staggered at an intermediate frequency IF. Echoes from virtual pulses form IF-modulated interference patterns with a reference wave. Samples of interference patterns are IF-filtered to produce high spatial resolution holographic data. PRI stagger can be very small, e.g., 1-ns, to produce a 1-ns virtual pulse from very long, staggered transmit pulses. Occupied Bandwidth (OBW) can be less than 10 MHz due to long RF pulses needed for holography, while spatial resolution can be very high, corresponding to ul tra-wideband (UWB) operation, due to short virtual pulses. X-Y antenna scanning can produce range-gated surface holograms from quadrature data. Multiple range gates can produce stacked-in-range holograms. Motion and vibration can be detected by changes in interference patterns within a range-gated zone.

Keywords*: Staggered pulse repetition interval, quadrature data, range-gated zone, holography, range delay, interferometry.*

I. INTRODUCTION

This thesis relates to radar and more particularly to interferometric and holographic radar. The principle can be used to form holograms, to form stacked holograms, to detect motion and vibration within a gated region, and to find range. Pulse echo and FMCW high resolution radars typically have emissions that are wideband to ultra-wideband (UWB).

UWB impulse radars emit short pulses of ½ to one RF cycle in duration, with corresponding bandwidths extending from 500 MHz to 10 GHz or more. Wideband pulse-echo radars emit bursts of RF sinusoids; tank level sensing radars typically emit 10 to 20 RF sinusoids in a burst with a corresponding bandwidth of greater than several hundred megahertz.

Similar bandwidths pertain to high resolution FMCW radars.

Operation of these high bandwidth radars is severely restricted by regulatory agencies such as the FCC. Examples of these restrictions include:

i. UWB radars can only be operated outdoors with extremely limited radiated power levels and only when handheld.

ii. Wideband tank level sensing radars can only be operated inside tanks and cannot be used to sense river levels, for example.

iii. ISM bandwidth is very limited, such as the 50 MHz wide 10.5 GHz band.

While high bandwidth radar is subject to severe regulatory limitations, operation without a range-gate introduces other severe limitations. It should be noted that the use of a range gate generally infers high bandwidth. Range gating usually requires high spatial resolution, which implies a narrow sampling aperture and matching narrow, high bandwidth emission pulse. Short range radars, and generally, radar sensors, frequently require very high resolution gating.

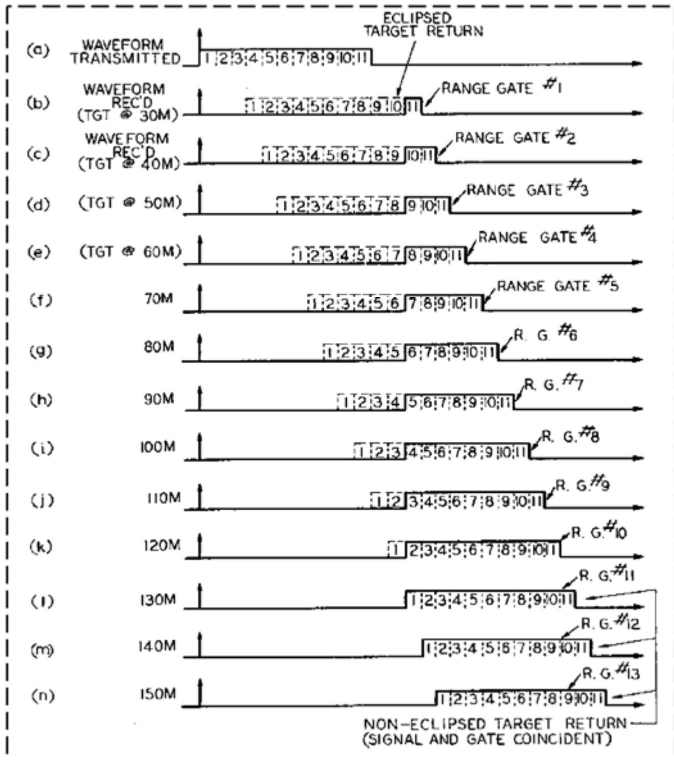
1.2 System Requirement:
CW Doppler radars are commonly used to sense motion. However, these radars have no maximum range limit. Undesired moving objects, i.e., clutter at any range can produce a response.

The lack of a range gate may be ideal for police speed-sensing radar, but it is completely undesirable for security alarms; a person moving outside a protected zone could false-rigger a nongated radar. A rangegate is clearly needed in many applications.
Numerous range-gated motion sensing radars exist in the previous research papers; yet they often require high bandwidths and are thus subject to tight regulatory restriction. Hence low bandwidth range-gated radar is needed.

2. RANGE GATED DETECTION SYSTEM:

The range discrimination of the radar is regulated by so called range gates. This means that the received echo signal is sampled at given time-slots and each of these points in time corresponds to a range gate in distance.

Figure – 1: Range Gating using binary coding.



(Source: U.S. Patent, Hubler; Malcolm F. et.al.)

A range-gated radar system which includes a phase modulator that modulates an R.F. generator with a signal which may be binary coded.

In a preferred embodiment, the binary signal is a periodic signal of 2. Suppose N -1 bits per period. Starting at some arbitrary point in the sequence, K contiguous bits are transmitted then M contiguous bits are passed over, then K more bits are transmitted, and so on. The quantities M+K and 2.sup.N -1 have no primary factors in common.

The radar system may be a doppler radar system using balanced digital processing which involves separating the upper and lower sideband components of modulation that exist in the return radar signal as a result of the motion of scatterers and subtracting them.When including a subsection you must use, for its heading, small letters, 12pt, left justified, bold, Times New Roman as here.

3. OBJECTIVE OF THE NEW SYSTEM:

i. To add a range gate to a holographic radar to exclude extraneous echoes.
ii. To add a range gate to a holographic radar to allow the formation of stacked holograms.
iii. To provide a radar with narrowband emissions combined with high spatial resolution.
iv. To provide a high resolution radar with narrowband emissions to comply with ISM band regulations.
v. To provide a low noise range gated narrowband motion sensor.
vi. To provide a narrowband, high resolution swept range A-scan radar.

When including a sub-subsection you must use, for its heading, small letters, 11pt, left justified, bold, Times New Roman as here.

4. DESCRIPTION OF THE SYSTEM:

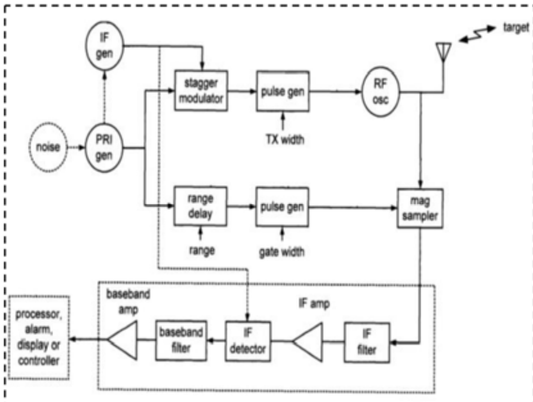
Here the FIG. 2 is a block diagram of an exemplary range gated holographic radar.

A PRI (pulse repetition interval) generator produces pulses that recur after a time duration or interval, e.g., in every 1-microsecond.

The reciprocal of PRI is PRF, the pulse repetition frequency, e.g., 1 MHz.

Noise generator can modulate the PRI to spread the RF emission spectrum and reduce interference from other spectrum users.

Fig – 2: Block Diagram of a range gated holographic RADAR



(Source: United States Defense Advanced Research Agency (DARPA))

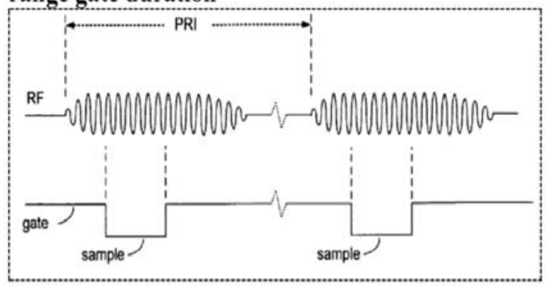
The PRI generator is coupled to stagger modulator. The stagger modulator gives one pulse for each PRI pulse it receives from the PRI generator. Some output pulses are delayed, or staggered, more than others. Stagger modulator is responsive to inputs from intermediate frequency IF generator. The IF generator can generate a squarewave, with a frequency of less than the PRF.

In response to the IF generator signal, the stagger modulator output consists of a pulse train of N pulses with no delay relative to its input, and then, N pulses that are delayed a fixed amount. The total time of these two epochs is 2N*PRI, and the reciprocal 1/(2N*PRI)=IF. N can be an arbitrary integer, 1, 2, 3, ... IF generator can be an independent oscillator, pseudorandom pulse generator, or coded pattern generator.

Stagger modulator drives a first pulse generator, which gives pulses to RF oscillator. The duration of the output pulses is greater than or equal to the pulse-echo duration of a pulse propagating from antenna to a desired target and back to antenna. An optional control input port labeled "TX width" allows the output width of pulse generator to be scaled, for example, in response to target range estimates or for motion detection zone control. RF oscillator gives RF pulses to antenna, each pulse consisting of a burst of two or more RF sinusoids as shown in FIG.3 which indicates a transmit RF burst.

The duration of the burst is long, long enough that it persists when the desired echo returns. Due to substantial pulse-echo delays encountered in most radar applications, the burst duration is long and the associated emission bandwidth is low, i.e., narrowband. Narrowband RF emissions are widely allowed by regulatory agencies in the unlicensed ISM bands.

Figure – 3: Transmitted RF burst, PRI and the range gate duration

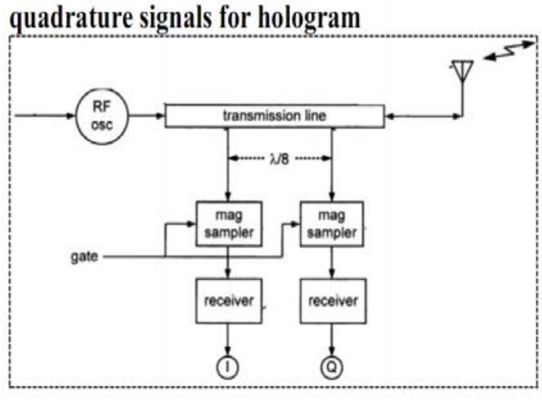


PRI generator is also coupled to range delay, which delays the PRI generator pulses by an amount equal to the expected target delay. An optional input labeled "range" can control the range gate timing in a specific manner. For example, the range input can be used to linearly sweep the range delay to produce an A-scan response at the output of radar. The range input can also be used to set the depth of a 2D scanned holographic radar image [6]. Changes in the range input can change the depth, or downrange, location of the hologram, so holograms stacked in depth can be produced.

The range control can also be adjustable, but fixed relative to the transmit RF burst, to set the sensing zone location in a motion sensing embodiment of radar. However the range delay element is controlled, a specific temporal relationship to the time of emission of the transmit pulse is involved, i.e., controlled timing is involved.

Range delay is coupled to second pulse generator, which generates gate pulses. The duration of the output pulses sets the temporal sampling aperture of magnitude sampler. The aperture must span at least two RF burst sinusoids, e.g., 200 ps for 10 GHz radar. An optional control input port labeled "gate width" allows the output width of pulse generator to be scaled, for example, in response to radar resolution requirements or to set motion sensing zone dimension.

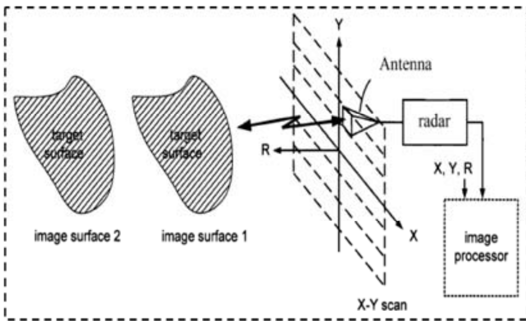
Figure – 4: Magnitude Sampler to produce quadrature signals for hologram



Magnitude sampler (Fig.4) gives samples to the IF filter. For each PRI, a sample is taken, and thus samples can occur at a high rate equal to the PRI. However, stagger modulator introduces an IF modulation component to the sample stream that IF filter passes while rejecting spectral components at the PRF and at frequencies below the IF, e.g., spurious Doppler components. Filter can be a BPF.

An optional IF amplifier can amplify the IF signal amplifier may also be located ahead of filter.

Figure – 5: Scanning of range gated radar to form stacked hologram



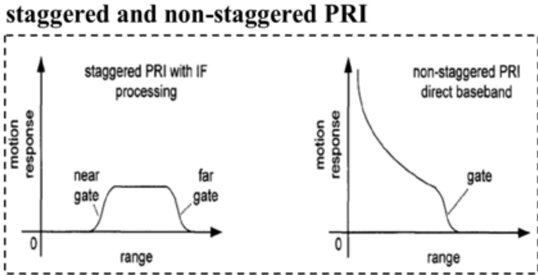
IF detector converts the IF signal to a baseband signal. It can be implemented with a synchronous demodulator or an envelope detector. The synchronous demodulator can be a mixer or analog switches driven by an IF local oscillator signal provided by IF generator. Alternatively, a rectifying type envelope detector can be used.

5. RESULT ANALYSIS:

FIG. 4 shows a response plot for a motion sensor implementation of radar. Response is plotted against moving target range and can be seen to be constant between the "near gate" and the "far gate." The flatness of the plotted response is idealized; actual response can be influenced by ambient pulse scattering, sampling convolution with the transmitted burst and practical non-idealities.

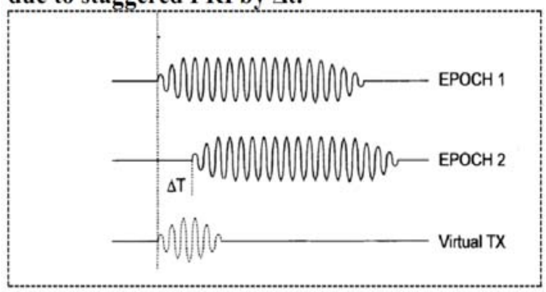
Response is absolutely zero beyond the far gate; there is no leakage.

Figure – 6: Comparison of the responses with staggered and non-staggered PRI



If there is no PRI stagger and there is no short, virtual transmit burst, then the response is seen to be absolutely zero beyond the far gate; there is no leakage. But, there is no near gate and the voltage response varies with 1/(range squared), rising very rapidly as target range closes in to zero. This is undesirable in a motion sensor since it causes excess sensitivity to local vibrations, to insects near the antenna, and to locally generated electronic noise such as switching devices, e.g., transistors, that can create changes in the local radar reflectivity.

Figure – 7: Virtual transmitted signal generated due to staggered PRI by Δt.



6. CONCLUSION AND FUTURE SCOPE:

This Radio Holographic RADAR analysis permits to use high-precision GPS/MET radio occultation measurements to identify detailed structures in the electron density profile in the upper atmosphere. Holographic Range gated radars can be used for surveying of building structures for determining the position of defects, reinforcement, voids and other heterogeneities without breakthrough. Under ground water flow and pipe line can be detected as well as it will help in finding landmine and can also work as metal detector.

As this Radar implements interference principle so very minute deflection can be viewed on a surface. It also has an ability to perform one-sided sounding, instead of double-sided sounding as in X-ray devices. Again it is able to detect not only metal objects, but also objects made from any dielectric materials provided that their permittivity is different from that of the medium.

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