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*S—B*AND COMBLINE BAND PASS FILTER FOR AIRPORT SURVEILLANCE RADAR

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Abstract

ABSTRACT

Airport surveillance radar is a radar used at airport to detect and display the presence and position in the aircraft terminal aircraft terminal which has two types of system: the Primary and Secondary radar. In this design, a band pass filter for ASR will be placed the in primary radar block. The filter has an important function to pass the frequency needed. In this case, the filter will pass the frequencies between 2.75 — 2.85 GHz or 100 MHz bandwidth with 2.8 GHz central frequency, which bandwidth 3 dB is 100 MHz that designed of Chebycev filter by microstrip line that is types of transmission line which the path is combline that filter have structure of resonators connected by ground. The nature of combline filter is the attenuation is unlimited to wavelength resonators.However, the main pass band resonator is very high and depends on the resonator length at center of the pass band, while the cut rate on the top side on the pass band can be made steeply The result of the filter output would be implemented by the network analyzer. After the filter spec is found, the simulation process would be implemented in CST in CST design studio suite to analyze an ideal design, then the result of the simulation is checked to qualify the standard of the implemented design in the hardware After the realization process in combline band pass filter, there are several parameters that will be analyzed at the parameters of this prototype, such as frequency response, insertion loss, return loss, central frequency, and bandwidth. The spec of this result passed the frequency 72.5 MHz — 2.947 GHz, insertion loss is -5.758 dB, and minimum return loss is -27.5 dB.

Keywords: Airport surveillance radar, BPF, combline, microstrip

1. Background

Indonesia is a big country with increasing mobilization services to provide human demand. Therefore, the airport efficiency becomes the moment of the mainstay. Airport Surveillance Radar (ASR) is a radar that is used to encourage the need of commercial aircraft services. The movement of aircraft is always monitored and guided. In the present, ASR cannot cover all all of the country areas because the amount of ASR is limited and the price is relatively high In addition, the available radar spare parts are still limited and new radars are costly as well. This problem can be solved when when radars can be produced in the country to reduce the cost line maintenance. The radar compositions are important as they will support the radar's good performance.. ASR parts placed on the transmitter or receiver, and the filter functions to pass or block the frequencies needed.

ASR radars system consist of both radars primary and secondary. Normally, Normally, the maximum radar at least can detect 60 miles radius (96 Km) from the airport which uses ASR require small bandwidth to get a good transmit data ASR requires a small bandwidth to provide a good data transmission. The primary radar, as the main in radar system, has frequency band between 2.7–2.9 GHz with the result that filter in the primary in air surveillance radar. It must have a compact design and able to filter the frequency selectively[1]. According to these reasons, this thesis will propose to design a band pass filter for Airport Surveillance Radar (ASR) with the central frequency 2.8 GHz using chebyshev method that will be implemented to a combline in microstrip transmission line .

2. Basic Concept

2.1 Filter

Filter is an electronic device to control control frequency, which will pass the frequency needed. According to he filter compound, there are active and passive filter. There are more several classes categorized by the filter characteristics and frequency responses. According of the filter compound, it's can be classed by active and passive [4]. There are several classes that can be explained by filter characteristics and frequency responses. Filters can be classed by several types according of characteristic filters which are Butterworth, Bessel, Chebhicev, Eliptic. Chebychev filter is a high Q filter that uses initial descent step at the stop band and the pass band required does not need any more responses. In this type, ripples are allowed. The approach used in all of the designs in this chapter is designing the normalization prototypes that are familiar and available for designers.

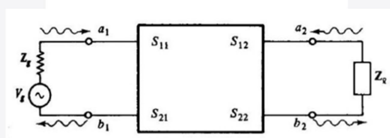
2.1.1 Filter Parameter

The realization filter design must contain several parameters explained by:

- The return loss is power losses which maximum power transfer does not happen. The return loss sources power reflection, hence on the other word, the reflection coefficient can be used to calculate the return loss which can be expressed by Formula 1

$$RL = 20\log\Gamma \quad (1)$$

- S-Parameters is a network formed from a black box consist of several components to electronics. S parameter is linear with a small input signal to produce an output that can be predicted. In this session, a circuit is used to design a frequency height. Thus, S-Parameters can perform good quality on Y, Z, and H parameters. Figure 2.3 is the S–Parameter with 4 ports and 2 terminals that can be approached by equation 2.3 and 2.4. If a1 and b1 are the forward and reverse voltages, the equation for obtaining matching condition and maximum transfer expressed by Figure 1



$$V_1 = Z_{11}l_{11} + Z_{12}l_{12} \quad (2)$$

$$b_1 = S_{11}a_1 + S_{12}a_2 \quad (3)$$

- Insertion loss is the loss of other power wave due to propagation. This loss is usually caused by transmission medium. The insertion loss also expressed by the input and output power ratio that can be considered by Formula 3 and Formula 4.

$$Li = 10\ Log_{\frac{Pt}{Pr}} \quad (3)$$

$$Li = 10\ LogS_{12} \quad (4)$$

2.2 Primary Surveillance Radar

The main radar type wave in the utilization of electromagnetic as radar system, especially in radar operation in air traffic, mainly functions as the transmitter and receiver, while the secondary radar functions as the support system[3]

The radar ability highly functions in the S-band microwave area. The surveillance radar designed with a simutanuously performing system self-test. The surveillance collects the data from the traffic control system. For antenna transmitter, waveguide component in the system configured in dual channel to reduce materials supplied, providing redundancy inherent high reliability of the system operation. In the consequence of power margins, damage degradation must be considered that the transmitter can maintain without interrupting the system. It uses low vertical but good horizontal resolution that give distance radial speed. A good target precision requires radar vertical position and actual speed. The aircraft purpose is detecting the target to monitor the vehicles movement on the ground since the target cannot mention its altitude directly. In addition, it requires a powerful emission which limits the scope.

2.3 Combline band pass filter

Combline filter is a filter which has neatly arranged structure with each end of resonator connected to ground. The filter resonator consists of transmission line elements which circuit connected between end sides.Transmission line from 1 to n which is connected to capacitor. In addition, the second pass band occurs above half wavelength. Therefore, the resonator lengths are equal The center frequency of the first pass can be approached by formula fr fo, which the resonator lengths are expressd in degrees.. The interest thing of comb line band pass filter can be approached by following

- Adequately compact.
- Designed very steeply.
- The clutch antenna element of the resonator is limited to a sufficient wide distance, which means a good coupling can be kept in a place with the least requirement.
- Have a strong stop band and the main band pass can be made over a bandwidth (broadband).
- The filter combination can be fabricated without dielectric material and the dielectric losses can be removed.

2.4 Microstrip line

Microstrip line is one of the most popular kind of Y planar transmission line. The primary transmission line is able to be integrated with the design of passive electronic devices. The effective dielectric constant can be interpreted by the electric constant of homogeneous medium that is replaced on the air and dielectric regions of the microstrip. The dielectric constant of a microstrip line given is approximately by the Formula 7

$$Z_o = \frac{60}{\sqrt{\varepsilon_e}} ln\left(\frac{8d}{w} + \frac{w}{4d}\right) \tag{5}$$

$$\alpha d = \frac{k_{o\epsilon_e} - tan\vartheta}{2\sqrt{\epsilon_e}(\epsilon_e - 1)} \tag{6}$$

$$\alpha c = \frac{R_s}{ZoW} \tag{7}$$

3 System Model and Proposed Technique

3.1 System Model

In this thesis will design a combline band pass filter and how the process technique of the combline band pass filter for primary airport surveillance rdars

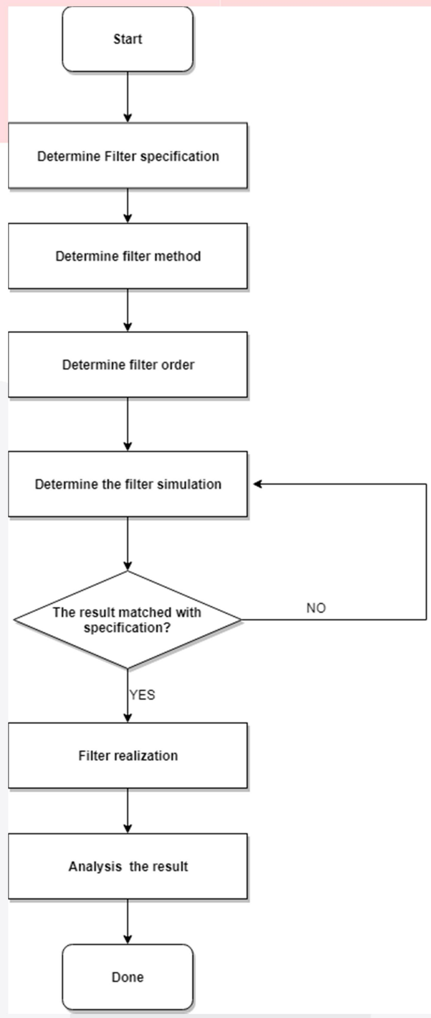


Figure 3. 1 System Model.

There are several steps to design passive filter. After finding and concluding the information about combline band pass filter for ASR, it is concluded that a measurement of good slope is more needed than the signal smoothness. Therefore, Chebychev response is the best one to use. The procedures include the filter design. A filter of primary ASR is an interesting idea to discuss that the first step is obtaining information about ASR and concluding that the frequency works between 2:75—2:85 GHz which the spec will be expressed by Table 1

Table 1. Microstrip and spec standards

	STANDAR	VALUE
MICROSTRIP	**Conductor Thickness**	**0.035 mm**
	Dielectric Substrate	**10.2**
	Substrate Thickness	**1.91 mm**
SPECS	**Frequency work**	**2.75--2.85 GHz**
	Bandwidth	**100 MHz**
	. Return loss	**Maximum 10 Db**
	Insertion loss	**Minimum 3.5 dB**

3.2 Combline Design Dimension

According of the basic theorem about combline and microstrip design in chapter 2, it will include the tep designs pressed by table 2

Table 2 Filter dimension

STANDAR	VALUE
Filter order	**7**
Resonators wide	**0.65mm**
Taps width	**1.791mm**
Resonators length	**9 mm**
Taps length	**6 mm**

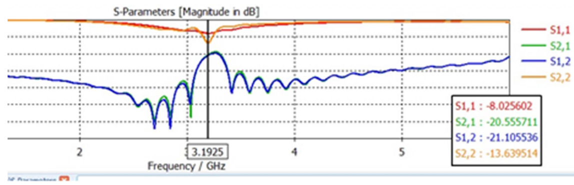


Figure 3.2 the results of the first response

Figure 3.2explain the result of early calculation. According of this reason the optimization is needed because the spec not yet reached.

3.3 Simulation Optimization

The simulation optimization is started by the obtained values from parameters trial during simulation. The results show out of matches desired by initial specifications. Therefore, the optimization process result such Table 1.3

Table 1.3 the optimization result

STANDAR	VALUE
Filter order	**7**
W1	**0.81 mm**
W2	**0.6 mm**
W3	**0.57 mm**
W4	**0.63 mm**
W5	**0.645 mm**
W6	**0.65 mm**
W7	**0.62 mm**
W8	**1 mm**
Resonators wide	**0.5mm**
Resonators length	**21.5 mm**
Taps length	**5 mm**

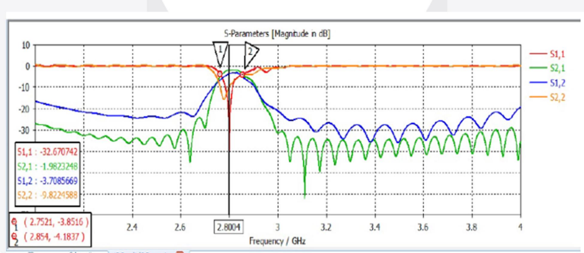


Figure 3.3 Optimization results

3.4 Measurement result

A filter has function to select frequencies needed which can be categorized well if the output is accordance to the device. In this undergraduate thesis, several specifications needed for filter measurement which include of return loss and insertion loss values, which both will describe the Bandwidth condition, work frequency, and filter type. Therefore, the data will describe measurement results which the simulation result displayed by CST design studio suite and the result of realization will be displayed by VNA (Vector Network Analyzer). The data explanation will be discovered by several parts. The result of measurement in network analyzer will be discovered by .

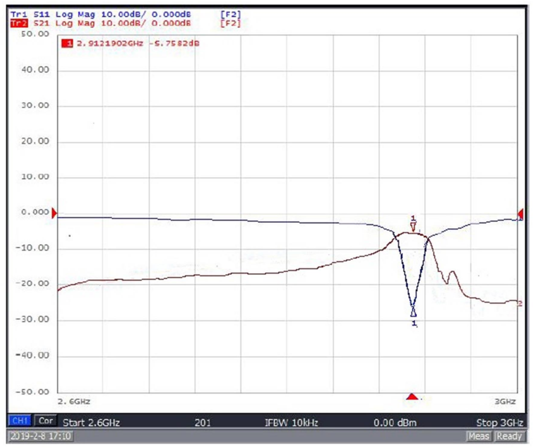


Figure 3.4 Optimization results

The return loss value is -27.08 on 2.91 GHz. To clarify the problem frequency response can be described by figure 4:9. The insertion loss value on frequency 2.91 GHz is -5.75 dB. To clarify the problem, frequency response can be described by figure 4:10. According to the return loss and insertion loss, it can be concluded that the filter realization have bandwidth 72.5 MHz on center frequency is 2.91 GHz. On the other hand, there is 110 MHz frequency shifting and 2.75 MHz bandwidth reducing. The filter simulation will be done in CST design studio suite software. Previously, the primary radar operates at a frequency the of 2.7 -- 2.9 GHz in the S band, therefore this filter can be operated if it is fixed by characterization to increase the insertion loss and to shift the work frequency.

3.5 System Performance

The performance system analysis shows the combline filter functional results of the realization by comparing the measurement results from the planned initial specifications and from the simulation results. The following is a comparison of the initial specifications, simulations and measurement results. Combline filter functionality in passing frequencies whose applications are contained in the Synthetic Aperture Radar system and dampens other frequencies that unneeded by the system because it can decrease the system work From the comparison of the specifications results, the simulations and results of the measurements above has a range is a range of frequency and bandwidth. From the comparison of the specifications results, the simulations and results of the measurements above has a range results show greater comparison with the specifications and simulation results. This will affect the work of the Synthetic Aperture Radar system which should only have a bandwidth of 100 MHz. The measurement results show 72.5 MHz which is caused by the working system of software used in simulating the measurement results, which is based on a Finite Integration in Technique (FIT). This design is more effective and simple than other simulators based on the FEM method.Then the measurement results also show the value of of return loss is still greater compared to the results of the design, meaning that there is still a lot of power reflected back to the source which means a less efficient use of power.And for And for the insertion loss, the measurement results are still too small compared to the measurement results, thus the output port will be small, since the combline filter works in -5-758 dB which should be -3 dB. This Chebyshev response has good selectivity, but the phase linearity depends on the ripple value used in the design, which is 0.1 dB.

4. Conclusion

Overall, the results of the bandwidth and return loss values have met the filter specifications, only the frequency of work and the insertion loss have changed a little value has not been reached, so to make this application work it needs to be repaired. The filter design requires a good S-parameter value to produce a filter with good performance. In this thesis, the return loss value is -27.5 dB and the insertion loss value is 5.7 dB. Changing values from S-parameter can change the filter bandwidth value.The result is a combline filter with a bandwidth of 100 MHz at the working frequency of 2.8 GHz. While the results of the realization of the filter is a combline filter with the bandwidth of 72.5 MHz and working frequency in 2.91 GHz. Substrate dissipation factor affects the formation of microstrip filters. If the bandwidth is narrow, the smaller the dispensation factor results and the smaller the insertion loss. On the other hand, the insertion loss value also affected by filter bandwidth. The smaller the bandwidth, the greater the insertion loss.Grounding design also greatly affects the results of the filter, especially for its insertion loss form. Using a full ground plan can reduce the insertion loss value. It will increase the bandwidth, reduce the return loss value each substrate. The port also has the optimum dielectric constant at certain frequencies.

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