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# Conditioning a current source using OCCII-GIC for EIT systems

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**Abstract:** A multi-Frequency EIT has been developed to evaluate the permittivity spectrum of a medium using an improved Howland source. Stray capacitance reduces the output impedance and useable maximum frequency. We have designed a circuit to cancel this capacitance, using an operational second generation Current Conveyor based on a General Impedance Converter (OCCII-GIC). The simulation shows the EIT system useable above 5MHz.

## 1 Introduction

The most recent topology for clinical and physiological applications of EIT system is based on applying a known value of low amplitude current and measuring potentials at multi frequencies in order to produce an impedance image. The associated effective output capacitance of the improved Howland current source and the parasitic capacitance create a total grounded capacitance that makes it impractical to produce an EIT system operating at high frequency. The use of a GIC in parallel with the output of the current source creates the opportunity to reduce the stray capacitance effect at high frequency [1-2]. It creates an RLC circuit with an LC resonant condition for high frequency. The LC resonance occurs when inductive and total capacitance impedances are equal in value at a particular frequency.

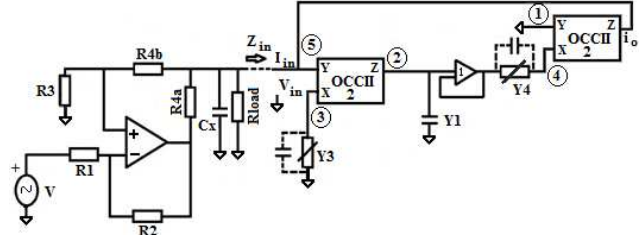
## 2 Method

The second generation current conveyor (CCII) is a flexible and versatile building block. The CCII is capable of conveying current with very different impedance levels and has significant advantages for use in high frequency applications [3]. The CCII provides a pure inductor by employing various active devices and passive elements for frequency dependent grounded inductors [4]. The combination of an op amp with the CCII produces the OCCII. The OCCII increases the accuracy compared to a CCII. The additional op amp connected in a negative feedback loops in each CCII to form the OCCII circuit, reduces the transfer function error in the conveying current. This OCCII-GIC as an inductor producer to cancel the total grounded capacitance in the EIT system can give improved performance over the common GIC using five passive elements and two op amps.

### 2.1 The proposed circuit topology

The proposed combination of OCCII-GIC and improved Howland current source is shown in Fig1. According to the schematic if  $Y_1 = C_1$ ,  $Y_3 = R_3$ ,  $Y_4 = R_4$ , the input impedance of the OCCII-GIC is:

$$Z_{in} = \frac{V_{in}}{I_{in}} = \frac{Y_1}{Y_3 Y_4} = \frac{sC_1}{(G_3 + sC_{ground-3})(G_4 + sC_{wiper-4})} = \frac{sC_1}{(G_3 G_4 - C_{ground-3} C_{wiper-4})} + \frac{C_1}{(G_4 C_{ground-3} + G_3 C_{wiper-4})} \quad (1)$$

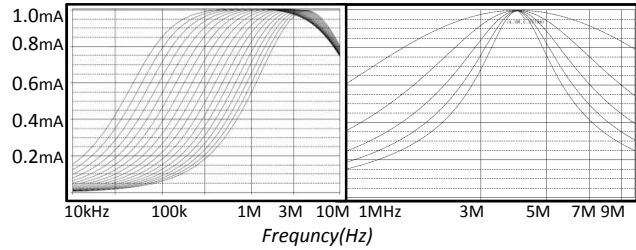


**Figure 1:** A schematic of an OCCII-GIC combined with an improved Howland current source circuit

The system cancels different capacitances at different frequencies using coarse and fine digital-pots,  $Y_3$  and  $Y_4$ , respectively. The OCCII uses three OPA656 operational amplifiers, input capacitance 2.8pF, and two AD844S ICs, output capacitance 4.5pF. The capacitances (from data sheet) of the 100step X9C102 digital-pot used is 10pF at both ends and 25pF at the wiper.

## 3 Results

Simulation results indicate that the OCCII-GIC performs as a parallel inductor cancelling capacitance effects at resonance. The expected additional capacitance from the multiplexers and cross-point switches is equal to 20.8pF (grounded). The simulation results of current through the load with different loads from 1kΩ to 5kΩ and a grounded 20.8pF capacitor in parallel with the load are shown in Fig 2.



**Figure 2:** The left simulation graph shows a multi-frequency AC sweep output of the OCCII-GIC and improved Howland current source. Digital-pot  $Y_4$  (100Ω to 5kΩ, increment in 10 logarithmic step per decade). The right simulation graph shows the AC sweep output at a frequency of 4MHz with different loads from 1kΩ to 5kΩ.

## 4 Conclusions

This paper presents a multi frequency OCCII-GIC circuit to cancel unwanted capacitance in an EIT system. The simulation of the EIT system shows it should be useable at frequencies above 5MHz.

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