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Adaptive Dynamic Filter using MOSFET Receiver

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Abstract: In Optical wireless communication systems a reliable link is required for user mobility under different channel conditions. In this paper, concept of adaptive receiver for bandwidth system using MOSFET is discussed that will maintain and enhance the reliability of the optical link for different channel conditions. The proposed system is found to be more sensitive to any variations in signal-to-noise ratio (SNR) at higher noise magnitudes. The circuit design consists of four circuits which are rectifier, low pass filter, dynamic filter, and output amplifier. The circuit was simulated for 43.775 kHz (0.01µf) to 0.2 MHz (44pF). The designed adaptive system can be used in existing optical system to vary the bandwidth of receiver for different applications.

Keywords: Dynamic filter, MOSFET, Receiver, Signal-to-Noise Ratio (SNR).

1. Introduction

In wireless communication system, the communication link needs to be reliable under varying channel conditions. These condition are depended in different conditions such as; distance between transmitter and receiver. These conditions are also dependent on obstructed and the strength of inter-symbol interference induced due to multipath dispersion for the optical link. The variable channel conditions can be observed and using signal-to-noise ratio (SNR) at the receiver end. Under contrary conditions, instead of experiencing the link failure, it is desirable to maintain the link for low data rates and bandwidth to maintain the link stability. In this condition, an adaptive bandwidth filter is needed for receiver with improved SNR, to maintain the reliability of transmission link for different channel conditions by varying noise/SNR [1]. The reliability issues for an optical fiber link for non-directed indoor optical wireless scenarios for different channel conditions is challenging [2-4]. In this paper, reliability of wireless communication system is demonstrated using adaptive bandwidth system via Metal Oxide Semiconductor Field-Effect transistor (MOSFET) is investigated. The designed adaptive filter system is found to be more delicate to any dissimilarities in SNR at high noise magnitudes. In the next section, brief introduction about developing the adaptable bandwidth using MOSFET and related studies of adaptable bandwidth using MOSFET are also discussed.

2. Literature Review

The variation in bandwidth can be achieved using different electronic circuit configuration such as; CMOS, FET and etc. Among these configuration MOSFET is most popular due to its reliably of handling the noise. MOSFET are used to develop various configuration of amplifiers and filters that can be used in optical communication [5]. The most related work, in designing the adaptive filter are discussed next.

R. R. Silva [6] investigated an active RC filters for dynamic range in MOS technology. The designed filter works in continuous-time and therefore provides the advantage of over sampled-data to remove the aliasing. In addition, the filter design is straight forward, based on well-established active RC filter theory. The behavior of the actual implementation was in good agreement with computer simulations and analytical results. The filter exhibited low noise and good linearity, resulting in wide dynamic range. C. Chang [7] has reviewed an Adaptive Compensation of MOSFET-C Filters. At high frequencies MOSFET-C filters suffer from Q- enhancement due to phase lag introduced by the finite Gain-Bandwidth of Operational amplifiers [8-9]. The designed system offers a new Adaptive compensation

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scheme which combines the simplicity of the passive schemes with the effectiveness of the active schemes. The new scheme was used to compensate for Q- enhancement in a universal MOSFET-C filter over a wide range of frequencies [10]. The new MOSFET-C universal filter was fabricated using a 2.0~ p-well MOSIS process [11].

3. Methodology of Designing Dynamic Filter

The designed adjustable dynamic filter using MOSFET for receiver is designed using simulation and verified using hardware. The simulation is carried out using ORCAD capture CIS 9.2 software tool.

3.1 Simulation Design

The simulation design methodology consist of dynamic MOSFET filter, output amplifier, low pass filter, rectifier and SNR system. In the next, each part is discussed in detail.

3.2 Dynamic MOSFET Filter

The dynamic MOSFET filter is implemented using an RC filter configuration using MOSFET resistors that has model number BSS83 which exhibits an ON-State resistance of 34Ω. This is the minimum resistance that the MOSFET resistor will exhibit when it enters the saturation region of the MOSFET, where in the ohmic region of its characteristics is much larger compared to 34Ω and thus the requirement of high MOSFET resistance is satisfied. Dynamic filter is designed by connecting 20. The design of dynamic MOSFET filter designed in ORCAD is shown in Fig. 1.

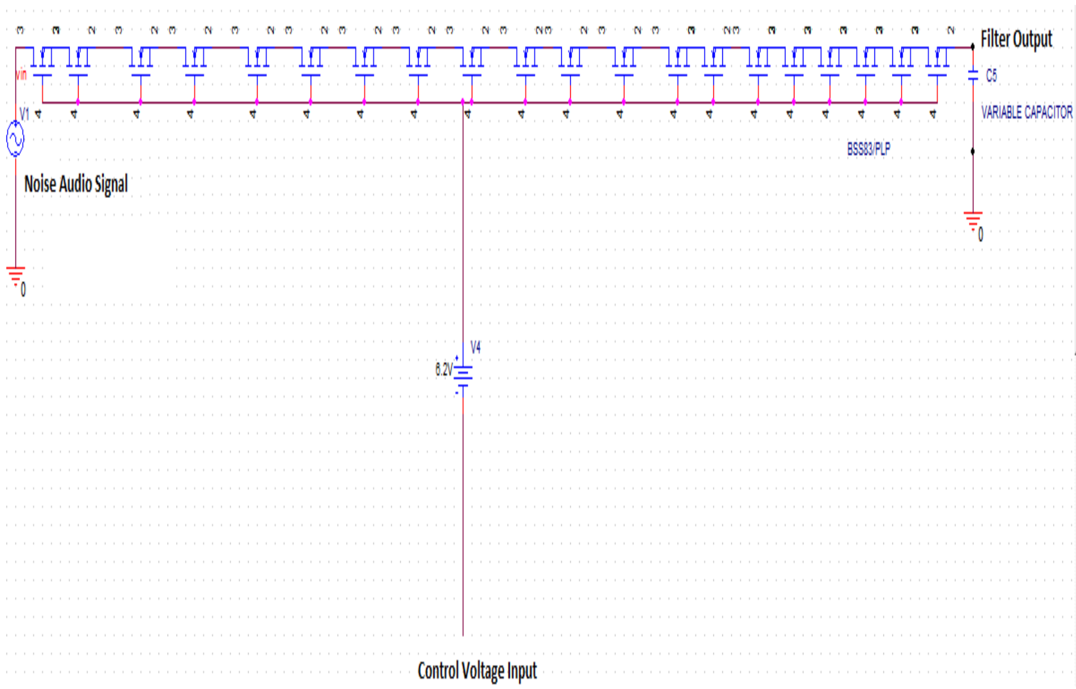


Fig. 1 -Dynamic MOSFET filter design in ORCAD.

MOSFETs resistor in series in order to obtain substantially higher overall resistance of the dynamic filter. Overall MOSFET resistance in the filter circuit will be 34 x 20 = 680Ω. The magnitude of the capacitance is calculated to obtain the cut-off at 5.319MHz for the highest noise level in the system and consequently for the lowest control (gate) voltage which is equal to the gate threshold voltage. The threshold gate voltage for BSS83 is 2.0 V at which the MOSFET resistor exhibits a resistance of 400 Ω. In the next, output amplifier is discussed.

3.3 Output Amplifier Using 741

The output amplifier is use to produce the output of the dynamic filter for measurement purpose. The amplifier design is demonstrated in Fig. 2. The amplifier circuit has no effect on the performance of the filter and this output amplifier only serves the purpose as output signal amplification only. The amplifier is designed using IC op-amp IC741.

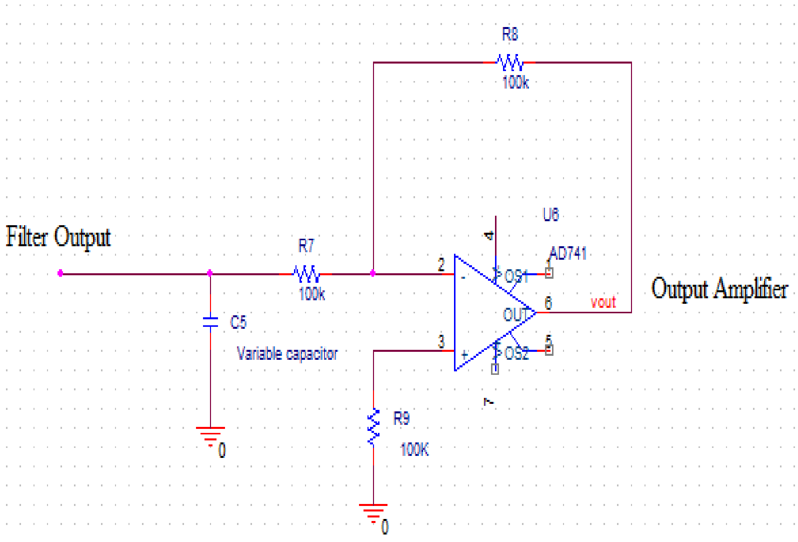


Fig. 2 -Output amplifier designed uisng Op-amp 47.

The signal at the output of the dynamic filter is fed to the inverting input of the amplifier and the gain (RF/R1) is adjusted until the value is equal to 1. The use of any offset compensating circuit is avoided and the amplifier is regarded as sufficiently ideal for all the practical purposes under consideration.

3.4 Low Pass Filter

The low pass filter separates the noise level from the signal level. It is assumed that the band frequencies 0-300Hz contains very little audio signal power. The low pass filter is implemented as the conventional passive RC filter with cut-off frequency at 300Hz. The designed low pass filter is shown in Fig. 3.

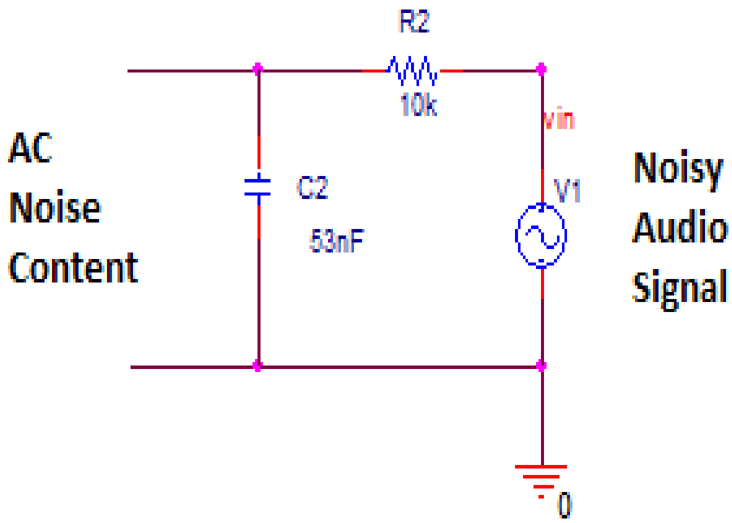


Fig. 3 -Designed low pass filter

The magnitudes of the capacitance and conventional resistance are decided so as to keep the power dissipation in the circuit within acceptable limits. Cut off frequency for low pass filter I is 300 Hz.

3.5 Rectifier

The half wave rectifier is designed for the purpose of converting the ac noise voltage into DC and thus providing the DC control voltage proportional to the noise level which is subsequently fed to the MOSFET gate. The designed rectifier is shown in Fig. 4.

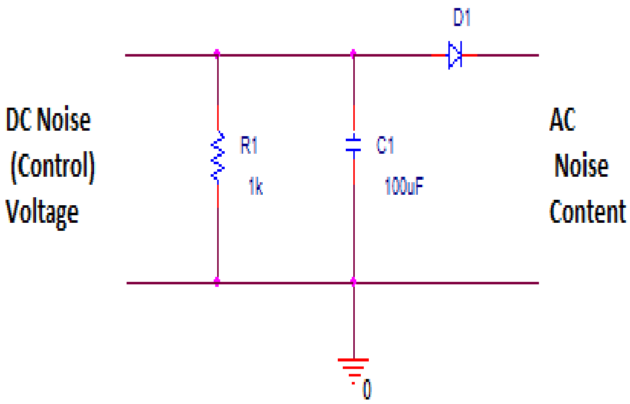


Fig. 4 -Designed rectifier.

3.6 SNR System

The SNR implementation is incorporated for the designed filter, output amplifier, and rectifier in a single system. The noisy audio signal is fed to the low pass filter in order to extract the noise content from the noisy signal. The noisy signal is also fed to the dynamic filter and in response to the changes in the noise level and hence the control voltage, the filter adjusts the signal bandwidth. As a result, the signal at the output of the noise filter possesses the same predetermined SNR irrespective of the changes in the noise level. The entire constant SNR system is fabricated on a single Printed Circuit Board (PCB) and is ready to be employed in any audio communication system.

3.7 Adaptive MOSFET Filter Prototype Development

The simulation design is verified using prototype. The hardware execution is carried out using circuit design and PCB fabrication.

3.8 Printed Circuit Board

A printed circuit board (PCB) is used to electrically connect electronic components using conductive trails. The printed circuit board design for the designed adaptive filter is shown in Fig. 5.

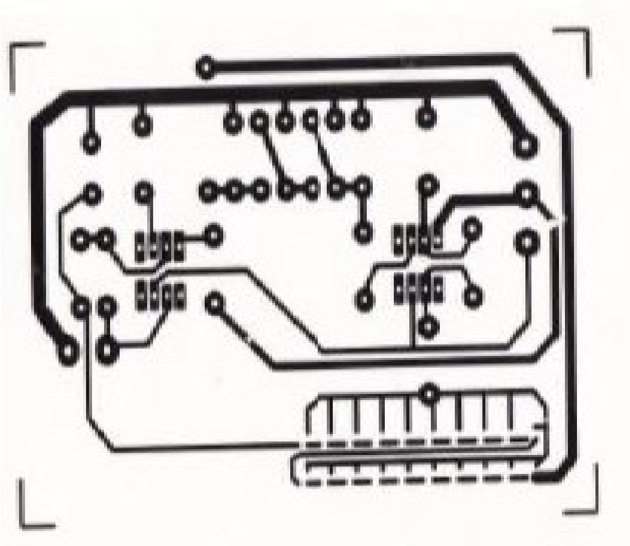


Fig. 5 -PC layout for designed dynamic MOSFET filter.

The prototype is tested using DC power supply, function generator (signal generator), oscilloscope and LCR meter. DC power supply is used to provide electric power to the circuit. Channel 1 is set to 6.2V for the highest control (gate) voltage that will fed into the MOSFET. Channel 2 is 5.1V that will fed into the operational amplifier (VC and VE). The designed circuit is tested for input of the function generator ranging as; 100Hz to 10 MHz. For channel 1, oscilloscopes is connected to Vout, and channel 2 is connected to input. The bandwidth is adjusted by varying the capacitance (C). In this work, capacitor measure are fixed at 0.001µF for testing the performance of the designed dynamic MOSFET filter. In the next section, the results are discussed for the designed system.

4. Results and Discussion

In this work, the circuit is tested using the prototype. The circuit was designed using ORCAD consists of numerous MOSFETs associated in series with gate terminals. These MOSFETs are combined to develop a common control terminal, and a capacitor in parallel combination to form a low-pass RC filter. The circuit was simulated and configure for two different arrays of cutoff frequency for 43.775 kHz (0.01µf) and 0.2 MHz (44pF). The pass band gain is restricted below 1dB margin to ignore the non-linearity in the occurrence a high noise level. The cutoff frequency value is different between practical and simulation because the actual value for capacitor used are not accurate. Channel 1 is Voutput and Channel 2 is Vinput. The formula used to calculate the gain is 20 Log (Vout/Vin). For overall measurement, the performance of the designed adaptive filter and achieved dynamic ranges of cut-off frequencies are imperfect by the aptitude of MOSFET due to its linear ohmic region. Due to this, to a certain extent, the magnitude of the cut-off frequency range can be organized by selecting the accurate magnitude of filter capacitor. However, the power loss due to extreme heating and following effects of huge capacitive impedance in the filter circuit have to be taken into account for modulated cut-off frequencies in the range of lower than 0.2 MHz.

Capacitor Value: 0.01µF

The frequency response for the adaptive MOSFET filter when capacitor values is 0.01µF is depicted in Fig. 6. The simulation shows a gain value of 0.44 at cut off frequency 3.0kHz. Comparing simulation to practical measurement where the gain is -2dB at around 1kHz. When the frequency is 10MHz the output noise increases, therefore gain and bandwidth decreases. The Practical measurement frequency response for 0.01µF is shown in Fig. 7.

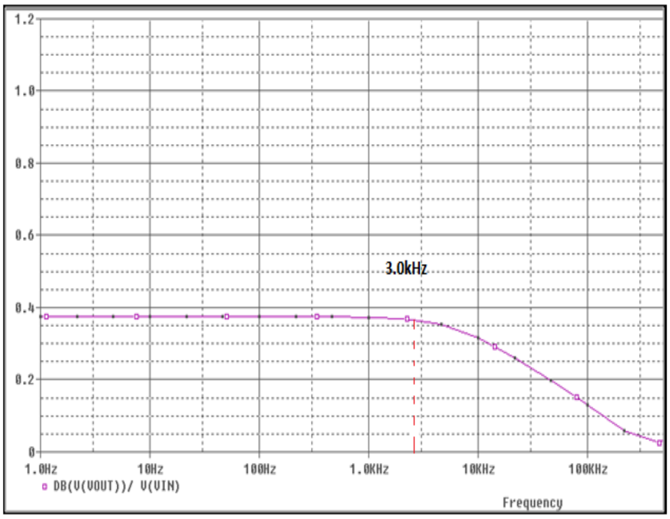


Fig. 6 -Simulation of 0.01µF

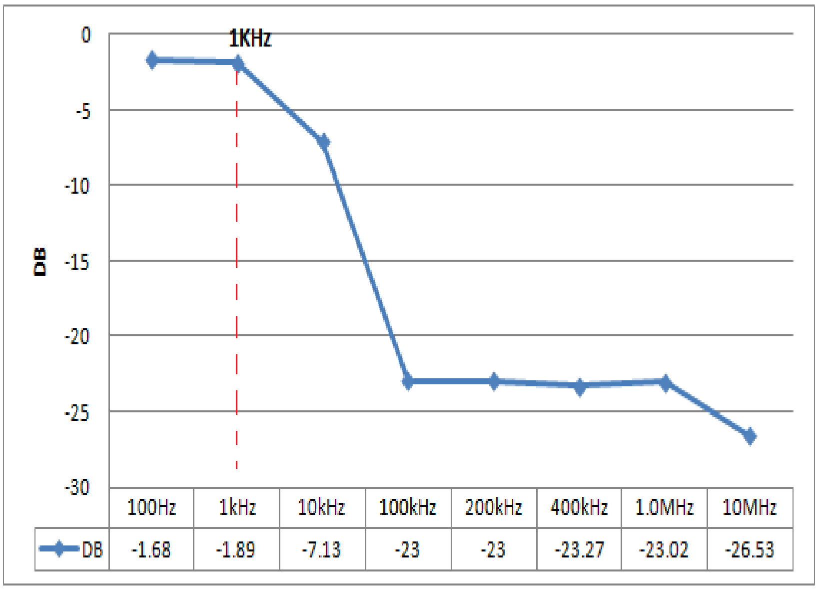


Fig. 7 -Measurements for Frequency response of 0.01µF

In the next, frequency response for the adaptive MOSFET filter when capacitor values is 44μF is descripted.

Capacitor Value: 44μF. The frequency response for the adaptive MOSFET filter when capacitor values is 44μF is shown in Fig. 8. The simulation shows a gain value of 0.6 at cut off frequency 2.0MHz. Comparing simulation to practical measurement where the gain is -3dB at around 200kHz. When the frequency is 10MHz the output noise increases, therefore gain and bandwidth decreases. The Practical measurement frequency response for 0.01μF is shown in Fig. 9.

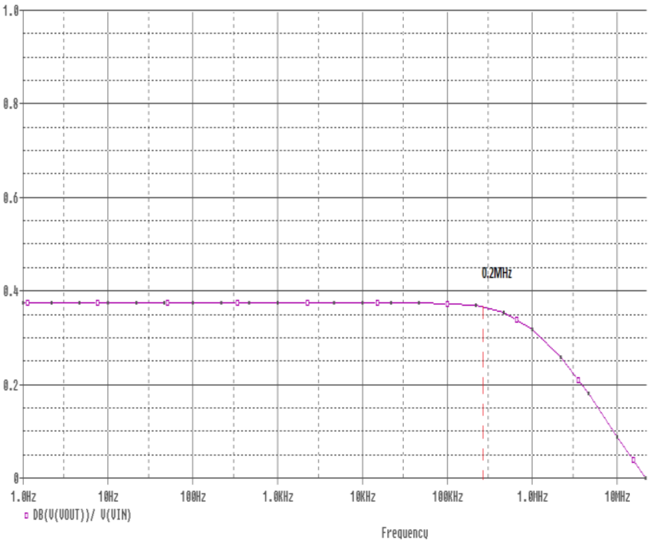
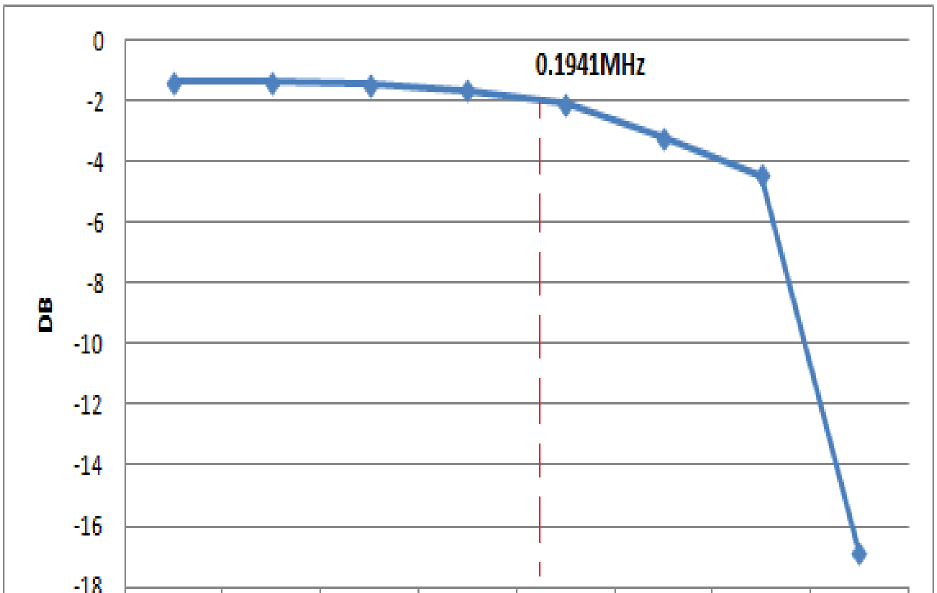


Fig. 8 -Simulation of 44μF



	100Hz	1kHz	10kHz	100kHz	200kHz	400kHz	1.0MHz	10MHz
DB	-1.34	-1.34	-1.45	-1.65	-2.06	-3.19	-4.44	-16.9

Fig. 9 -Measurements for Frequency response of 44μF

5. Conclusion

In the conclusion, the design of adaptive MOSFET was simulated and prototype was fabricated and tested. The maximum cut-off frequencies is configured for simulation is 0.2 MHz with capacitor of value 44pF which is near to compensate the SNR differences in the optical wireless communication for different channel conditions. The noisy audio signal is fed in into the low pass filter in order to extract the noise content from the noisy signal. The noise content is then rectified and converted into a DC and is subsequently fed into MOSFET gate as a control voltage. The noisy signal is also fed as the dynamic filter and in response to the changes in the noise level and hence the control voltage of the filter adjusts the signal bandwidth. As a result, the signal at the output of the noise filter possesses the same predetermined SNR irrespective of the changes in the noise level. The entire constant SNR system is fabricated on a single Printed Circuit Board (PCB) and is ready to be employed in any audio communication system.

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