Indonesian Journal of Electrical Engineering and Computer Science
Vol. 3, No. 1, July 2016, pp. 136 ~ 142
DOI: 10.11591/ijeecs.v3.i1.pp136-142

Design, Simulation and Fabrication of Band Pass Filter 308 MHz Narrow Bandwidth Using Technology Surface Mount Technology (SMT) on FMCW Radar Frequency Generators

I Dewa Putu Hermida, Deni Permana, Iqbal Syamsu
Telecommunication Division, Research Center for Electronics and Telecommunications,
Indonesian Institute of Sciences (P2ET-LIPI)
Jl. Sangkuriang, Gedung 20, Lantai 4, Bandung 40135, INDONESIA
Ph. 022-2504661, Fax. 022-2504659
Corresponding author, e-mail: idewaputu@gmail.com, denny@ppet.lipi.go.id, iqbalsyamsu@gmail.com

Abstract

Has been research a band pass filter with a steep slope the working frequency 308MHz with 4 MHz bandwidth used in navigation radar system. To overcome this, the design is done by using two filters are combined. Merger This filter consists of a single filter consisting of a low pass filter with a cutoff frequency that works at a frequency of 310 MHz, and a high pass filter with a cutoff frequency that works at a frequency of 306 MHz Type filter is used to generate the elliptic filter steepness better by ignoring the ripple in the pass band for narrow bandwidth. For a low pass filter, stop band width (Fs) approximately 20% of the cutoff frequency occurs at a frequency of 372 MHz, with stop band depth (As) of about -55 dB As for the high pass filter, stop band width (Fs) approximately 20% of the cutoff frequency that occurred at a frequency of 244.8 MHz, with stop band depth (As) of about -55 dB. The output filter is used as a clock on direct insert digital synthesizer (DDS). Using the components of surface mount technology (SMT), then the resulting circuit with its small dimensions, compact and has a high Q. Elsie used in the simulation stage software version 2.72, the manufacturing process using protel 99SE, and the stage of measurement using a vector network analyzer (VNA) Advantest R3770 type.

Keywords: *SMT, elliptic filter, stop band width, stop band depth*

1. Introduction

Radar that have meaning radio detection and ranging is a system that can detect objects using radio waves. One type of radar that can transmit power with lower pick as well as the transmitted signal cannot be cut or detained by other radar is a type of radar FMCW (frequency modulated continuous wave) [6]. This type of radar would emit radio waves continuously modulated signal with a triangular shape (triangular wave), socalled continuous wave. In signal processing, the signal reflected by the target will be compared with the signal sent that will produce the beat frequency [6]. For the purposes of synchronization, then used a clock signal generated from the same source (coherent) [5].

To generate clock frequencies required by the DDS (direct digital synthesis), then the signal is taken directly from DRO (dielectric resonant oscillator) with through -20dB directional coupler who works at a frequency
X Band. The signal is then carried out the division in stages, so that the resulting frequency is still within the scope of the DDS that is less than or equal to 400 MHz [5].

By looking at the block diagram in Figure 1, it would require a filter with narrow bandwidths and has a small dimension. In the manufacturing stage filter is realized using SMT components, so it can produce its small dimensions and high Q. Narrow band filter is a filter that has a band width smaller than one-tenth of its resonance frequency (B <0,1ωr) [4], [8]. Comparison between the resonant frequency and bandwidth known as the quality factor (Q) of the circuit. Q shows the selectivity of the circuit, the higher the Q value the more selective the filter circuit. To fitter narrow bandwidths, the Q of the circuit is greater than 10. The band-pass filter arranged to filter high-pass and low-pass filter as in Figure 2 above [4], [8].

Received February 2, 2016; Revised May 25, 2016; Accepted June 10, 2016

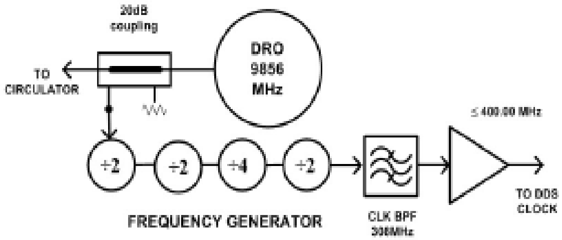

Figure 1. Frequency Generator FMCW Radar System [2]

Filter is an electronic device designed to dampen a specific frequency signal, and passes the signal on another frequency. Filters can also be used as frequency capping at a certain frequency spectrum. The band pass filter is a filter designed to pass a frequency range between, which combines low pass filter with a high pass filter [1], [4].

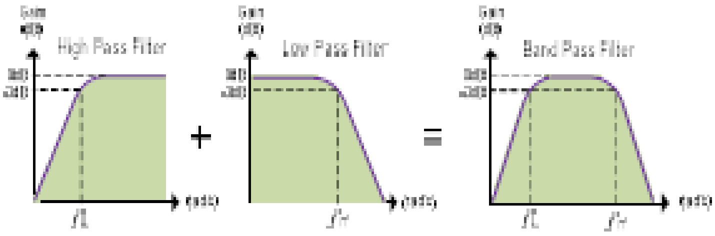

Figure 2. Composite High Pass Filter and Low Pass Filter

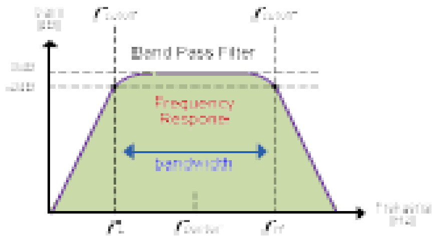

Figure 3. Frequency Response Band Pass Filter

In the design of the filter, octave has a double meaning or divide the frequency, whereas a decade means ten times or one-tenth times the frequency. Thus, the gradient or slope roll off or stop band called fall-off is defined by the level of the order as follows [1], [4] :

a. The first-order filter (1st order), its roll off is -6 dB / octave or -20 dB / decade
b. The second-order filter (2nd order), its roll off is -12 dB / octave or -40 dB / decade
c. The third-order filter (3rd order), its roll off is -18 dB / octave or -60 dB / decade

In designing the simplest filter is a filter with the first order. Strengthening the input signal is -20 dB for each frequency change multiple of 10 at band transition, called the strengthening of -20 dB / decade. To design a low under cooling second order filter, its gain is -40 dB / decade or -12 dB / octave [1], [7]. Thus, the performance of the filter is the formation of two times, wherein the second order has higher complexity due to a two-tier arrangement in series of a first order filter. Cut-off frequency is defined as the point of demarcation between pass band to stop band, so that at the point of a cut-off frequency when the voltage 2 time of strengthening its□strengthening decreased by 0.707 or 1/pass band [1], [7]. To maintain the slope of the cut-off in the low-order, then used elliptic filter has a ripple though less well in the pass band and stop band regions when compared with the Butterworth filter and the Chebyshev filter [4], [9].

2. Design, Simulation and Fabrication

Using software simulation version 2.72 of tone software elsie, then the stage of designing and simulating the characteristics of a high pass filter cut-off frequency -3 dB at 306 MHz, the Order of 7 pole filter, stop band width (Fs) of about 20% in the the frequency range of 245 MHz, with stop band depth (As) of about -55 dB [3], [7].

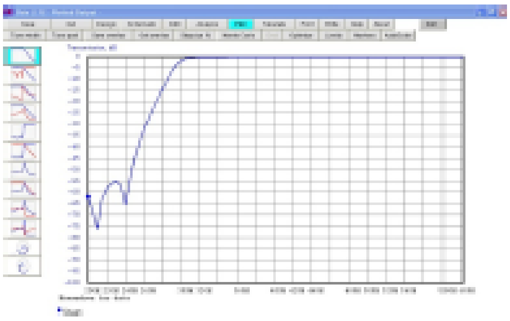

Figure 4. Simulation of Transmission (dB) with Software Elsie Versi 2.72 [3]

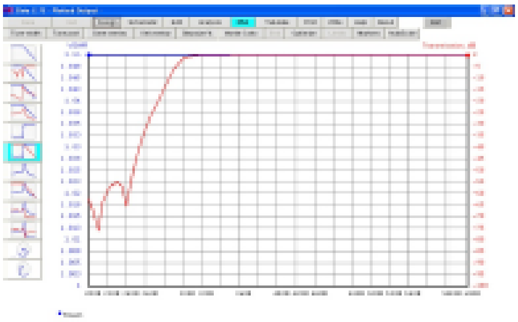

Figure 5. Transmission and Simulation of SWR with Software Elsie Versi 2.72 [3]

Figure 6. Schematic of High Pass Filter 306 MHz [3]

Design and simulation of low pass filter with a cut-off characteristics of -3 dB at a frequency of 310 MHz, the Order of 7 pole filter, stopband width (Fs) of about 20% in the frequency range of 372 MHz, with stopband depth (As) of about -55 dB [3].

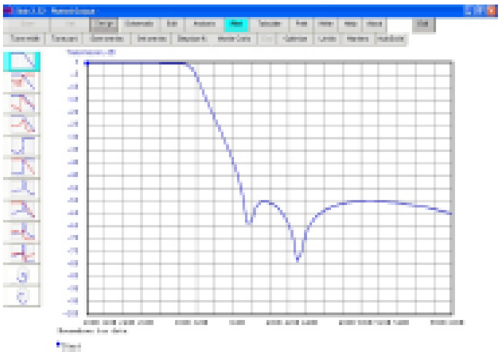

Figure 7. Simulation of Transmission (dB) with Software Elsie Versi 2.72 [3]

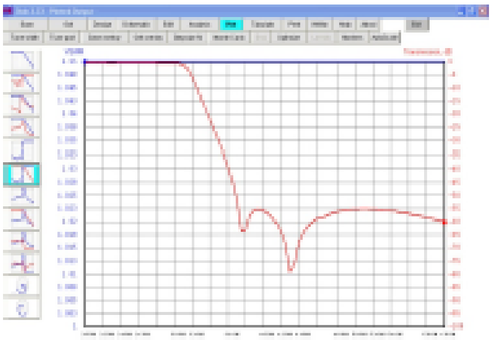

Figure 8. Transmission and Simulation of SWR with Software Elsie Versi 2.72 [3]

Figure 9. Schematic of Low Pass Filter 310 MHz [3]

With protel 99 SE design software for PCB, the simulation results in the form of a schematic of the filter circuit is then made its PCB.

Figure 10. PCB Low Pass and High Pass Filter

Figure 11. Fabrication Low Pass Filter 310 MHz

By using measuring equipment VNA (vector network analyzer) type Advantest R3770 network analyzer 300 kHz -20 GHz, the filter that has been simulated and fabricated measurement laboratory scale.

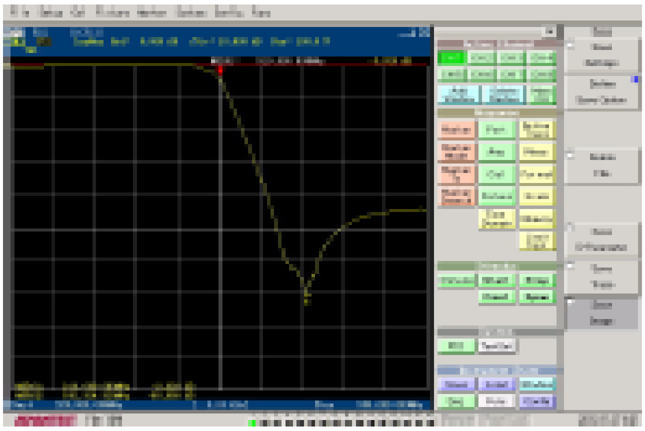

Figure 12. Results of Laboratory Scale Measurements of 310 MHz Low Pass Filter.

Figure 13. Fabrication High Pass Filter 306 MHz.

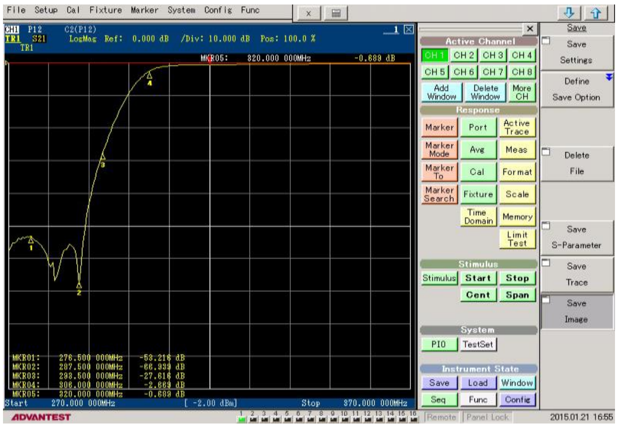

Figure 14. Results of Laboratory Scale Measurements of 306 MHz High Pass Filter.

Figure 15. Fabrication Band Pass Filter 308 MHz

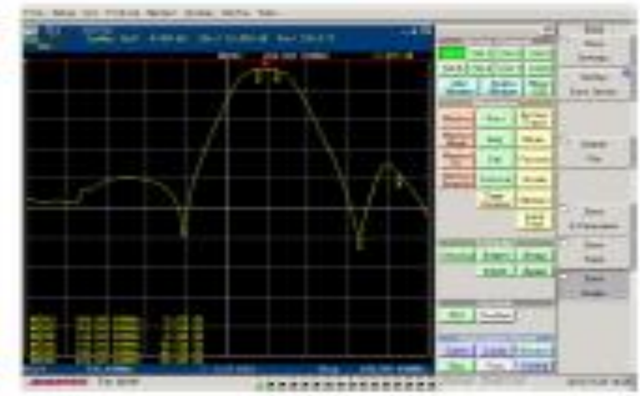

Figure 16. Results of Laboratory Scale Measurements of 308 MHz Band Pass Filter

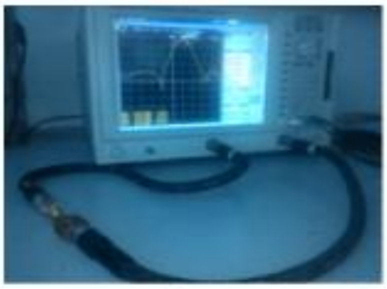

Figure 17. Measurement of 308 MHz Band Pass Filter in The Laboratory

3. Discussion

After the simulation, then do the manufacturing stage. The first step taken in the manufacturing stage is partially fabricated, it aims to determine the performance of each part. From the measurement results of laboratory scale, it can be seen the performance of each part has to meet the characteristics specified. Thus, the next step is the process of integration by combining the low pass filter and a high pass filter and then measuring to a band pass filter.

By using software version 2.72 Elsie on stage simulating transmission on the plot produced high pass filter circuit as in figure 4. cutoff 300HMz -3dB frequency and to stop band width (Fs) 20% of the cutoff frequency that occurred at a frequency of 240 MHz, with stop band depth (As) about -65dB. When compared with planning where -55dB stop band depth, it can be seen that at this stage of the simulation has sharper results about -65dB, with wider cutoff. If the simulation result is compared with the results of manufacturing, it can be seen in Figure 14. cutoff 305HMz -3dB frequency and to stop band width (Fs) 20% of the cutoff frequency that occurred at a frequency of 287.5 MHz, with stop band depth (As) around -66.339 dB. When compared with the results of simulation where -65dB stop band depth, it can be seen that at the manufacturing stage has sharper results around -66.339dB, with a narrower cutoff.

In a series of low pass filter, resulting transmission plot as in Figure 7. The -3dB cutoff frequency for the stop band 315HMz and width (Fs) 20% of the cutoff frequency that occurred at a frequency of 375 MHz, with stop band depth (As) around -64dB. When compared with planning where -55dB stop band depth, it can be seen that at this stage of the simulation has sharper results about -64dB, with wider cutoff. If the simulation result is compared with the results of manufacturing, it can be seen in Figure 12. The cutoff -3.02dB on 310HMz frequency and to stop band width (Fs) 20% of the cutoff frequency that occurred at a frequency of 331.314 MHz, with stop band depth (As) around -60.939dB. When compared with the results of simulation where - 64dB stop band depth, it can be seen that at this stage of the simulation has sharper results about -64dB, with cutoff accordance with the plan.

The measurement results fabrication band pass filter (BPF) 308 MHz can be seen in Figure 16 and 17 shows the center frequency measured at marker 1 is 308 MHz, marker 2 and marker 3 each measured 305 MHz and 312 MHz so this filter bandwidth at 7 MHz. Marker 1 to peak level measured at -2.978 dB remained above the -3 dB as half the maximum power requirements. This filter is eligible sharpness slope where stop band width (Fs) 20% of the cutoff frequency of about 20%. It can be seen from the results of measurements on the marker 4 and marker 5 in which each measured 378 MHz power levels -59.584 dB at 248 MHz power level -55.874 dB.

4. Conclusion

By comparing the results of the design and simulation as well as see the results of measurements at the manufacturing stage, it can be concluded that the 308MHz band pass filter that was planned has met the specification. In planning, the planned bandwidth of 4MHz while manufacturing is 7MHz results, but these results are still in the requirements specification for a narrow band because the Q value of the circuit is greater than 10. Stop band width (Fs) 20% of the cut-off frequency planned to stop band depth (As) of -55 dB, while the results of fabrication is -60dB. As for the dimensions of the filter, has a small size and compact because it employed the component surface mount technology (SMT).

Acknowledgment

This work was financially supported by LIPI Program 2015.

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