Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

Design and Comparison of Quadratic Boost Converter with Boost Converter

Selva Kumar. R
M.E-Power Electronics and Drives,
Bit Sathyamangalam, India

Vignesh.C. J
M.E-Power Electronics and Drives,
Bit Sathyamangalam, India

Gayathri Deivanayaki. V. P
M.E-Power Electronics and Drives,
Bit Sathyamangalam, India

Naveena.P
M.E-Power Electronics and Drives,
Bit Sathyamangalam,India

***Abstract-* In this paper the output voltage in renewable energy sources is improved by using DC-DC converter topology. Basically Boost converter is used for improving the voltage gain. In this converter switching frequency is limited, hence the output voltage is reduced. To overcome this issue, by combining the components of two boost converter by using single switch which improves the switching frequency and output voltage of converter. In this proposed paper for comparing the voltage stress and efficiency by using two converters topology.**

Keywords- Boost converter, Quadratic Boost Converter, Voltage stress.

I.INTRODUCTION

In recent years for a great number of appliances dc-dc converter topology is employed. Normally in renewable energy system, the system having low output characteristics to recover this demand DC-DC converter topology is implemented. For maintaining the dc output voltage range in PV array and fuel cells, converter can be used to improve the output voltage. But during the switching operation the voltage stress will be raised. While choosing the converter the concentrating features are; when switch is turn on it must attain the zero voltage crossing, when Photovoltaic array is connected to the grid the converter should provide the high terminal voltage for low input range. The converter which gives the high output range at low voltage stress is more efficient. Voltage gain generally based on the duty ratio hence by choosing the passive components the duty cycle ratio can be limited [7].

II. BOOST CONVERTER

Boost converter is used to step up the given voltage to the desired voltage. The input to this converter may be from any DC source like rectifiers,solar panel,battaries etc,. The circuit diagram for Boost Converter is shown below,

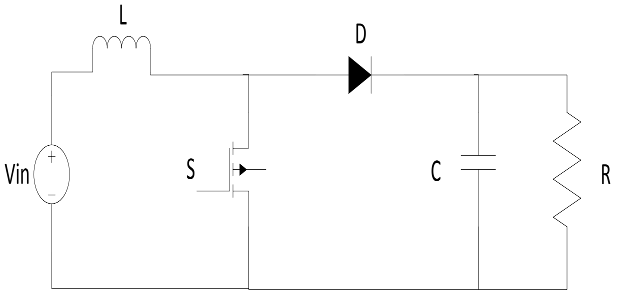

Fig.1 Circuit diagram for Boost converter

Two modes of operations are there,

Mode 1:

When the switch S is closed the inductor gets charged through the supply voltage and stores the energy. In this mode inductor current increases gradually, but we assume that the charging and the discharging of the inductor are linear. The diode blocks the current flowing and so load current remains constant which is being supplied due to the discharging of the capacitor.

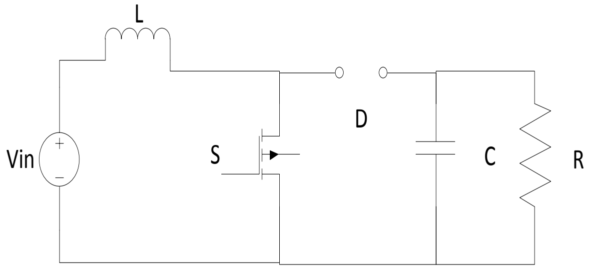

Fig.2 Circuit Diagram for Mode 1 Operation

Mode 2:

When the switch S is open, the diode becomes forward biased. The energy stored in the inductor changes it polarity to discharge through diode and charge the capacitor. Now, the capacitor supplies voltage to load. The load current remains constant throughout the operation.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

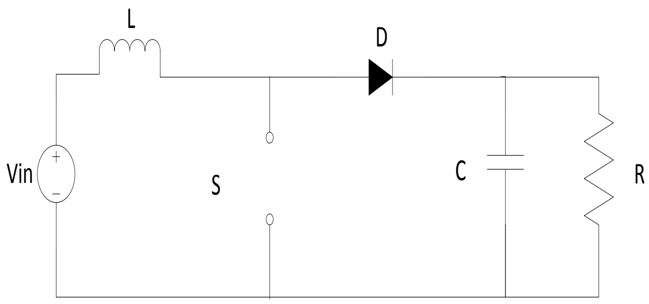

Fig.3 Circuit Diagram for Mode 2 Operation

2.1 Output Equation for Boost Converter

The voltage-current relation for the inductor L is,

$$i = \frac{1}{L}\int_0^t V dt + i_0 \text{ or}$$

$$V = L\frac{di}{dt} \qquad \text{..............} (1)$$

When the switch is turned on,

$$\Delta i = \frac{(V_{in}-V_{Trans})T_{on}}{L} \qquad \text{..............} (2)$$

When the switch is turned off,

$$\Delta i = \frac{(V_{out}-V_{in}+V_D)T_{off}}{L} \qquad \text{..............} (3)$$

By equating the Δi , we can solve the V_{out}

$$V_{out} = \frac{V_{in}-V_{Trans}\delta}{(1-\delta)} - V_D$$

Neglecting the voltage drop across diode V_D and transistor V_{Trans},

$$V_{out} = \frac{V_{in}}{(1-\delta)} \qquad \text{..............} (4)$$

2.3 Simulation results for boost converter

The Boost converter is simulated by using MATLAB 2013 and the circuit is shown in Fig.4. The input voltage given to the circuit is 10V and it works on 1 kHz switching frequency. Duty ratio (δ) is varied to boost the output voltage in desired value.

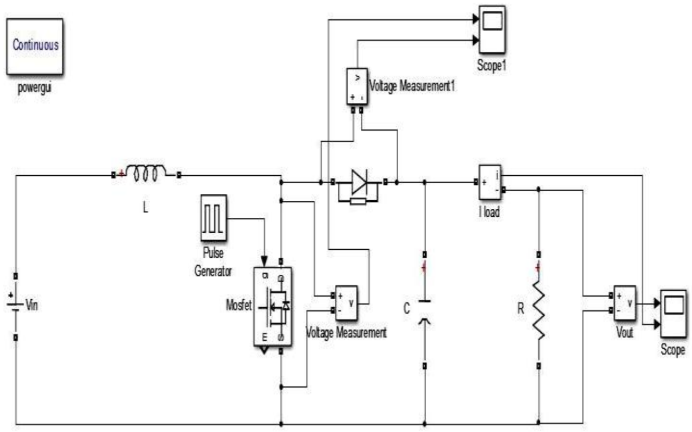

Fig.4 Simulation Circuit for Boost Converter

The inductor values for the converter is designed by using the formula given below,

$$L = \frac{(1-\delta)^2 \delta R}{2F_s} \qquad \text{..............} (5)$$

Where,

δ = duty cycle
R = load
F_s = switching frequency

The capacitor values are designed from the formula given below,

$$C = \frac{\delta V_o}{V_r R F_s} \qquad \text{..............} (6)$$

Where,

V_r = Ripple voltage
V_o = Output Voltage

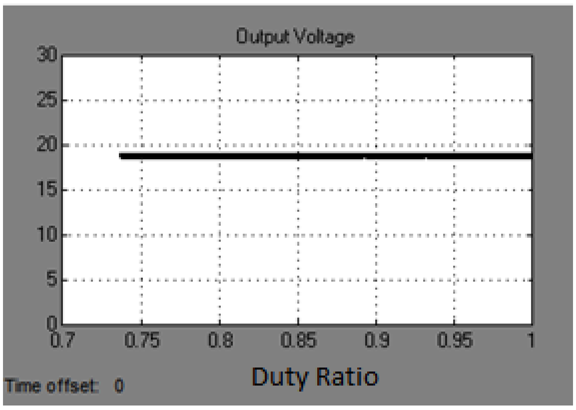

Fig.5 Output Voltage for Boost Converter

Theoretically, the switches are ideal so there are no losses in the circuit. But in simulation circuit switches are non-ideal, therefore losses will occurs in the output voltage Thus the comparison is shown in Fig.6

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

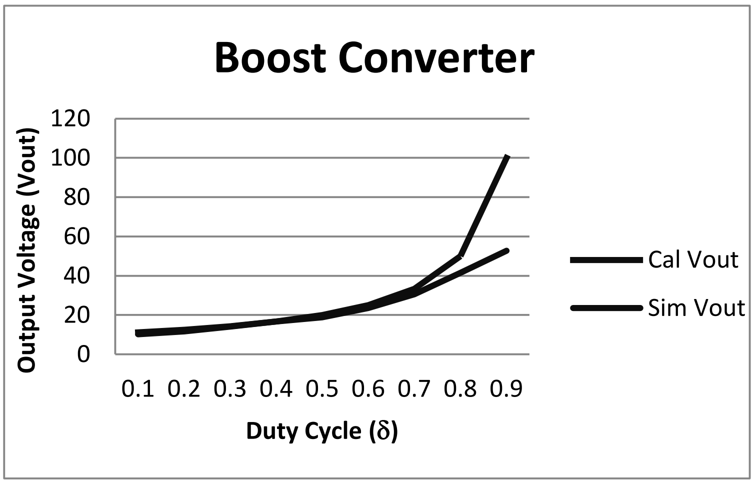

Fig.6 Calculated and Simulated Output Voltage for Boost Converter

III. QUADRATIC BOOST CONVERTER

The quadratic boost converter with a single switch is shown in Fig.7 where E is the input voltage, VC_2 the output voltage and S independent switch. This model usually requires active and passive switches are to be appearing in pairs and to form a three-terminal network. However, this methodology can be extended for the analysis of the quadratic boost converter with a single switch, which contains an active switch and three passive switches. Thus, diode D2 and transistor switch S are replaced by the corresponding current source, and diodes D1 and D3 by voltage sources.

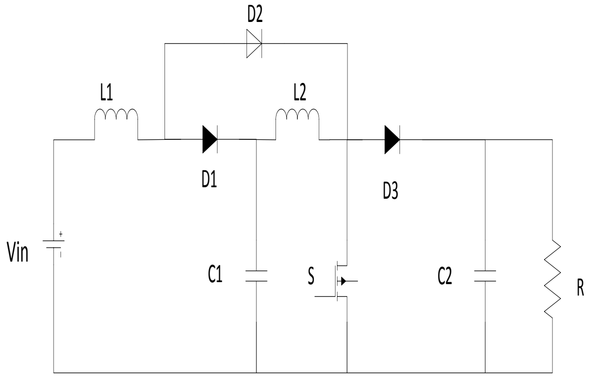

Fig.7 Circuit Diagram for Quadratic Boost Converter

Mode 1:

The circuit operation is based on the assumption that the switch S is ideal in operation and capacitors C1 and C2 is taken as large value so that the voltage across the capacitors VC1 and VC2 are nearly constant over a switching period. When switch S is turned on D2 is forward biased, whereas D1 and D3 reverse biased. Currents are supplied to L1 and L2 by V_{in} and C1 respectively. The mode 1 circuit of quadratic boost converter is given below in Fig.8.

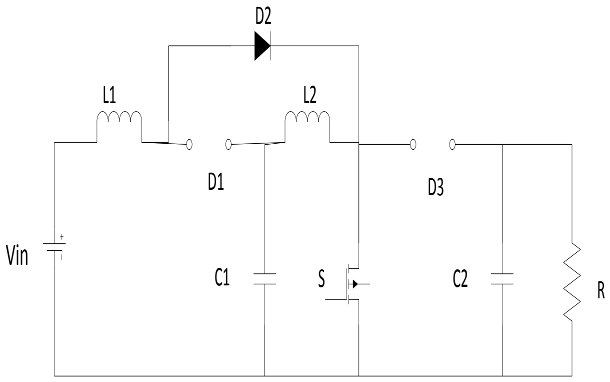

Fig.8 Circuit Diagram for Mode 1 Operation of Quadratic Boost Converter

Mode 2:

In this condition D1 and D3 are forward biased, whereas D2 reverse biased. L1 and L2 are charging C1 and C2 respectively. During this state, iL1 and iL2 is decreased. The mode 2 circuit of quadratic boost converter is given in Fig.9

3.1 Equation for Quadratic Boost Converter

During mode 1state, i_{L1} and i_{L2} are increased by the amount defined by

$$(\Delta i_{L_1})_{ON} = \frac{V_S \delta T}{L_1} \qquad \text{............... (5)}$$

$$(\Delta i_{L_2})_{ON} = \frac{V_{C1} \delta T}{L_2} \qquad \text{............... (6)}$$

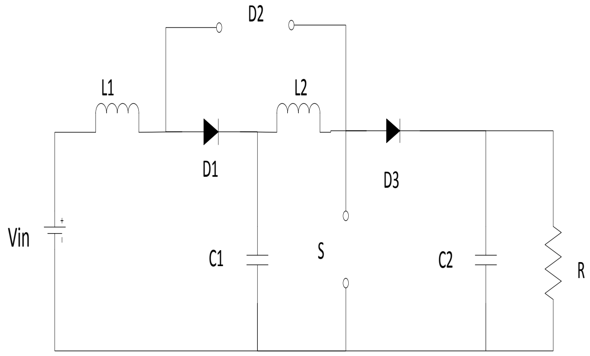

Fig.9 Circuit operation for Mode 2 of Quadratic Boost converter

In mode 2 state, i_{L_1} and i_{L_2} are decreased and it is expressed by

$$(\Delta i_{L_1})_{OFF} = \frac{(V_{in} - V_{C_1})(1-\delta)T}{L_1} \qquad \text{............. (7)}$$

$$(\Delta i_{L_2})_{OFF} = \frac{(V_{C_1} - V_o)(1-\delta)T}{L_2} \qquad \text{............. (8)}$$

Hence the output voltage from the mode 1 and mode 2 operation is

$$V_o = \frac{V_S}{(1-\delta)^2} \qquad \text{............. (9)}$$

The inductor (L_1) is selected as per the formula given below,

$$L_1 = \frac{\delta V_S}{2F_S \Delta I_{L_1}} \quad \text{................ (10)}$$

$$I_{L_1} = \frac{I_0}{(1-\delta)^2} \quad \text{........... (11)}$$

The inductor (L_2) is selected as per the formula given below,

$$L_2 = \frac{\delta V_S}{2F_S \Delta I_{L_2}} \quad \text{........... (12)}$$

$$I_{L_2} = \frac{I_0}{1-\delta} \quad \text{............... (13)}$$

The capacitor (C_1) is selected as per the formula given below,

$$C_1 = \frac{I_O \delta}{(1-\delta)\Delta V_{C_1} F_S} \quad \text{............... (14)}$$

$$V_{c_1} = \frac{V_S}{1-\delta} \quad \text{............... (15)}$$

The capacitor (C_2) is selected as per the formula given below,

$$C_2 = \frac{I_O \delta}{\Delta V_{C_2} F_S} \quad \text{................ (16)}$$

$$V_{c_2} = \frac{V_{C_1}}{1-\delta} \quad \text{............... (17)}$$

On the component selection, For duty cycle ratio 0.1 the inductor L_1 is 0.004 H, capacitor selection C_1 is 0.0004 F, inductor L_2 is 0.005 H and capacitor selection C_2 is 0.0072F.

3.3 Simulation results for Quadratic Boost Converter

The quadratic boost converter is simulated with the input voltage of 10V. The switching frequency used is 1 kHz. The simulation circuit diagram for the quadratic boost converter is given below in Fig 10.

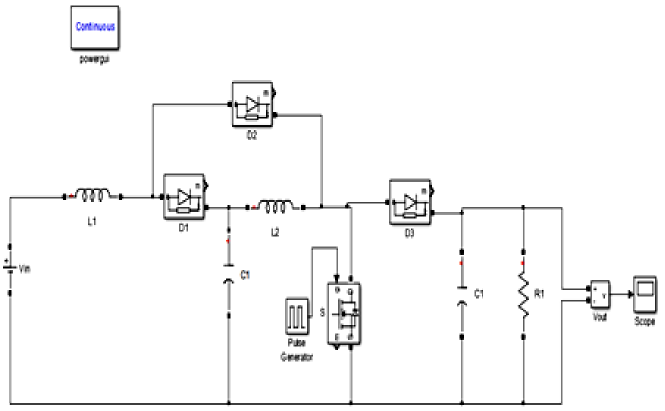

Fig.10 Simulation Circuit Diagram for Quadratic Boost Converter

If V_S=10V, δ=0.5 then the output voltage is given by 40V for the duty cycle 0.5 whereas the simulation output is 35.45V for the same input voltage.The simulation output of quadratic boost converter is shown below in Fig .11

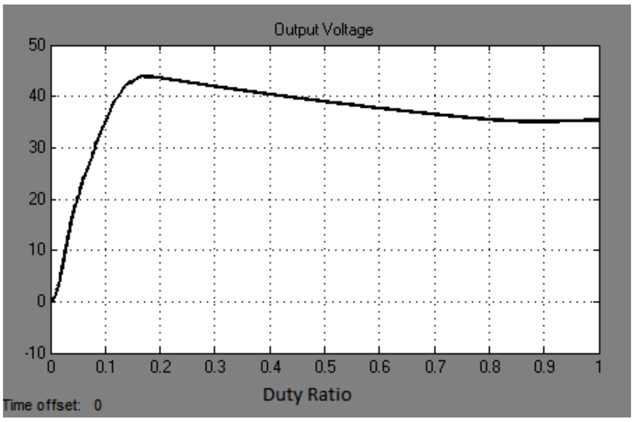

Fig.11 Output Voltage of Quadratic Boost Converter

Theoretically, the switches are ideal so there are no losses in the circuit. But in simulation circuit switches are non-ideal, therefore losses will occurs in the output voltage Thus the comparison is shown in Fig.12

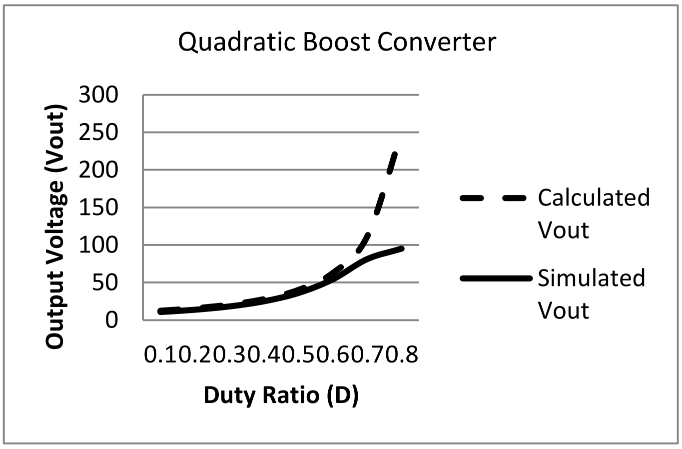

Fig.12 Calculated and Simulated Output Voltage for Quadratic Boost Converter

IV. COMPARISON RESULTS

For Boost converter on the basis of theoretical and simulated output it is verified that for the input voltage of 10V the output get boosted only upto 20V at duty ratio 0.5.But in Quadratic Boost converter for the same input voltage the output get boosted up to 40V for same duty ratio.

Table.1 Output Analysis of Boost Converter

Duty Ratio	Boost Converter				
	Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Efficiency
0.2	10	3	11.63	1.173	45%
0.5	10	7.5	18.91	1.891	48%
0.7	10	14.9	30.57	3.057	62%

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 01, January-2016

Table.2 Output Analysis of Quadratic Boost Converter

Duty Ratio	Quadratic Boost Converter				
	Input Voltage (V)	Input Current (A)	Output Voltage (V)	Output Current (A)	Efficiency
0.2	10	0.3	13.54	0.1354	61%
0.5	10	1.85	35.35	0.3535	67%
0.7	10	10.5	88.26	0.8826	74%

Table.3 Efficiency Comparison

Duty Ratio	Efficiency	
	Boost Converter	Quadratic Boost Converter
0.2	45%	61%
0.5	48%	67%
0.7	62%	74%

Voltage stress on switches

The switching pulse is given to the switches to transfer the maximum output to the load from the given input. When the switching pulse is given to the switches then there will be some stress on the switches due to frequent turn on and turn off. The stress on the switches is shown below in Fig.13.

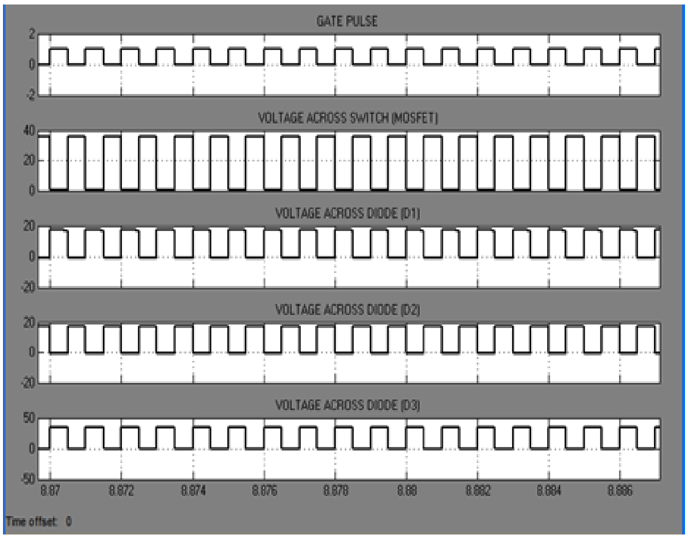

Fig.13 Waveform For Voltage Stress On Switches

V.CONCLUSION

The voltage stress across the switches should be reduced to increase the efficiency of the converter. The boost converter is limited by switching frequency because of the stress on the switch. The quadratic boost converter has more switching components but it has equal stress as boost converter. On same duty ratio quadratic boost converter provides with high output voltage then the boost converter. As comparison results the quadratic boost converter is convinent for the PV panel and fuel cells then the boost converter.

VI. REFERENCES

[1] Pranshu Agarwal, Rajeev Kumar Singh" A Modular Magnetically Coupled Quadratic Boost Converter for Microsource Applications" in IEEE at 7th IET International Conference on Power Electronics, Machines and Drives (PEMD 2014).

[2] M. G. Ortiz-Lopez, J. Leyva-Ramos, L. H. Diaz-Saldierna, J. M. Garcia-Ibarra and E. E. Carbajal-Gutierrez" Current-mode control for a quadratic boost converter with a single switch"in Power Electronics Specialists Conference, 2007. PESC 2007. IEEE .

[3] K.Tattiwong and C. Bunlaksananusorn,Analysis "Design and Experimental Verification of a Quadratic Boost Converter"in Proceedings 10th IEEE Region conference TENCON,2014.

[4] Muhammad Aamir, Mahmood Younas Shinwari, "Design, Implementation and Experimental Analysis of Two-Stage Boost Converter for Grid Connected Photovoltaic System" in Proceedings of 3rd IEEE International Conference on Computer Science and Information technology,2010.

[5] K.H .Beena, Anish Benny" Analysis and Implementation of Quadratic

[6] Boost Converter for Nanogrid Applications"in IJAREEIE Vol. 4, Issue 7, July 2015.

[7] Mustafa A. Al-Saffar, Esam H. Ismail, and Ahmad J. Sabzali" High Efficiency Quadratic Boost Converter"

[8] S. Park and S. Choi, "Soft-switched CCM boost converters with high voltage gain for high-power applications," IEEE Trans. Power Electron., vol. 25, no. 5, pp. 1211–1216, May 2010.

[9] Q. Zhao, F. Tao, and F. C. Lee, "High-efficiency, high step-up dc–dc converters," IEEE Trans. on Power Electronics, vol. 18, no. 1, pp. 65–73, Jan. 2003.

[10] B.-R. Lin, J.-Y. Dong and J.-J. Chen, "Analysis and Implementation of a ZVS/ZCS DC-DC Switching Converter with Voltage Step-Up," IEEE Trans. Ind. Electron., vol 58, no. 7, pp. 2962-2971, Jul. 2011.

[11] R. Kadri, J. P. Gaubert, G. Champenois, "Performance Analysis of Transformless Single Switch Quadratic Boost Converter for Grid Connected Photovoltaic Systems," IEEE Electrical Machines Conference., 2010, pp. 1-7.

[12] A. A. Fardoun, E. H. Ismail, "Ultra step-up DC-DC converter with reduced switch stress," IEEE Transactions on Industrial Electronics, Vol. 46, no. 7, pp. 2025-2034, Sep. 2010.