

Research Migration Project

<https://esim.fossee.in/research-migration-project>



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Title of the circuit: Design and Simulation of an 8th-Order Active Band-pass Filter for UHF RFID Systems using MFB Topology

Theory/Description: Radio Frequency Identification (RFID) systems operate in noisy environments where isolating the weak signal from the antenna is critical. The reader's front-end requires high-performance active filters to reject out-of-band noise, image frequencies, and harmonics. This circuit utilizes a Multiple Feedback (MFB) topology to implement an 8th-order active band-pass filter. The MFB topology is chosen because it allows for high Q-factors, narrow bandwidths, and provides signal amplification. By cascading stages, an 8th-order filter is achieved, yielding a sharp roll-off rate approaching -60dB/decade. This ensures the strong stop-band attenuation necessary to meet the specifications for EPC Class-1 Generation-2 standard UHF domain RFID receivers.

Reason to reproduce with eSim: The original circuit was validated using proprietary, commercial software (NI Multisim 11.0). Reproducing this complex, high-order active filter in eSim validates the capabilities of open-source EDA tools for advanced RF and analog front-end design. It provides significant educational value by demonstrating how to migrate commercial filter designs to an open-source workflow (KiCad and Ngspice), making the verified schematic accessible to students, researchers, and developers without requiring expensive software licenses.

Expected Outcome/outputs: The simulation is expected to demonstrate a functioning band-pass filter with a defined mid-band frequency and narrow bandwidth suitable for RFID signal isolation. The AC analysis (Bode plot) will validate the frequency response, showing the precise center frequency, peak gain, and the steep roll-off characteristics(-60dB/decade) corresponding to an 8th-order filter. Transient analysis will demonstrate the filter's time-domain behavior and stability when processing sinusoidal inputs.

Circuit Diagram(s):

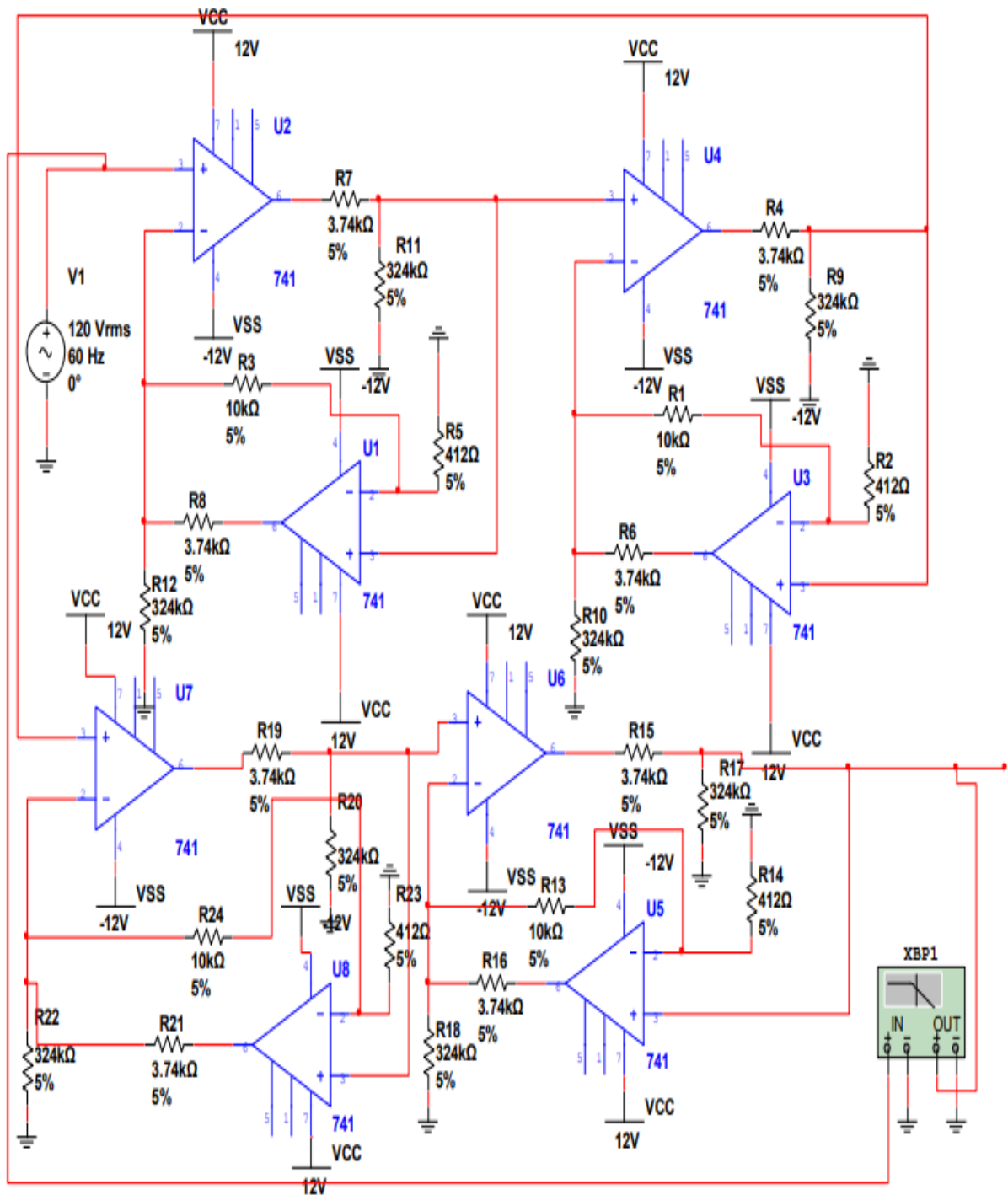


Figure 1: Reference schematic of the 8th-Order MFB Active Band-pass Filter to be migrated to eSim. (Source: Atsuwe et al., IJRSI Vol. 8, Issue 3).

Block Diagram (s):

[Noisy RF Input] → [Stage 1: 2nd-Order MFB Filter] → [Stage 2: 2nd-Order MFB Filter] → [Stage 3: 2nd-Order MFB Filter] → [Stage 4: 2nd-Order MFB Filter] → [Clean 125 kHz Output]

Description: The 8th-order filter is realized by cascading four identical 2nd-order Multiple Feedback (MFB) band-pass filter stages. The noisy input signal from the RFID antenna passes sequentially through each stage, with each block incrementally increasing the attenuation of out-of-band frequencies, resulting in a highly filtered and amplified output.

Expected Results (Input, Output waveforms and/or Multimeter readings) :

- **AC Analysis Plot:** A frequency response graph (Gain vs. Frequency) showing a distinct curve peaking at the target mid-band frequency with a sharp decline on both the lower and upper stop-bands, matching the Multisim results from the paper.
- **Transient Analysis Plot:** Time-domain input and output voltage waveforms showing the attenuation of frequencies outside the passband and the amplification of the signal at the resonant frequency.

Research Paper:

Title: Synthesis of 8th order Active-Band pass filter for UHF Radio Frequency Identification System using MFB Topology

Author: Atsuwe, B.A., Amah, A. N., and Igwue, G.A.

Page No.: 01-05

Link: <https://www.rsisinternational.org/journals/ijrsi/digital-library/volume-8-issue-3/01-05.pdf>

Source/Reference(s):

- International Journal of Research and Scientific Innovation (IJRSI), Volume VIII, Issue III, March 2021.
 - Ngspice User Manual (for configuring AC and Transient simulation directives in eSim).
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