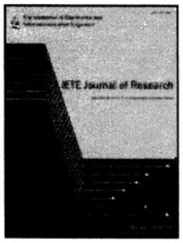

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IETE Journal of Research

ISSN: 0377-2063 (Print) 0974-780X (Online) Journal homepage: http://www.tandfonline.com/loi/tijr20

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To cite this article: V T Ingole FIETE & A A Ghatol FIETE (1997) On Selenium Voltage Variable Capacitor for Electronic Tuning, IETE Journal of Research, 43:5, 391-393, DOI: 10.1080/03772063.1997.11416006

To link to this article: http://dx.doi.org/10.1080/03772063.1997.11416006

Published online: 26 Mar 2015.

IETE Journal of Research
Vol 43, No 5, September-October 1997, pp 391-393

On Selenium Voltage Variable Capacitor for Electronic Tuning

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Selenium diode with hyperabrupt profile to be used at variable voltage capacitor (VVC), is fabricated. The capacitance exponent of the order of one is achieved by suitable thermal treatment. Low frequency applications of such selenium VVC in L-C tuner and first and higher order active filter (Butterworth) are suggested. Experimental results are discussed.

Indexing terms: Selenium device, VVC, Filter.

VOLTAGE Variable Capacitor (VVC) is also known as varactor diode. VVC means a device whose reactance can be varied in controlled manner by a bias voltage. The literature [1, 2] generally deals with VVC of silicon and germanium devices and their applications in high frequency circuits. An exhaustive treatment on silicon VVC and its applications in active filters, detector, harmonic generator, VCO, tuning, mixing, frequency modulator and importance of hyperabrupt junction having higher capacitance exponent (n = 2) is highlighted by Norwood & Shatz [3]. In silicon junction the realization of hyperabrupt junction requires a special fabrication technique as reported by Moline a Foxhall [4]. Since the basic depletion capacitance depends on the junction area, capacitance only of few hundred pF could be realized in case of silicon or germanium devices owing to limited junction area. Such limitation confines their use in HF range circuits. A hyperabrupt selenium diode as reported by the authors [5-7], can be fabricated with large to very large junction area and hence their depletion capacitance. By using such devices as VVC, circuits involving low frequency applications can be effectively designed. The present paper discusses the low frequency application of such fabricated device in active filter and tuned circuits.

EXPERIMENTAL CIRCUITS, RESULTS AND DISCUSSIONS

A device is fabricated by vacuum depositing selenium, insulation layer and cadmium on a bismuth coated substrate and treated at 215°C for 90 minutes is described by the same authors [5,6] to get capacitance exponent equal to 1 and higher Q (quality factor). Devices of 1 sq cm area having unbiased depletion capacitance of the order of 50 nF are selected for the present experiments.

TUNABLE FIRST ORDER FILTER (BUTTERWORTH)

Figure 1 shows the circuit of filter comprising the selenium VVC(C2). The corner frequency (f_c) and gain (A) of the circuit is given by equation 1 and 2 respectively.

$$f_c = 1/(2\pi\, C_i\, R) \quad (1)$$

where C_i = incremental depletion capacitance of VVC.

$$A = |V_o/V_i| = \frac{(1 + R_f / R_1)}{\sqrt{(1 + 2\pi f\, C_i\, R)}} \quad (2)$$

where f = frequency in Hz and A is the circuit gain.

The input voltage (V_i) is kept at 200 mV (rms) and out put voltage (V_o) is measured at a fixed bias voltage (V_r) for different frequencies (f). The reverse bias voltage (control voltage) across VVC is varied by adjusting the potentiometer R_p. Five sets of measurement are taken at different control voltage (V_c). Circuit gain (A) is plotted against f in Fig 2. It is observed that the gain amplitude decreases at 20 dB/decade for a fixed V_c. It is further observed that the corner frequency (f_c) increases with increase in negative bias voltage V_c thus first order tunable active filter is realized. These observations show that selenium VVC can be effectively used in a first order active filter and it's application can be extended to filters of higher order by suitably modifying the circuit.

L-C TUNING CIRCUIT (VCO)

Figure 3 shows a circuit of an L-C tuning circuit comprising the selenium VVC in a VCO configuration.

The resonant frequency (f_o) of the circuit is given by

$$f_o = \frac{1}{2\,\pi\,\sqrt{(L\, C_i)}} \quad (3)$$

The resonant frequency (f_o) is found out by varying the input frequency to the circuit at a fixed reverse bias voltage (control voltage V_c). The experiment is repeated by varying the control voltage (V_c) to find the respective f_o and plotted against $-V_c$ in Fig 4. It is observed that the resonant frequency increases linearly with the control

Paper No 111-B; received 1997 January 2; revised 1997 May 27;

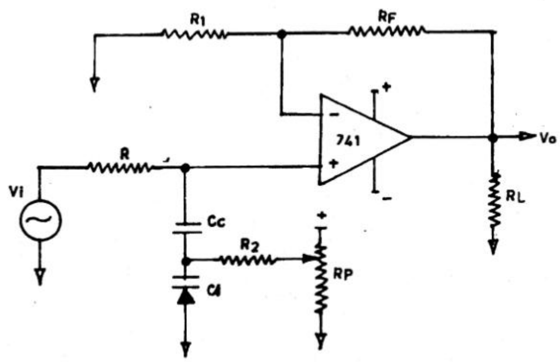

Fig 1 Tunable first order butterworth filter comprising selenium VVC (C_i) with a variable control voltage

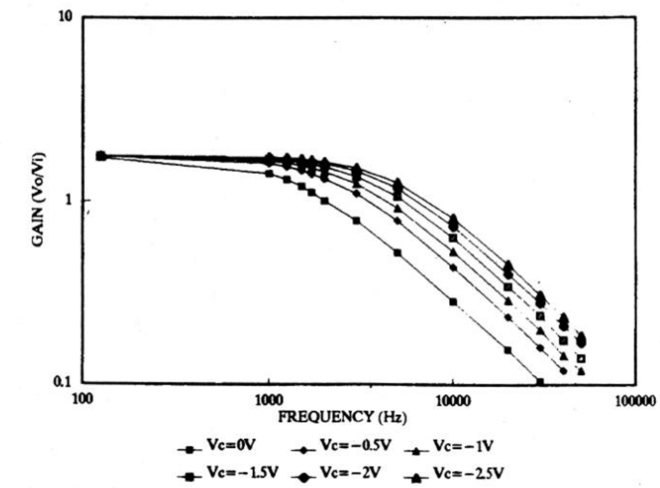

Fig 2 Gain-frequency plot at different control voltage

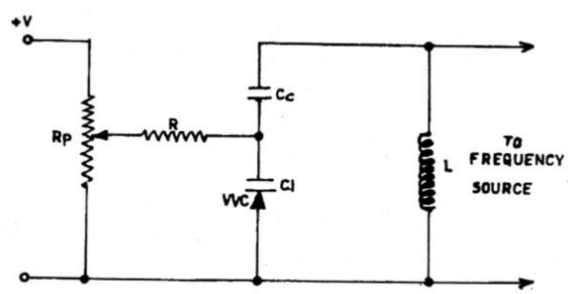

Fig 3 L-C tuned circuit comprising selenium VVC (C_i) with a variable control voltage

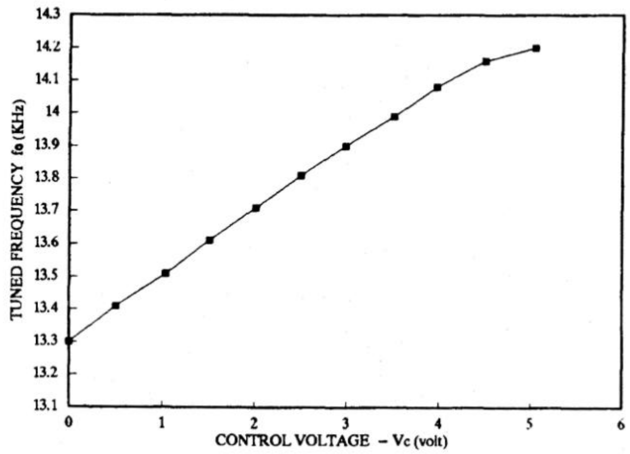

Fig 4 L-C circuit tuned frequency v/s control voltage plot

voltage up to $V_c = -4$ V but tends to saturate at higher V_c. Similar concept, using selenium VVC may be extended in the applications like frequency modulation (FM) etc.

CONCLUSIONS

It is shown that selenium device can be used in VVC configuration and can be effectively incorporated in low frequency active filters and tuning circuits.

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