ELECTRONICALLY TUNABLE BANDPASS FILTER

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ABSTRACT

An electronically tunable bandpass filter is presented. It is a combline filter realized in microstrip form. The filter is made tunable by using the variable capacitance of a GaAs fet (or of a varactor). With the use of this technique it is possible to achieve relative bandwidth from 8% to 30%, a tuning bandwidth up to 50% and a center frequency up to 18 GHz. A remarkable characteristic of this device is that it requires no driving current and it presents only a capacitive load (of about 10 pF) to its driver. So, we have an electronically tunable filter with a tuning time of a few nanoseconds. This paper describes method of design, simulation and performance of some monolitic realizations of the filter.

SYNTHESIS

The structure of the filter is shown by Fig. 1. We have N microstrip resonators of equal width and lenght. The lumped capacitors (all of equal capacitance) are the variable capacitance of a GaAs fet. Many methods can be adopted for the synthesis of the filter. In our case, because of the narrow bandwidth of the filter, a step by step procedure has been used:

1) Calculate the capacitance value needed for the frequency variation in the desired bandwidth.

2) Choose the dimensions of the resonator w and l so that l/w>2 and the resonance frequency of the resonator is equal to the lowest frequency in the desired tuning range.

3) Determine the tapping point lt and the spacing between adjacent resonators using the well known "coupling coefficient and Qex method" as illustrated in Fig. 2. (A transmission line trasformer at input is used to circumvent the difficulty of having the tapping point too much near to the grounding point of the resonator).

SIMULATION AND DESIGN

It is possible to simulate a microstrip combline filter on conventional microwave CAD programs (such as TOUCHSTONE) if the order of the filter N (or the number of coupled lines) is up to three. If N>3 we have to implement an appropriate simulation program or we have to use an equivalent circuit for the N coupled microstrip lines (for example with the use of GRAYZEL identities). Three filters in microstrip on allumina in three different tuning ranges: 6-9 GHz, 9-14 GHz & 14-18 GHz have been designed. The same filters have been also realized in GaAs MMIC form using the PLESSEY Foundry.

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RESULTS

Figs. 3 show the CALMA layouts and the RF performances of the three MMIC realizations of the tunable filters for the three different tuning ranges.
Fig. 4 shows the test equipment for measuring the tuning time of the filter with a typical measured performances which shows a tuning time less than 10 nSeconds. An integrated component has been realized using said three filter cells; the measured filtering characteristic, over the full 6-18 GHz band, is shown in Fig. 5.

REFERENCES

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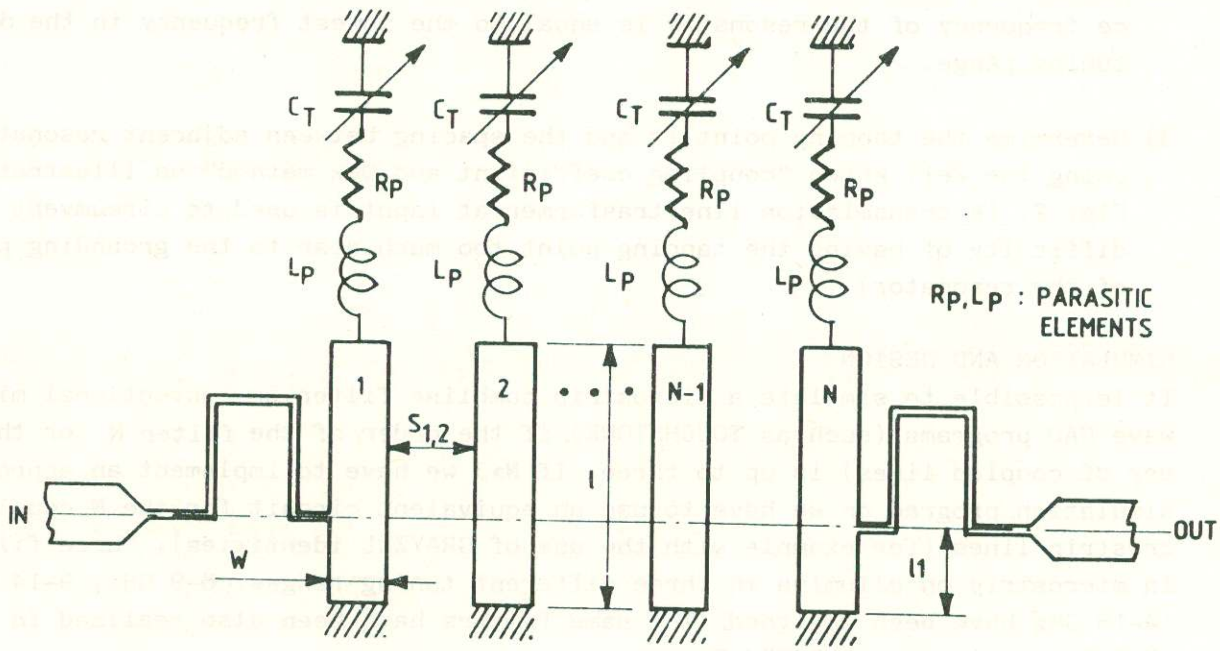
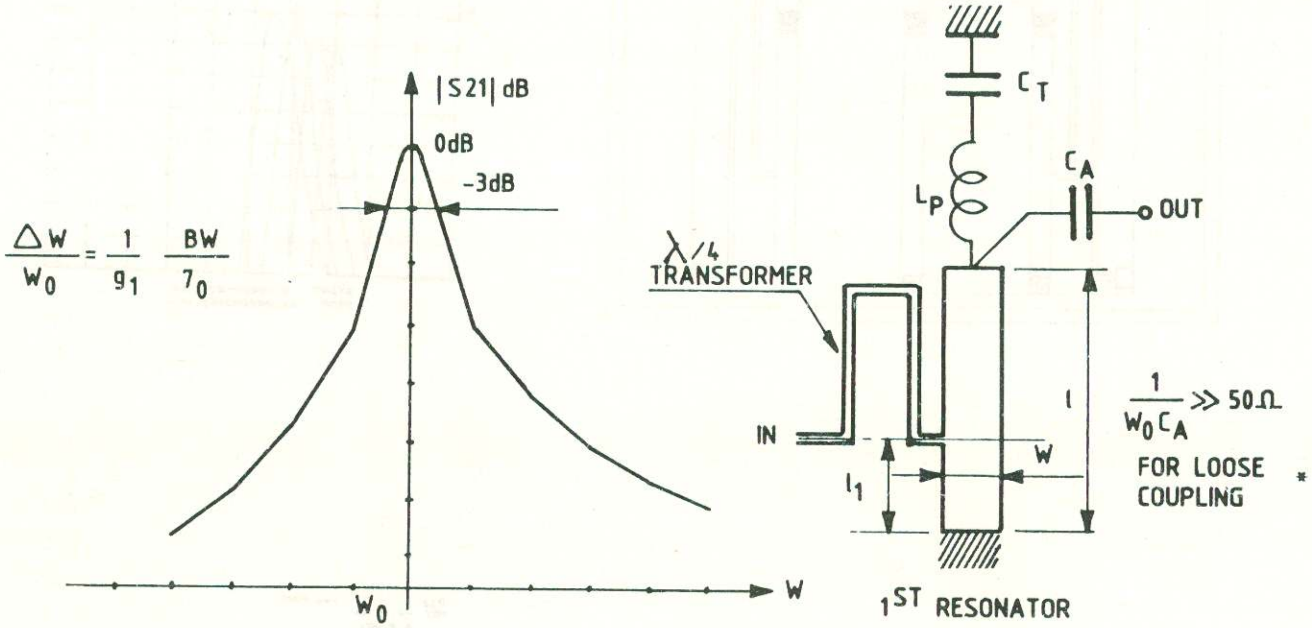


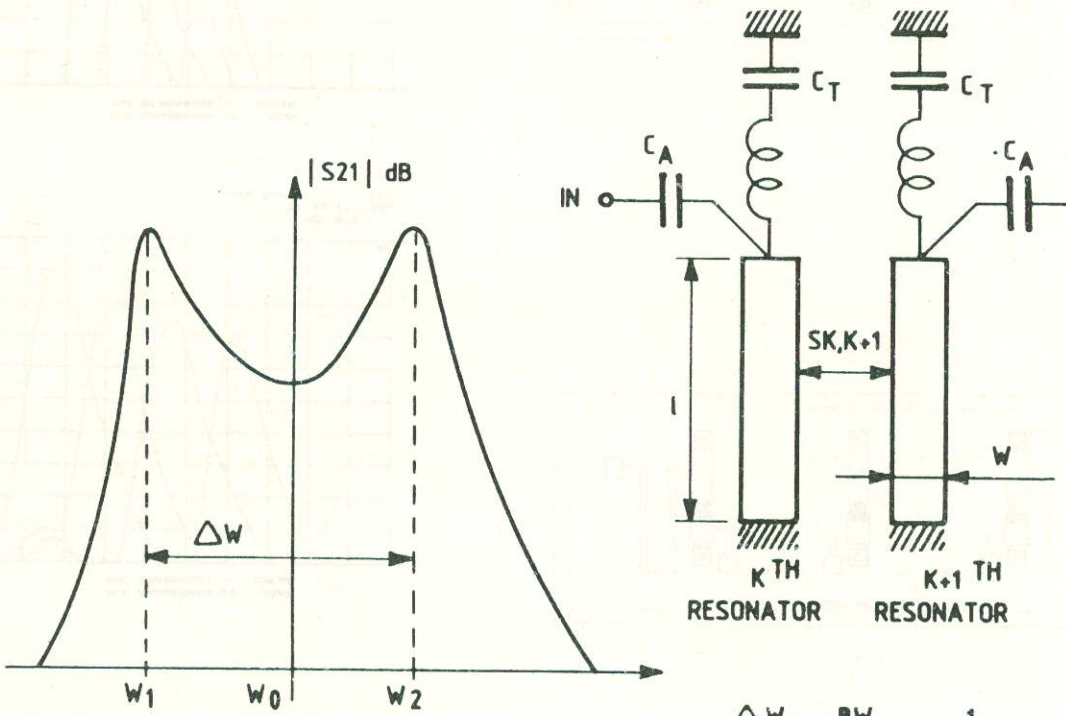
FIG. 1 : STRUCTURE OF THE MICROSTRIP COMBLINE FILTER

FIG. 2

1) CHOOSE THE TAPPING POINT l1 SO TO HAVE :



2) CHOOSE THE COUPLING BETWEEN EACH PAIR OF ADJACENT RESONATORS (SK, K+1)

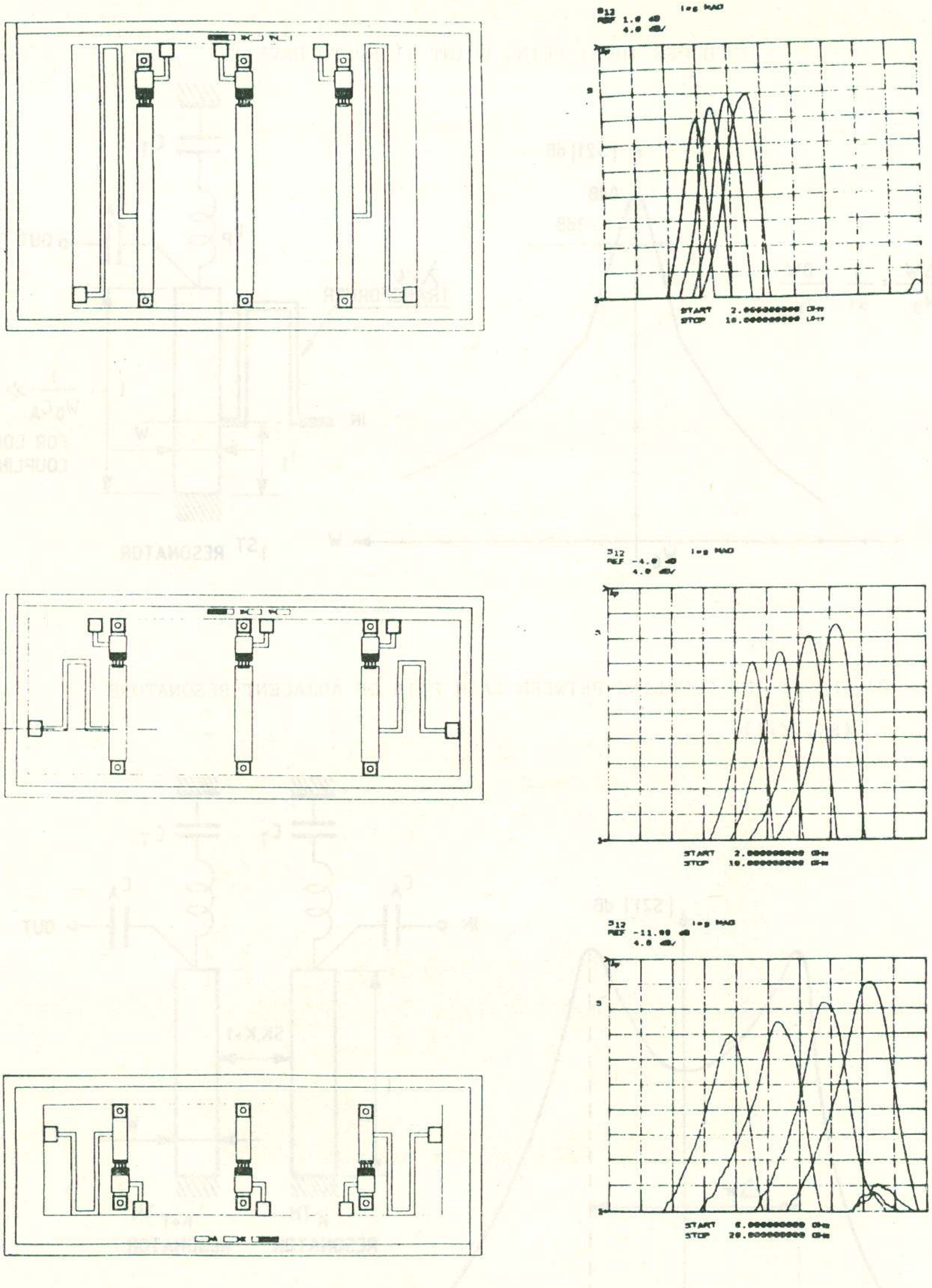


$$\frac{\Delta W}{W_0} = \frac{BW}{f_0} \frac{1}{\sqrt{g_K g_{K+1}}}$$

WHERE f_0, BW ARE THE DESIRED CENTER FREQUENCY AND BANDWIDTH OF THE FILTER

* FOR EXAMPLE: IF f_0 = 6 GHz CA $<$0.1 pF

FIG. 3


log MAG
REF 1.0 dB
4.0 dB/
START 2.000000000 GHz
STOP 10.000000000 GHz
log MAG
REF -4.0 dB
4.0 dB/
START 2.000000000 GHz
STOP 10.000000000 GHz
log MAG
REF -11.00 dB
4.0 dB/
START 6.000000000 GHz
STOP 20.000000000 GHz

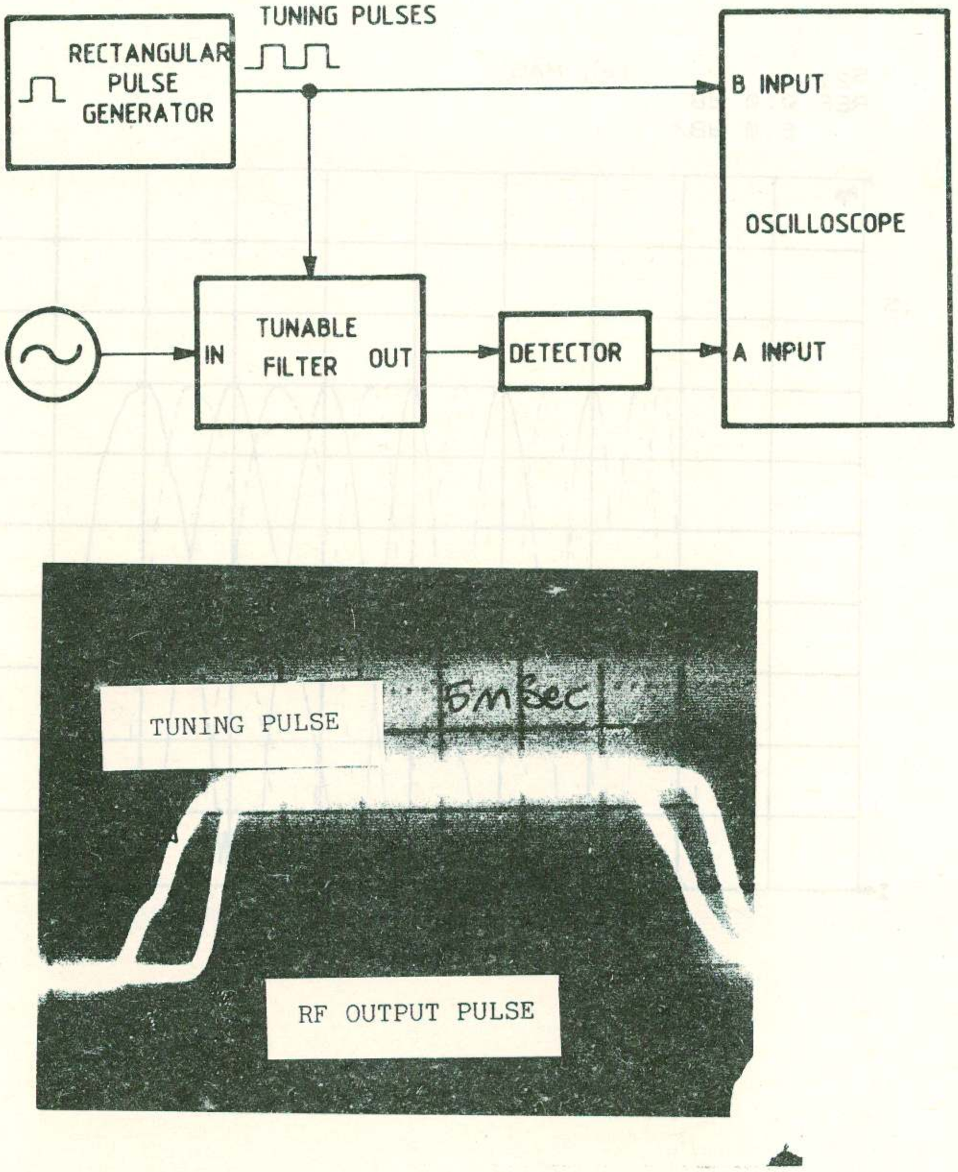
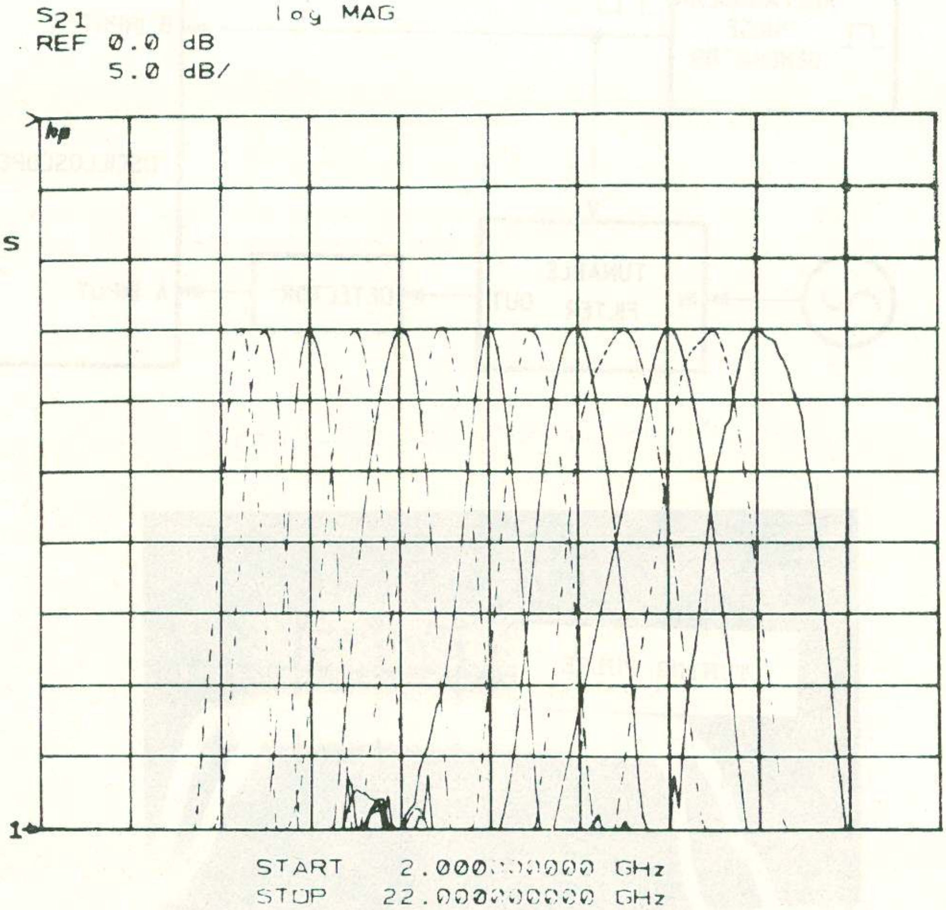

TUNING PULSES
RECTANGULAR PULSE GENERATOR
B INPUT
OSCILLOSCOPE
TUNABLE FILTER
IN
OUT
DETECTOR
A INPUT
5msec
TUNING PULSE
RF OUTPUT PULSE

FIG. 4

FIG. 5


S21
log MAG
REF 0.0 dB
5.0 dB/
hp
S
1
START 2.000000000 GHz
STOP 22.000000000 GHz