A NOVEL 2-4 GHZ MULTI-PASSBAND TUNABLE AND GAIN CONTROLLED MINIATURE ACTIVE EQUALIZER/FILTER

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ABSTRACT

This paper presents the design and performance of a novel tunable active equalizer/filter intended for use in wide band systems such as EW. The proposed circuit operates in the range 2-4 GHz, it has a simple circuit topology, low cost in manufacturing, narrow instantaneous bandwidth (100-200 MHz), has a gain control of more than 20 db and has an instantaneous multi-band capability.

INTRODUCTION

Many microwave sub-systems need some type of equalizer network to compensate for various parasitic effects, which usualy cause fluctuations or ripple in the system gain or phase vs. frequency. This is particulary important for wideband systems, like those used for EW applications. In such systems, a wide range of frequencies is covered because the system must handle a large number of signals at different frequencies. However, since each individual signal is narrow band, once the signal is received it is beneficial to decrease the system bandwidth in order to improve the dynamic range and selectivity. All the above requirements can be solved by incorporating in the system an active equalizer circuit with the following properties:
1) Wide tuning range to cover the entire system bandwidth.
2) Multi-passband response to enable handling of several signals simultaneously.
3) Narrow band response at each passband (dynamic range, selectivity).
4) Gain control to compensate for possible large ripple of gain vs. frequency of the system.
5) Small size (incorporation in airborne sytems).

This problem has been addressed in the past, and several circuits have been suggested [1-3]. These circuits have some of the above mentioned capabilities. In this paper we present a novel circuit, which performs all of the above requirements in a simple and elegant way. In addition to fulfilling all of the above requirements the new circuit also offers:
1) Simple circuit topology.
2) Low cost and simple manufacturing.
3) Narrow bandwidth achieved without high Q circuits.
4) Gain control implemented by a simple variable resistor.

EQUALIZER CIRCUIT DESIGN

The building block of the equalizer circuit is presented in Fig.1. The network is basically a feedback amplifier, which incorporates an amplifier in the main branch and a feedback circuit made up of a series combination of parallel resonant circuits. Each resonant circuit includes a fixed inductor, a variable capacitor and a variable resistor. In principle, several resonant circuits can be incorporated to achieve the multi passband capability. In our design we included only two such circuits to demonstrate the concept.

The network operates as follows: The feedback circuit is a multiband simple one section bandstop filter, so that it allows large feedback at all frequencies except in the vicinity of the resonant frequencies. The strong feedback reduces dramatically the gain of the network, so that gain is exhibited only at the stopbands of the feedback network. Thus, a simple one section bandstop filter is converted into a narrow bandpass filter. Frequency tuning is achieved by the variable capacitor, and gain control is implemented by the variable resistor. To avoid parasitic oscillations the gain of the amplifier

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must be limited to around 15-20 db. If higher gain values are required, it can be achieved by a cascade connection of several units as in Fig.1. In our initial implementation we incorporated only one section.
Another problem is the large mismatch of the above network, due to the large feedback. This problem can be solved by either circulators or attenuators at the ports of the final circuit (not for each section); however, a better solution is to use amplifer chips, which can achieve the desired matching and add gain (rather than loss). We have used the latter approach.
The amplifier used in the equalizer circuit is a Texas Instruments 8226 MMIC chip, which is small (58x73x6 mils) and low cost. The inductors are self-made air inductors with Q value around 40 at 1 GHz. The variable capacitors are Frequency Sources GaAs varactor diodes with a capacitance range 1 to 5 pF and a Q value of 220 at 1 GHz. The variable resistors are MA/COM PIN diodes. The equalizer was designed for the frequecy range 2-4 GHz, and includes one section of the type shown in Fig. 1 and two additional amplifiers of the same type (8226), one at the input port and one at the output port, which serve as both isolators to improve input and output matching and also increase the gain of the unit.

EQUALIZER CIRCUIT STRUCTURE

The circuit layout of the initial equalizer circuit is depicted in Fig. 2. It is built as an MIC circuit on duroid substrate. In the region that includes the resonant circuit the ground metal has been removed to avoid degradation of the inductors Q. The figure shows the equalizer section and the two additional amplifiers. The circuit was packaged into a custom designed metal box. The equalizer was designed by using Touchstone software. To demonstrate the capabilities of the suggested circuit typical calculated gain response for a three section equalizer is presented in Figs. 3 and 4. Fig. 3 depicts the response of the equalizer with both resonant circuits tuned to the same frequecy. Shown is the respone for several tuning adjustements over the frequency range of the circuit. The results show a reasonably narrow bandwidth (100 to 200 MHz), a peak gain of 35 to 42 db and a dynamic range of more than 15 db. In Fig. 4 the calculated response with the two resonant circuits set to different frequencies is shown. This demonstrates the multi-band capability of the equalizer circuit. The gain control capability is also demonstrated in Fig. 4 by varying the resistance value in one of the resonant circuits. A gain control range of 20 db is shown. The expected performance of the actual circuit, namely one section only, was calculated and is presented in Figs. 5 and 6. Fig. 5 is a tuning curve (same as Fig. 3), and Fig.6 is a two-band setting (same as Fig. 4). For the single stage equalizer the dynamic range is only around 10 db and the gain control range is around 10 db. Due to technical difficulties, it was impossible to present here the experimental results by the due date of the paper. These results will be presented in the symposium.

CONCLUSIONS

This paper presents a novel equalizer circuit for use in wideband systems such as EW applications. The new circuit has all the important properties normally required for such an application. The circuit is relatively simple and low cost, and can be implemented in MMIC.

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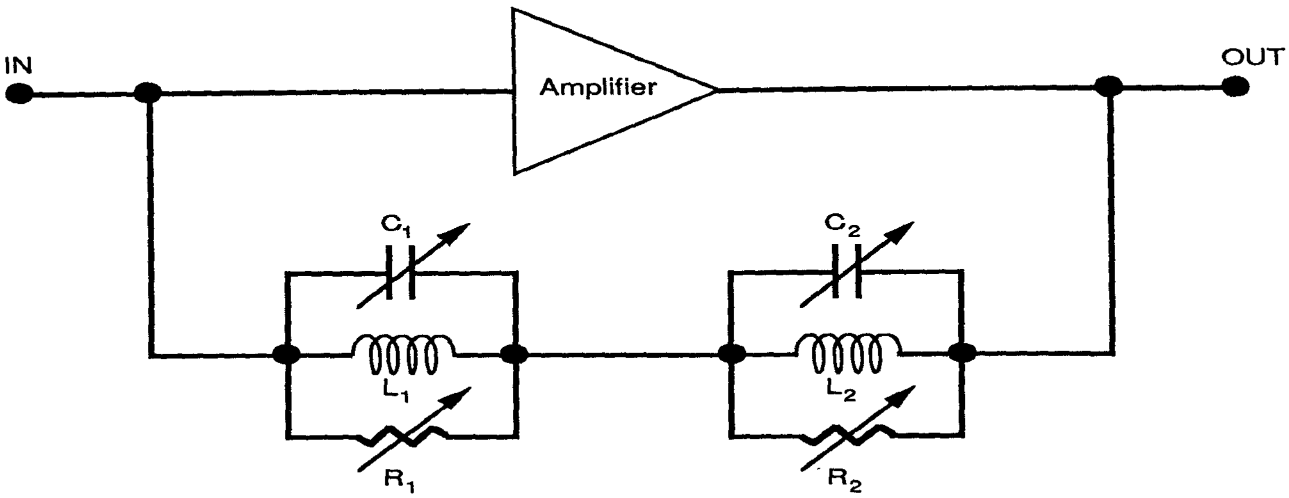

Fig. 1 Equalizer Building Block

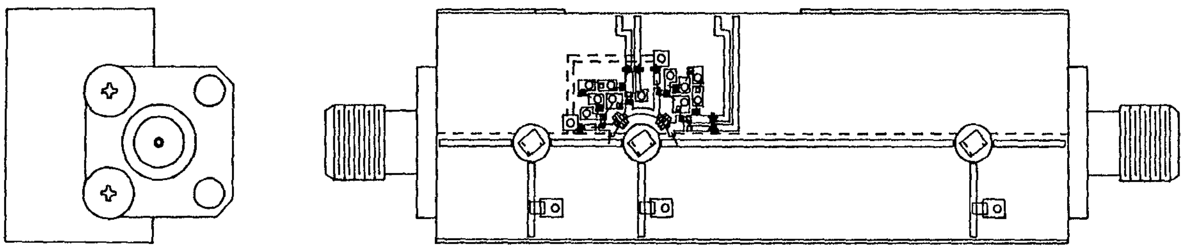

Fig. 2 One stage Equalizer circuit with input and output amplifiers

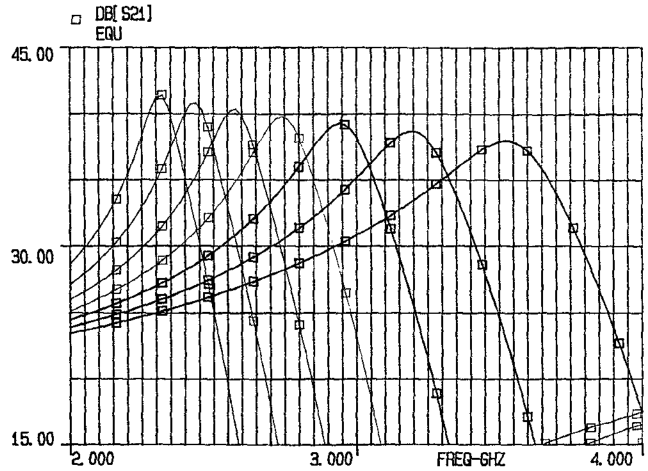

Fig. 3 Tuning curve for the three stage equalizer

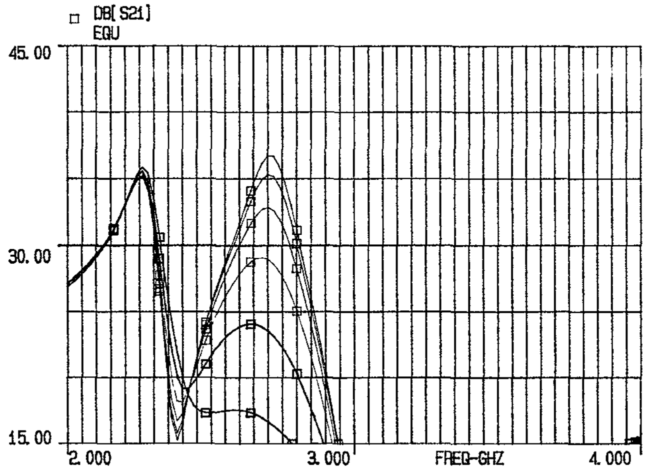

Fig. 4 Two-band gain control demonstartion of the three stage equalizer

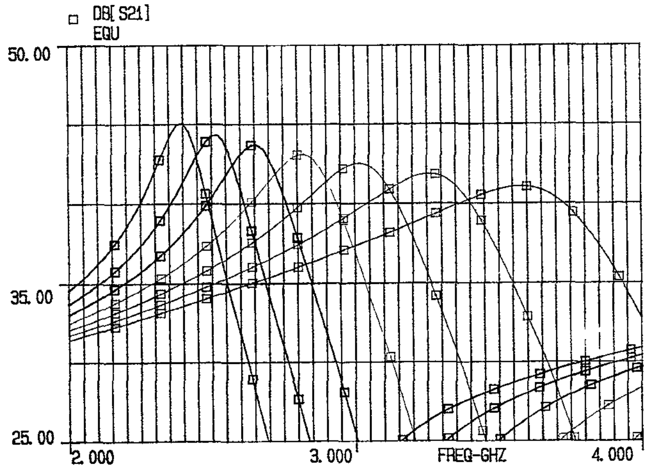

Fig. 5 Tuning curve for the single stage equalizer

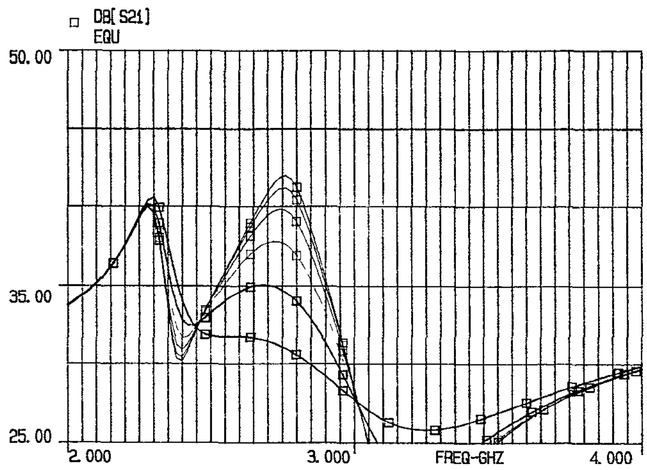

Fig. 6 Two-band gain control demonstartion of the single stage equalizer