References:

1. M. Skolnik, Introduction to Radar System, Chapter 11, Macgrow–Hill, 1985.
2. F.M. Gardner, Phase lock Techniques, Chapter 3, Wiley, 1975
3. F.Behnia, M.S. report, Sharif university of Technology, 1988 (report is in persian language).

Input Signal Level (mv)	Input noise Level (mv)	Input S/N (db)	Lock Situa - - tion	Output Perfor- -mance
0.5	0	∞	Unlooked	Not Acceptable
0.8	0	∞	Unlooked	Not Acceptable
1.2	0	∞	Locked	Acceptable
1.2	0.8	3.5	Locked	Noisey but rea- -dable
1.6	0.8	6 .	Locked	Good

Table 2. Searching of Input Threshold.

Input Noise Level (mv)	Input Signal Level (mv)	S/N (db)	Probability Of Detection
6	0	0	———
6	16	8.5	Very High

Table 3. Probability of Detection V.S. Input S/N Ratio

Clutter Level (mv)	Signal Level (mv)	S/C (db)	Probability of Detection
8	0	———	———
8	18	$\simeq$ 3	Very High

Table 4. Digital Output Performance V.S. Input Clutter Change.

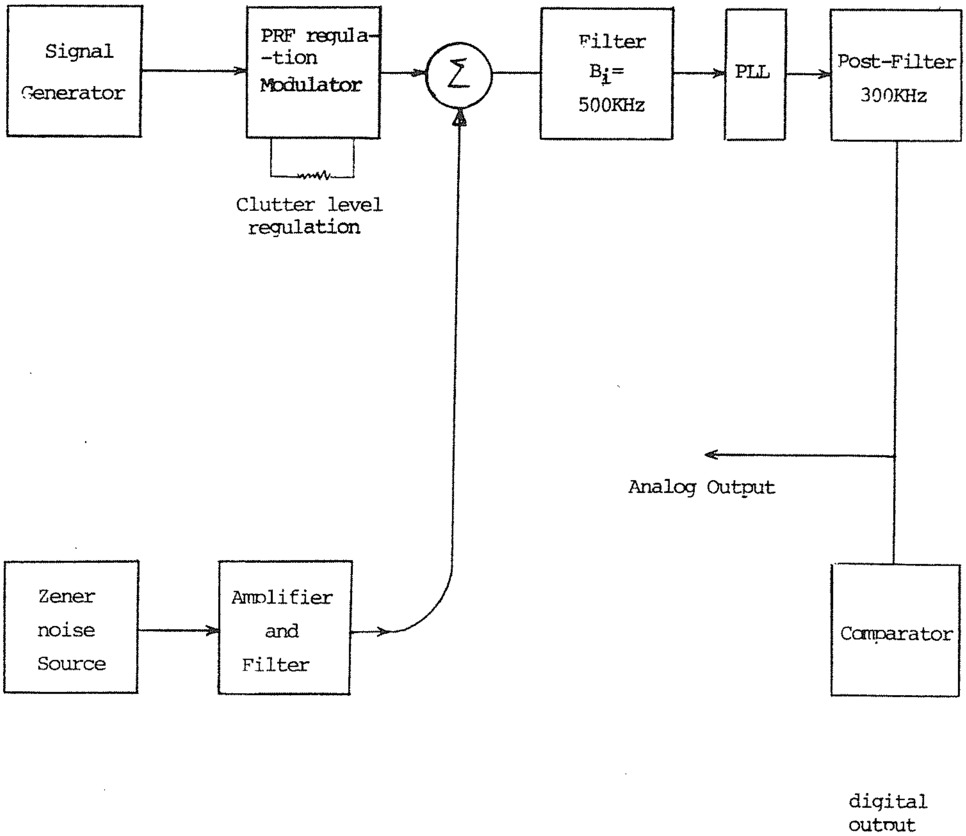

Fig. 2. Block Diagram of Teat Procedure.

Input S/N (db)	Lock Situation	Output Performance
14	Lock	very Good
9.5	Lock	Good
8	Lock	Not Bad
3.5	Critical Point	Not Good

Table 1. Lock Situation and Output Performance V.S. Input S/N Ratio

and input signal frequency. This change will improve the improvement factor, although measurement of f_d will not be accurate. In other words by improved phase — lock - loop technique,Doppler estimation will not be possible but it's detection will be possible for small input signal to noise ratio while input level is appropriate for interested lock range as shown in fig. 1.

As shown in Fig. 1,f_0 should have some difference Δf from input intermediate frequency, 30 MHz. Also f_0 should be chosen to get some amount of immunity due to clutter. Input amplitude should be higher than some level in order to observe the affect of input signal band on the phase — lock — loop; i.e. to be in the lock — range.

III. Expriment and it's Results:

A. Exprimental System:

To check the theory given in section II we set system shown in Fig2.

In this system, signal generator and modulator simulates controllable frequency modulated signal instead of real Radar echo & clutter. Signal charac— teristics are: 30 MHz intermediate frequency, 3 μ see pulse width, with 2000 Hz PRF. Zener diode, ampli— fier and filter simulate noise by producing 4 MHz BW noise around 30 MHz, Σ addes signal to noise with controllable S/N and controllable level of clutter. Phase — lock — loop is made by NE 560 IC. Com— Parator is schmitt trigger with 40 mv and 20 mv threshold.

B. Expriment Results:

Based on systems shown in Fig. 2. We have done following expriments:

I) Analog Output Performance V.S. Input S/N Ratio

Table 1. showes the output performance V.S input signal to noise ratio. The result shows that system can detect the target when input S/N ratio is above 8 db.

II) Analog Output Performance V.S. Input Level

Table 2. shows the result of this experiment. The goal is to find the minimum detectable signal level with applying the minimum readable noise level 0.8 mv. The result shows that input level must be above 1.2 mv in order to detect the Doppler frequency affect of the target.

III) Digital Output V.S. Input S/N Change

Table 3. shows the experiment with noise, observing the digital output. The result shows that with S/N ratio above 8.5 db, detection can be properly done.

IV) Digital Output performance V.S. Input Change

Table 4. showes the experiment with clutter, observing the digital output. It shows that S/C above 3 db, the detection can property done.

The detail of the above experiments can be found in refrence [3] which is in persian language.

IV. Conclusion

Using phase — lock — loop by giving appropriate difference between the free running frequency of VOC and input frequency; Doppler frequency can be detected when signal to noise ratio is as low as 3.5 db. This system may be used for ARM (Antiradiation Missile) detection, In order to improve detection performance in the presence of burst input and clutter.

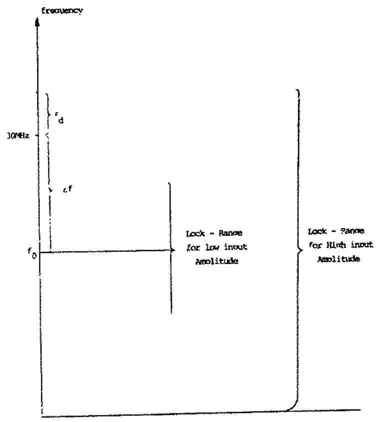

Fig. 1. Frequency schem for phase — lock — loop.

Doppler Detection by Improved Phase – Lock – Loop – Technique

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ABSTRACT

Phase – Look – Loop has not already been used as Doppler detection because of short radar pulse duration and low Doppler frequency. We have shown both theoritically and exprimentally that P.L.L. technique can be improved to do so, by giving artificial difference between input and voltage controlled oscillator free running frequency. This technique has an application for low level signal to noise ratio such as antiradiation missle detection.

I. Introduction:

Doppler frequency in MTI Radar can not usually be measured because of low Doppler frequency f_d and high bandwidth of signal, Bi [1]. Phase-lock-loop has the following relation between input and output & signal to noise ratio [2].

$$(S/N)_0 = 3(S/N)_i f_d^2 B_i / (2 B_0^3) \qquad (1)$$

where B_0 is the bandwidth of output lowpass filter. Assuming Radar with f_d = 2 Khz, B_0= 300 KHz and B_i = 500 KHz, Eq(1) will be as following in dB:

$$(S/N)_0 = (S/N)_i - 40 \text{ dB} \qquad (1)$$

Which shows that because of low Doppler fre – quency and high bandwidth of pulsed signal the improving factor is very low, but the above relation is still valid for lower input signal to noise ratio, i–e. when interesed target cross – section is small (for example for antiradiation missle detection), this technique works as following theoretical arguement and exprimental results.

II. Theoretical Consideration of Improved Phase – Lock – Loop Technique:

The reason that phase – lock – loop gives low improvement factor as was shown in Eg (1) is that Doppler frequency, f_d is very small, compare to intermediate input frequency bandwidth, B_i. The suggested improved technique that can change this issue is as following:

- We increase fd artificially; i.e. give some fixed difference between free running frequency of VCO