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Grounded capacitors single resistance controlled oscillator using single FTFNTA

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In this manuscript, grounded capacitor single resistance controlled oscillator using four terminal floating Nullor transconductance amplifier (FTFNTA) is presented. It requires only one FTFNTA, two grounded resistors and two grounded capacitors. Oscillation condition (OC) and oscillation frequency (OF) are solely controlled through resistors. The non-ideal behaviour of the proposed structure has also been analyzed. Sensitivity analysis shows that the proposed structure is insensitive to component variations. The simulation results have been demonstrated and discussed using a SPICE simulation using 180 nm TSMC technologies. Monte Carlo analysis is also analysed for the proposed structure.

Keywords: FTFNTA, Sinusoidal oscillator, SRCO

1 Introduction

An oscillator is a very important part of the various applications such as mixture, SSB generation, in a telecommunication system, in vector generation, and selective voltmeters[1,2]. So due to large application uses; oscillator is always an area of interest for researchers. An enormous variety of oscillators present in the literature reported by different authors[3-31]. The oscillators manifest one or more of the following flaws such as: use of two or more active building blocks (ABBs)[3-13], intemperate use of passive elements[5,7,9-12,15-20,24,28] dependency of OC and OF[5,15-20,23,24,27,29,30] use of floating components[4,5,10-12,15,17,19] and non-availability of the condition of oscillation[31] which causes instability. These oscillators were designed by using various different active building blocks (ABB). But till now no oscillator structure is reported in the literature using FTFNTA ABB. So an SRCO using FTFNTA is proposed here. Detailed comparison on the basis of number of passive components used, only grounded elements are used or not and independent control of OC and OF is given in Table 1.

In this manuscript, an endeavour is made to suggest a new topology for a sinusoidal oscillator using only one FTFNTA ABB and four grounded passive components (2R+2C).

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2 FTFNTA

The FTFNTA, a recently introduced CM active block reported in[32], is a combination of FTFN at i/p stage accompanied with OTA at the o/p stage. The circuit schematic of a FTFNTA is shown in Fig. 1. It is a six-port device. Amongst the available ports, the X and Y are I/P ports and Z, W, O+ and O- are the O/P ports. Port W evinces low impedance while all other port has high impedance. Both X and Y ports are buffered, i.e. no current will flow through these ports. The output current I_{O+} and I_{O-} has a transconductance gain incorporated with it. The characteristic equation of FTFNTA is stated in Eq. (1).

$$\begin{bmatrix} I_X \\ I_Y \\ V_X \\ I_Z \\ I_{o+} \\ I_{o-} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ \alpha & 0 & 0 \\ 0 & -\beta & 0 \\ 0 & 0 & \gamma g_m \\ 0 & 0 & \gamma g_m \end{bmatrix} \begin{bmatrix} V_Y \\ I_W \\ V_Z \end{bmatrix} \quad ...(1)$$

$$g_m = \sqrt{I_B \mu_n C_{ox} \left(\frac{W}{L} \right)} \quad ...(2)$$

where I_B is bias current, μ_n is Mobility of free charge carrier present in the channel, C_{ox} is gate-oxide layer capacitance, W is channel width, L is channel length.

Table 1 – Comparisons of the proposed oscillator with previous reports in[15–31,34,35] all are designed using only one active building block (ABB).

Reference	Active Element	Number of (R+C)	Only grounded elements	Technology	Supply voltages (V)	Independent control of OC and OF
15	FTFN	5+3	Yes	3 µm	±5	No
		4+3	No			
		4+3	No			
		5+2	No			
16	DVCCC	3+2	yes	1.2 µm	±3.3	No
17	FTFN	5+2	No	3 µm	±5	No
18	CMSRCO	3+2	Yes	0.5 µm	±5	No
19	CFOA	3+3	No	AD844	±12	No
20	DVCCC	3+2	Yes	1.2 µm	±3.3	No
21	FDCCII	2+2	Yes	0.18 µm	±2.5	Yes
22	CCIITA	2+2	Yes	PR100N, NP100N	±3	Yes
23	VDCC	2+2	Yes	0.18 µm	±0.9	No
24	DD-DXCCII	3+2	Yes	0.18 µm	±1	No
25	VDCC	2+2	Yes	0.7 µm	±2.5	Yes
26	CG-VDCC	0+2	Yes	0.35 µm	±2.5	Yes(fixed frequency)
27	MVDVTA	1+2	Yes	0.13 µm	±0.75	No
28	DVCCTA	3+2	Yes	0.25µm	±1.25	Yes
29	FB-VDBA	1+2	Yes	OPA860	±5	No
30	MDVCC	2+2	Yes	0.13 µm	±0.75	N0
31	VDTA	0+2	Yes	0.25 µm	±1.5	Yes(fixed frequency)
34	VDTA	0+2	Yes	0.25 µm	±1.5	Yes(fixed frequency)
35	DVCCCTA	0+2	Yes	0.25µm	±1.25	Yes
Proposed	FTFNTA	2+2	Yes	0.18 µm	±1.6	Yes

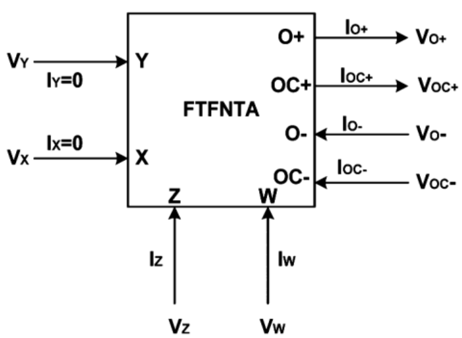

Fig. 1 – Circuit schematic of a FTFNTA.

α is the voltage transfer gain, β is the current transfer gain and γ is the transconductance transfer accuracy. Ideally, the value of α, β and γ is unity. These α, β and γ are accountable for the nonideality of FTFNTA.

3 Proposed Oscillator

The proposed oscillator comprises of one FTFNTA ABB, two resistor and two capacitors as displayed in Fig. 2**.** Only grounded passive components are used so it is acceptable for fabrication.

The characteristic Equation will be:

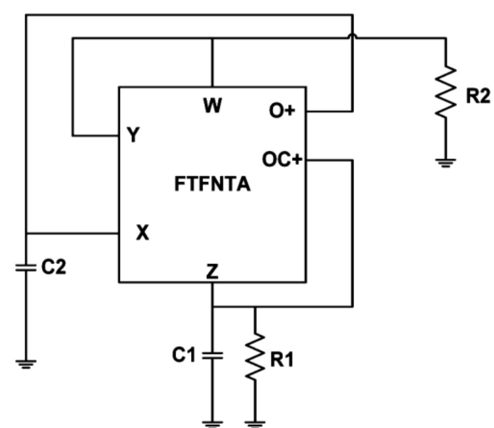

Fig. 2 – Proposed Oscillator Topology.

$$s^2 + s\frac{1}{c_1}\left(\frac{1}{R_1} - g_m\right) + \frac{g_m}{R_2 c_1 c_2} = 0 \qquad ...(3)$$

So, oscillation frequency (OF) and oscillation condition (OC) are determined as:

$$\text{OF: } \omega_0 = \sqrt{\frac{g_m}{R_2 c_1 c_2}} \qquad ...(4)$$

OC: $\frac{1}{R_1} - g_m \leq 0$ ...(5)

From Eqs (4) and (5) it is clear that OF is solely controlled by g_m and OC is solely controlled by R_1. Due to this, it is a single resistance controlled oscillator (SRCO).

4 Nonideal and Sensitivity Analysis

Due to the nonidealities present in ABBs the port characteristics of these ABBs are deviated from its ideal characteristic[14,33]. The primary nonideality in FTFNTA is due to α, β and γ. By considering the effects of parameters α, β and γ, the modified OC and OF of the oscillator will be:

OC: $\frac{1}{R_1} - \gamma g_m \leq 0$ ...(6a)

OF: $\omega_0 = \sqrt{\frac{\gamma g_m}{\alpha R_2 c_1 c_2}}$ ...(6b)

So it is evident from Eqs (6a) and (6b) that nonideality will affect the OC and OF. This can be curtailed by minimising the tracking errors $\alpha = 1 - \in_v$, $\beta = 1 - \in_i$ and $\gamma = 1 - \in_t$.

Nonideality also arises due to the parasitic resistor and capacitor connected in parallel with each terminal. Figure 3 shows the general schematic of nonideal parasitic of FTFNTA.

The schematic of the proposed oscillator with nonideality is given in Fig. 4.

At Y-W terminal

$R_{eq1} = R_2 \| R_Y \| R_w$ ...(7)

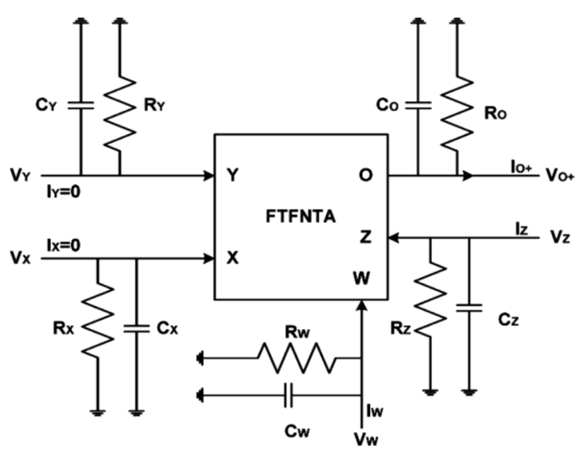

Fig. 3 – Schematic of nonideal parasitic FTFNTA[32].

$C_{eq1} = C_Y + C_W$ ...(8)

At X-O+ terminal

$R_{eq2} = R_O \| R_X$ ...(9)

$C_{eq2} = C_O + C_X + C_2$ ...(10)

At Z-O+ terminal

$R_{eq3} = R_Z \| R_{O+} \| R_1$ ...(11)

$C_{eq3} = C_O + C_Z + C_1$ ...(12)

The characteristic Equation of the oscillator under nonideal condition is:

$$s^2 C_{eq2} C_{eq3} + s(C_{eq3} g_{eq2} + C_{eq2} g_{eq3} + C_{eq1} g_m - C_{eq2} g_m) + g_{eq1} g_m - g_{eq2} g_m = 0$$ ...(13)

OC: $C_{eq3} g_{eq2} + C_{eq2} g_{eq3} + C_{eq1} g_m = C_{eq2} g_m$ ...(14)

OF: $\omega_0 = \sqrt{\frac{g_{eq1} g_m - g_{eq2} g_m}{C_{eq2} C_{eq3}}}$ ...(15)

where g_{eq1}, g_{eq2} and g_{eq3} is the inverse of equivalent resistance R_{eq1}, R_{eq2} and R_{eq3} respectively.

It is evident that the OC and OF are pretentious by parasitic of FTFNTA. The ramification of parasitic

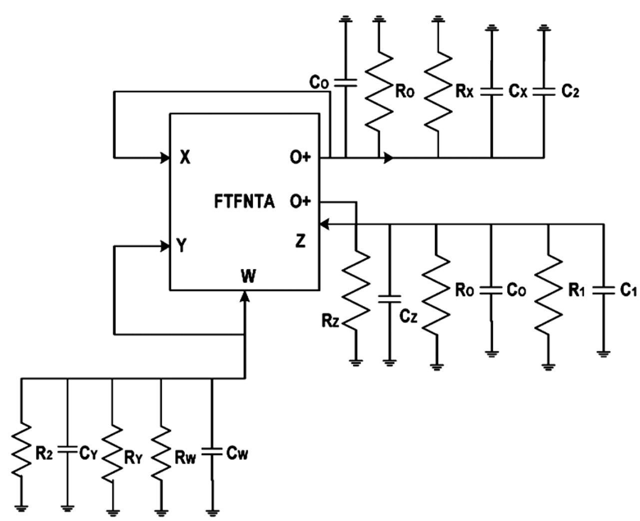

Fig. 4 – Schematic of proposed oscillator with nonideality.

capacitors C_{eq2} and C_{eq3} can be neglected as they are parallely connected with C_1 and C_2 by calibrating the designed value. Effect of resistance R_{eq1} and R_{eq2} are eliminated by external resistance R_1 and R_2. C_{eq1} and R_{eq2} are compensated by the coupling capacitor C_c and resistance R_c.

The sensitivity ω_0 of for the designed oscillator is analysed w.r.to the passive components and nonideal parameters. Equations (16) and (17) give the sensitivities of ω_0, and all the values are lying in the specified range from -1 to 1.

$$S_{g_m}^{\omega_0} = 0.5; S_{R_2}^{\omega_0} = S_{C_1}^{\omega_0} = S_{C_2}^{\omega_0} = -0.5 \quad ...(16)$$

$$S_{\beta}^{\omega_0} = S_{\gamma}^{\omega_0} = 0.5; S_{\alpha}^{\omega_0} = -0.5 \quad ...(17)$$

5 Simulation Results and Discussion

To verify the response of the oscillator PSPICE simulation is performed using 0.18 μm CMOS technology. The theoretical computation of the proposed oscillator out-turn that the frequency of oscillation is 653 kHz. The specifications for designed oscillator is g_m = 679 μA/V (for I_B = 600 μA) and R_1 = 1.5 KΩ, R_2 = 4 KΩ, C_1 = C_2 = 0.1nF. The transient and steady state response of oscillator is furnished in Figs 5 and 6. The simulated OF is approximately 640 kHz furnished in Fig. 7.

The Monte Carlo simulation effectuates to examine the robustness of the proposed oscillator by considering the outcome of ten samples for 10% Gaussian deviation on resistor R_1. Figure 8 shows that

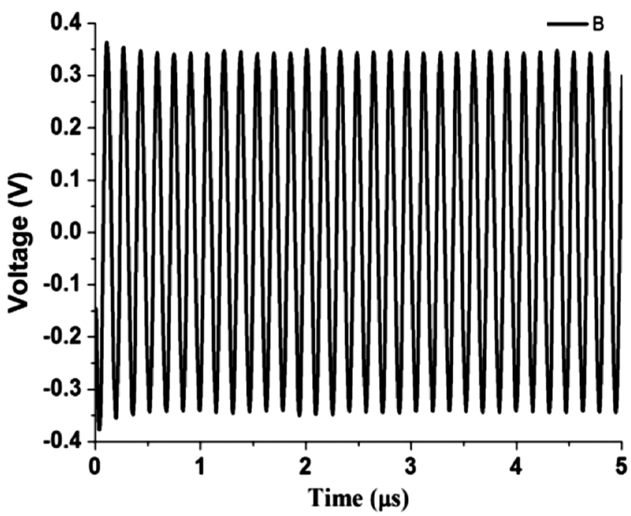

Fig. 5 – Simulated oscillator response including transient.

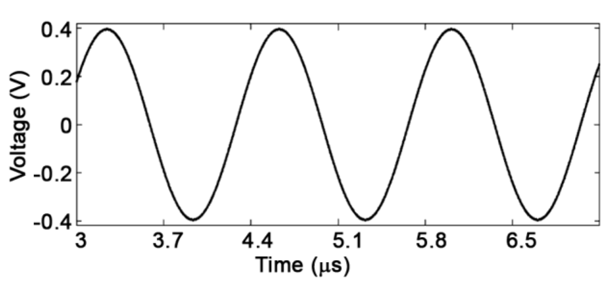

Fig. 6 – Simulated steady-state waveform of oscillator output.

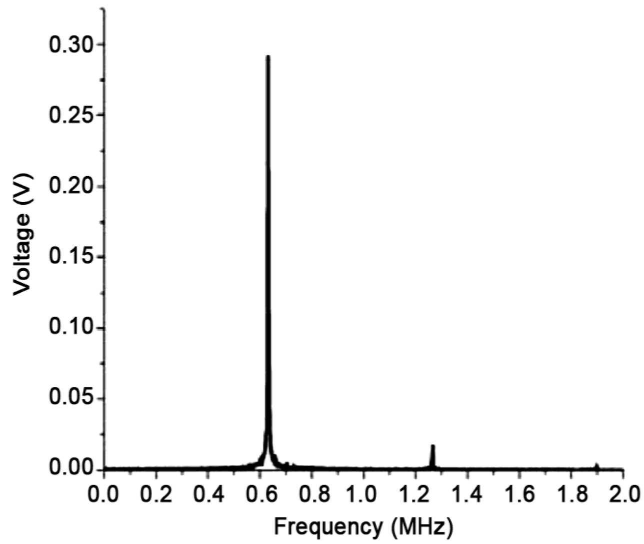

Fig. 7 – Fourier response of oscillator output.

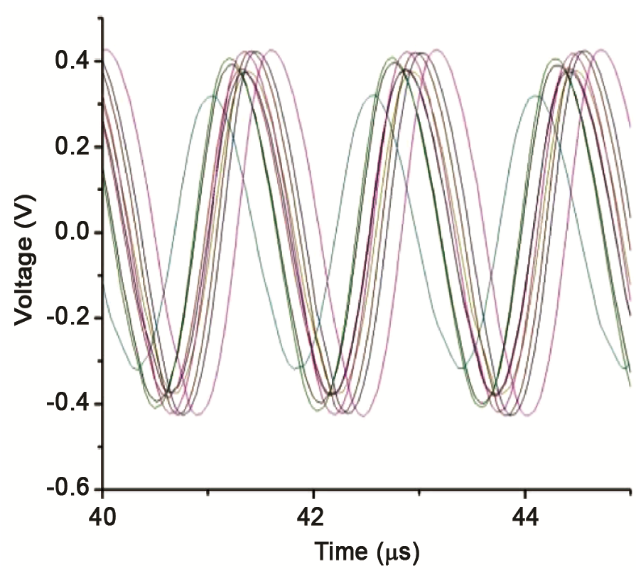

Fig. 8 – Monte Carlo simulations.

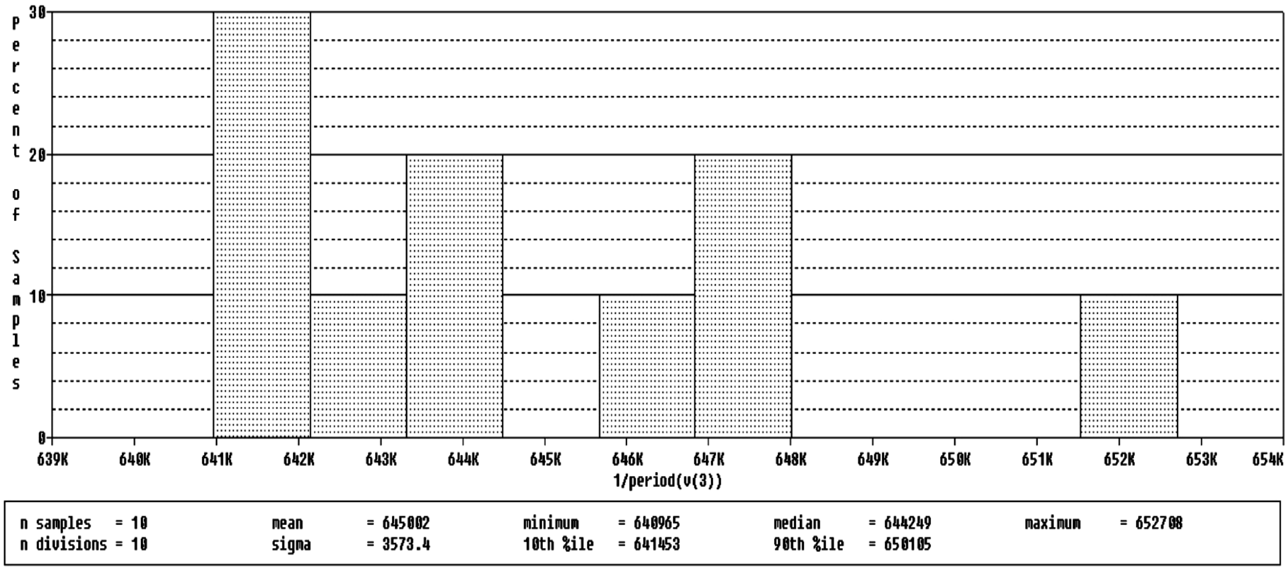

Fig. 9 – Histogram of proposed oscillator (for 10% deviation).

there is a very low alteration in OC by modifying the resistor R_1. Figure 9 shows the histogram in which OF remains around to its standard value 640 kHz for a deviation of 10% or less.

6 Conclusions

An extensive comparison is given in Table 1 which reveals that the proposed oscillator is more preferable than the previously existing oscillators. In this manuscript, an SRCO employing only one active building block i.e. FTFNTA has been presented. FTFNTA is a new and versatile ABB. Previously; no oscillator circuit was reported, using FTFNTA in the literature. The presented oscillator circuit offers the independent control on OC and OF through resistors. It uses all grounded passive elements. Monte Carlo analysis is carried out which shows that the higher stability of the oscillator with respect to the parameter variation for 10%.

References

1 Horang J W, *Comput Electr Eng*, 31 (2005) 81.

2 Prasad D, Bhaskar D R & Singh A K, *Radioengineering*, 20 (2011) 354.

3 Tangsrirat W & Tanjaroen W, *Indian J Pure Appl Phys*, 48 (2010) 363.

4 Abuelmatti M T & Al-azher H A, *Frequenz J RF-Eng Telecommun*, 53 (1999) 27.

5 Tangsrirat W, Prasertsom D, Piyatat T & Surakampontorn W, *Int J Electron*, 95 (2008) 1119.

6 Lahiri A, *Analog Integr Circ Sig Process,* 68 (2012) 303.

7 Abuelmatti M T, *Analog Integr Circ Sig Process*, 24 (2000) 253.

8 Prasad D, Srivastava M & Bhaskar D R, *Circ Syst*, 4 (2013) 169.

9 Horang J W, Hou C, Chang C, Chung W, Tang H & Wen Y, *Int J Electron*, 92 (2005) 21.

10 Horang J W, Chou H P & Shiu J C, *Proc Int Symp Circ Syst*, (2006) 441.

11 Keskin A U & Biloek D, *IEEE Proc-Circ Dev Syst*, 153 (2006) 214.

12 Al-Zaher H, *Int J Circ Theory Appl*, 36 (2008) 953.

13 Srivastava M, Prasad D & Bhaskar D R, *Contemp Eng Sci*, 7 (2014) 1501.

14 Fabre A, Saaid O, Wiest F & Boucheron C, *IEEE Trans Circ Syst-II: Analog Dig Sig Process*, 44 (1997) 436.

15 Abuelma'Atti M T & Al-Zaher H A, *IEEE Trans Circ Syst II*, 46 (1999) 69.

16 Gupta S S & Senani R, *Electron Lett*, 36 (2000) 195.

17 Cam U, Toker A, Ciceko˘glu O & Kuntman H, *Analog Integr Circ Signal Process*, 24 (2000) 231.

18 Chang C M, Al-Hashimi B M, Chen H P, Tu S H & Wan J A, *Electron Lett*, 38 (2002) 1071.

19 Senani R & Sharma R K, *IEICE Electron Exp*, 2 (2005) 14.

20 Aggarwal V, Kilinc S & Cam U, *Analog Integr Circ Sig Process*, 49 (2006) 181.

21 Horng J W, Hou C L, Chang C, Chou H P, Lin C T & Wen Y H, *ETRI J*, 28 (2006) 486.

22 Lahiri A, *Radioengineering*, 18 (2009) 522.

23 Prasad D, Bhaskar D R & Srivastava M, *Electron J*, 18 (2014) 81.

24 Chaturvedi B & Mohan J, *Electron J*, 19 (2015) 94.

25 Sotner R, Jerabek J, Prokop R & Kledrowetz V, *Electron Lett*, 52 (2016) 1016.

26 Sotner R, Jerabek J, Petrzela J & Dostal T, *Proc 21st Int Conf on Appl Electron* (2016) 237.

27 Alpaslan H, *Microelectron J*, 51 (2016) 1.

28 Uttaphut P, *Przegląd Elektrotechniczny*, 92 (2016) 229.
29 Yesil A, Kacar F & Gurkan K, *J Electr Eng*, 67 (2016) 137.
30 Abaci A & Yuce E, *Int J Electron Commun (AEU)*, 76 (2017) 86.
31 Tangsrirat W, *Indian J Pure Appl Phys*, 55 (2017) 254.
32 Tarunkumar H, Singh Y S & Ranjan A, *Int J Electron*, (2019) 683.
33 Zouaoui-Abouda H & Fabre A, *Analog Intigr Circs Sig Process*, 47 (2006) 13.
34 Banerjee K, Singh D & Paul S K, *Analog Integr Circ Sig Process*, 100 (2019) 495.
35 Jaikla W, Siripruchyanun M & Lahiri A, *Microelectron J*, 42 (2011) 135.