ANALYSIS AND IMPLEMENTATIONS OF FILTERS TO IMPROVE THE EFFECTIVENESS OF DC TO DC CONVERTERS

S.Gowri[1]

[1]*Electronics and Instrumentation Engineering, RVS College of Engineering and Technology, (India)*

ABSTRACT

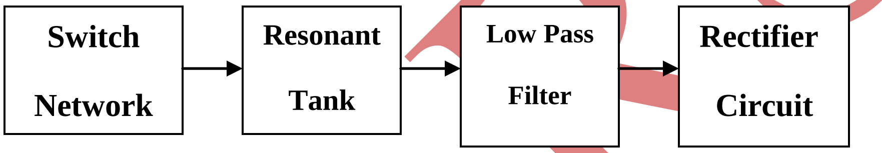
The switching power converter plays a vital role in power energy converter applications. In particular, DC to DC converter is most widely used in industrial and commercial purposes. In conventional method, pulse width modulation controls power flow by interrupting current and voltage through switching action with duty cycle control. In which voltage or current across the switch is abruptly interrupted called hard switched PWM. That the switches are required to withstand high switching stresses with safe operating area. By using snubber circuit, the switching power losses are transfer from switch to the snubber circuit. It is not possible to reduce the switching power losses. In this paper switching losses and electromagnetic interference are minimized and improve the energy conversion efficiency using a loaded resonant filtering topology. Among the soft switching dc to dc converters, loaded resonant converter has low switching losses, low stresses, highly flexible to convert energy, high switching frequency and low noise characteristics Hence this method is proposed in this paper to meet all the above mentioned criteria and analyze this circuit into various types of filters to attenuate the signals and also equalizer is to reduce the distortion to increase the efficiency of the output .

I INTRODUCTION

Among the uses of power converters in power electronic technology plays a vital role in energy conversion applications. In particular dc to dc converters are used in both industries, commercial and residential purpose. Semiconductor switches are the major component of energy conversion. To control power semiconductor switches with the help of pulse width modulation technique. It controls the power by interrupting the current or voltage through means of switch action with control of duty cycle. In which the voltage or current across the semiconductor switch is interrupted to provide the hard switching. It needs the capability of withstanding the such kind of stresses. By using snubber circuit the switching losses are transfer from switch to snubber circuit the stresses are reduced not removed. so we prefer the dc to dc converter for high energy conversion efficiency. This method comprises the resonant Dc to alternating current inverter and a rectifier. Depending on the energy is extracted from a resonant tank resonant converter is used with rectifier at the output terminal.

In this proposed method is used to analyze the resonant tank circuit to reduce the content of the ripples and switching losses. When the hard switching is replaced by soft switching ZVS technique the ripple content could be minimized only .It is possible to remove the noise by analyzing the tank topologies of different kinds of filters. The proposed method is to analyze the LLCC, t-type , π type , m-derived t type ,m-derived π type, composite filters for converting the Dc energy to Dc. While filtering, noise can be minimized, losses are reduced with the comparison of all types of filters and attenuators are used to reduce the some amount of specified loss between source and a matched load without altering the impedance relationship. Equalizer is to provide compensation against distortions that occur in a signal while passing through an electrical network. Hence this proposed method is used to analyze the different kinds of filters to improve the efficiency and reduce the ripples and electromagnetic interference when converting energy from DC to DC

II.BLOCK DIAGRAM DESCRIPTION



The switching power converter plays a vital role in power energy converter applications. In particular, DC to DC converter is most widely used in industrial and commercial purposes. In this switch network Resonant converters are included in a wide range of converters. The strategy of using one is to design a highly efficient converter while eliminating a common disadvantage of traditional implementations based on Pulse-Width Modulation (PWM) – high switching losses. The basic idea behind a resonant converter is to operate the MOSFETs with either a sinusoidal voltage or by running a sinusoidal current through it. The switching instant must be selected in proximity to the zero crossing of the sinusoidal voltage or current. Resonant tank contain resonant L-C networks whose voltage and current waveforms vary sinusoidal during one or more subintervals of each switching period These sinusoidal variations are large in magnitude, and the small ripple approximation does not apply. Some types of resonant converters:

- Dc-to-high-frequency-ac inverters
- Resonant dc-dc converters
- Resonant inverters or rectifiers

A low-pass filter is an electronic filter that passes low-frequency signals but attenuates. (reduces the amplitude of) signals with frequencies higher than the cutoff frequency Low-pass filters exist in many different forms, including electronic circuits (such as a hiss filter used in audio), anti-aliasing filters for conditioning signals prior to analog-to-digital conversion, digital filters for smoothing sets of data, acoustic barriers blurring of images, and so on. The moving average operation used in fields such as finance is a particular kind of low-pass filter, and can be analyzed with the same signal processing techniques as are used for other low-pass filters. Low-pass filters provide a smoother form of a signal, removing the short-term fluctuations, and leaving the longer-term trend. A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification The simple process of rectification produces a type of DC characterized by pulsating voltages and currents (although still unidirectional). Depending upon the type of end-use, this type of DC current may then be further modified into the type of relatively constant voltage DC characteristically produced by such sources as batteries and solar cells.

III.CIRCUIT DESCRIPTION AND OPERATING PRINCIPLES

Energy shortages have created the demand for a energy conversion efficiency. The growth of electronic equipments has increasing the demand of energy conversion and high power density of dc to dc energy power converter. In this soft switching is most popular in dc to dc conversion a capacitive filter output is decoupled from the resonant stage for a significant period during the switching cycle. The series parallel circuit are not convenient to operate safely with a short circuit at a switching frequency close to the resonant frequency. The two capacitors C1 & C2 on the input are large and split the voltage of the input Dc source. The element L1,L2,C form the resonant tank. The load resistor R is connected across a bridge rectifier through low pass filter. If we assume the 50% duty cycle over a switching period T. Each bidirectional power switch has an active Because of ac to dc conversion, is provided by rectifying the current through resonant inductor. consequently the voltage across the bridge rectifier has constant amplitude +Vo and –Vo depending upon the positive and negative current. Based on the above observation dc to dc converter can be analyzed with various types of filters LLCC, t-type , π type , m type, m-derived t type ,m-derived π type, composite filters instead of filtering section.

The resonant tank consists of three resonant components: Lr, Cs and Cp. The resonant tank of SPRC can be looked as the combination of SRC and PRC. Similar as PRC, an output filter inductor is added on secondary side to math the impedance. For SPRC, it combines the good characteristic of PRC and SRC. With load in series with series tank Lr and Cs, the circulating energy is smaller compared with PRC. With the parallel capacitor Cp, SPRC can regulate the output voltage at no load condition. The parameters of SPRC designed for front end DC/DC application From the operating region graph, it can be seen that SPRC narrow switching
frequency range with load change compare with SRC. Compare the switching waveforms, the input current in much smaller than PRC and a little larger than SRC. This means for SPRC, the circulating energy is reduced compare with PRC. Same as SRC and PRC,, the converter is working close to resonant frequency at300V. At high input voltage,

the converter is working at higher frequency faraway from resonant frequency. Same as PRC and SRC, the circulating energy and turn off current of MOSFET also increase at high input voltage. The turn off current is more than 10A.With above analysis, we can see that SPRC combines the good characteristics of SRC and PRC. Smaller circulating energy and not so sensitive to load change. Unfortunately, SPRC still will see big penalty with wide input ranged sign. With wide input range, the conduction loss and switching loss will increase at high input voltage. The switching loss is similar to that of PWM converter at high input voltage. By analysis, design and simulation of SRC, PRC and SPRC, the conclusion is that these three converters all cannot be optimized at high input voltage. High conduction loss and switching loss will be resulted from wide input range. To achieve high switching frequency and higher efficiency, we have to look for some other topologies.

3.1 LCL Resonant Converter

Three traditional resonant topologies were analyzed in above part. From the results, we can see that all of them will see big penalty for wide input range design. High circulating energy and high switching loss will occur at high input voltage. They are not suitable for front end DC/DC application .Although above analysis give us negative results, still we could learn something from it .For a resonant tank, working at its resonant frequency is the most efficient way. This rule applies to SRC and PRC very well. For SPRC, it has two resonant frequencies. Normally, working at its highest resonant frequency will be more efficient. To achieve zero voltage switching, the converter has to work on the negative slope of DC characteristic From above analysis, LCC resonant converter also could not be optimized for high input voltage. The reason is same as for SRC and PRC; the converter will work at switching frequency far away from resonant frequency at high input voltage. Look at DC characteristic of LCC resonant converter, it can be seen that there are two resonant frequencies. One low resonant frequency determined by series resonant tank Lr and Cs. One high resonant frequency determined by Lr and equivalent capacitance of Cs and Cp in series. For a resonant converter, it is normally true that the converter could reach high efficiency at resonant frequency. For LCC resonant converter, although it has two resonant frequencies, unfortunately, the lower resonant frequency is in ZCS region. For this application, we are not able to design the converter working at this resonant frequency. Although the lower frequency resonant frequency is not usable, the idea is how to get a resonant frequency at ZVS region. By change the LCC resonant tank to its dual resonant network, by change L to C and C to L, a LLC resonant converter could be built. The DC characteristic of LLC converter is like a flip of DC characteristic of LCC resonant converter. There are still two resonant frequencies. In this case, Lr and Cr determine the higher resonant frequency. The lower resonant frequency is determined by the series inductance of Lm and Lr. Now the higher resonant frequency is in the ZVS region, which means that the converter could be designed to operate around this frequency. But because of lack of understanding of characteristic of this converter, it was used as a series resonant converter with passive load. Which means it was designed to operate in switching frequency higher than resonant frequency of the series resonant tank of Lr and Cr. When operating in this region, LLC resonant converter acts very similar to SRC. The benefit of LLC resonant converter is narrow switching frequency range with light load and ZVS capability with even no load. In this dissertation, some unexplored operating region of LLC resonant converter will be investigated.

Within these operating regions, LLC resonant converter will have some very special characteristic, which makes it an excellent candidate for front end DC/DC application. A network, either T or π is said to be of the constant-k type if $Z_1$and Z_2 of the network satisfy the relation

$$Z_1Z_{2=}K^2\text{-------------------------------}\mathbf{(1)}$$

Where Z_1 and Z_2 are impedances in the T and π sections Eq 1 states that Z_1 and Z_2 are inverse if their product is a constant, independent of frequency. K is a real constant that is the resistance K is often termed as design impedance or nominal impedance of the constant K-filter. The constant K, T, π type filter is also known as the proto type because other more complex networks can be derived from it. Where $Z_{1\,=}j\,w_L$ and Z_2 $=1/\,j\,w_C$ Hence $Z_1\,Z_2$ $=L/C=K^2$ which is independent of frequency

$$Z_1\,Z_2= L/C= K^2\text{------------------------}\mathbf{(2)}$$

Since the product Z_1 and Z_2 is constant, the filter is a constant-k type. From eq.2 the cut off frequencies are $Z_1/4\,Z_2$ $=0$,

i.e. $-\omega^2LC/4 = 0$

f=0 and $Z_1/4\,Z_2 = -1$

. $-\omega^2LC/4= -1$

$$F_c= 1/\,\pi\,\sqrt{LC}\text{---------------------------}(3.3)$$

The pass band can be determined graphically. The reactance's of $Z_1$and 4 Z_2 will vary with frequencies. The cut off frequency at the intersection of the curves Z_1 and -4 Z_2 is indicated as $f_{c.}$ On the X-axis as $Z_1=4\,Z_2$ at cut off frequency, the pass band lies between the frequencies at which $Z_1=0$ and $Z_1=-4\,Z_{2.}$All the frequencies above $f_{c.}$ lie in a stop or attenuation band. Thus, the network is called a low pass filter. Also we know that $K=\sqrt{LC}$ is called design impedance or the load resistance

$$K^2 = L/C$$

$$\Pi^2 f_{c.}{}^2K^2 C^{\,2} = 1$$

$C=1/\,\Pi\,f_{c.}\,K$ gives the value of the shunt capacitance and $L=K^2\,C$ gives the value of the series inductance

3.2 M-Derived T& Π -Section

That the attenuation is not sharp in the stop band for k type filters. The characteristic impedance , Z_0 is a function of frequency and varies widely in the transmission band. Attenuation can be increased in the stop band by using ladder section i.e. by connecting two or more identical sections. In order to join the filter sections, it would also have the same pass band. However , cascading is not a proper solution from a practical point of view. This is because practical elements have a certain resistance , which gives rise to attenuation in the pass band also. Therefore , any attempt to increase attenuation in stop band by cascading also results in an increase of α in the pass band. If the constant K section is regarded as the prototype. It is possible to design a filter to have rapid attenuation in the stop band and the same characteristics impedance as the prototype at all frequencies. Such filter is called m-derived filter. If the shunt arm is series resonant , its impedance will be minimum or zero. Therefore the output is zero and will be correspond to infinite attenuation at this particular frequency. Thus at

$$f_{\alpha}\ 1/m\,\omega r\,C = 1-m^2/4m\,\omega r\,L \text{ where } \omega r \text{ is the resonant frequency}$$

$$\omega r^2 = 4/(1-m^2)LC$$

$$f_{r=} 1/\pi_{\sqrt{LC}}/(1-m^2)$$

Since the cut off frequency for the low pass filter is $f_{c=} 1/\pi_{\sqrt{LC}}$

$$f_{\infty=} f_c/\sqrt{(1-m^2)}\text{----------------------}(3)$$

$$(\text{or})\quad m=\sqrt{1-(f_{c/}\,f_{\infty})^2}\text{--------------}(4)$$

If a sharp cut-off is desired f_∞ should near to f_c.from Eq.3it is clear that for the smaller the value of m, f_∞ comes close to f_c..Eq.4 shows that if f_c and f_∞ are specified, the necessary value of m may then be calculated. Similarly, for m derived π section, the inductance and capacitance in the series arm constitute a resonant circuit thus at f_∞ a frequency corresponding to infinite attenuation ,

i.e at f_∞

$$m\,\omega r\,L = 1/(1-m^2/4m)\ \ \omega r\,C$$

$$\omega r^2 = 4/LC(1-m^2)$$

$$f_{r=} 1/\pi_{\sqrt{LC}}/(1-m^2)$$

$$\text{since,}\qquad f_r = 1/\Pi_{\sqrt{LC}}$$

$$f_{r=} f_c/\sqrt{(1-m^2)} = f_{\infty}\text{--------------}(5)$$

Thus for both m-derived low pass networks for a positive value of m($0<m<1$),$f\ \alpha > f\ c$. Equations (3) or (4) can be used to choose the value of m, knowing f_c and f_r. The variation of attenuation for a low pass m-derived section can be varied from $\alpha=2\cosh\text{-}1\sqrt{z1/4z^2}$ for $f_c<f<f_\infty$. For $z_1=j\,\omega\,L$ and $z_2=-j/\,\omega\,c$ for the prototype.

$$\alpha=2\cosh^{-1} m f/f_c/\sqrt{1-(f/f_\infty)^2} \qquad \beta=2\sinh^{-1} m f/f_c/\sqrt{1-(f/f_c)^2} * (1-m)^2$$

3.3 Composite Filter

In previous sections constant k-type filter has very low attenuation near cut-off frequency but as signal frequency is moved farther away from fc, attenuation increases. On the other hand , an m-derived filter has a very high attenuation close to cut-off frequency but at frequencies farther away from f α, attenuation decreases. Therefore, it is common practice to use one or more prototype and m-derived filter sections together in order to obtain best results. In addition to this, half sections are also included for impedance matching. The filter circuit so obtained is termed as composite filter. In order to get the best result composite filters should consist of One or more prototype constant-k section to produce cut-off or transition between transition band and the stop band at specified frequency f c. One or more m-derived section to give in finite attenuation at a frequency f∞ in the neighborhood of the cut-off frequency. Two terminating m-derived half section with m=0.6 to give reasonable constant input and output impedance. All these are joined in the ladder type. Such combinations give any desired characteristic, by choosing the proper value of m's. Figure shows the typical attenuation characteristics of the low pass filter for the prototype m-derived and composite filter. The composite filter gives appropriate results shown in fig If the shunt arm is series resonant , its impedance will be minimum or zero. Therefore the output is zero and will be correspond to infinite attenuation at this particularfrequency. Thus at f_α

$$1/m\,\omega r\,C = 1-m^2/4m\,\omega r\,L, \qquad \text{where } \omega r \text{ is the resonant frequency}$$

$$\omega r^2 = 4/(1-m^2)LC$$

$$f_{r=}1/\pi_{\sqrt{LC}}/(1-m^2)$$

Since the cut off frequency for the low pass filter is $f_{c=}1/\pi_{\sqrt{LC}}$

$$f_{\infty=} f_c/\sqrt{(1-m^2)} \text{-------------}(6) \qquad (\text{or}) \qquad m=\sqrt{1-(f_{c/}f_\infty)^2}\text{--------------------}(7)$$

If a sharp cut-off is desired f_∞ should near to f_c..from Eq(6),it is clear that for the smaller the value of m, f_∞ comes close to f_c..Equation(7)shows that if f_c and f_∞ are specified, the necessary value of m may then be calculated. Similarly, for m derived π section, the inductance and capacitance in the series arm constitute a resonant circuit thus at f_∞ a frequency corresponding to infinite attenuation ,

i.e at f_∞

$$m\,\omega r\,L = 1/(1-m^2/4m)\ \omega r\,C$$

$$\omega r^2 = 4/LC(1-m^2)$$

$$f_{r=}1/\pi_{\sqrt{LC}}/(1-m^2)$$

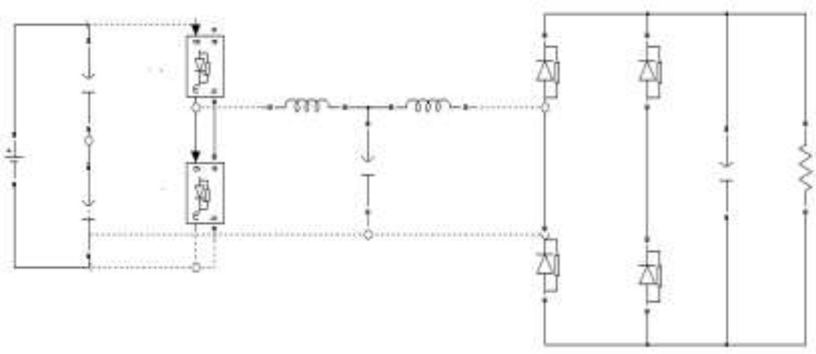
$$\text{since,} \qquad f_r = 1/\Pi_{\sqrt{LC}}$$

$$f_{r=}\, f_c/\sqrt{}(1-m^2) = f_{\infty}\text{-----------}(8)$$

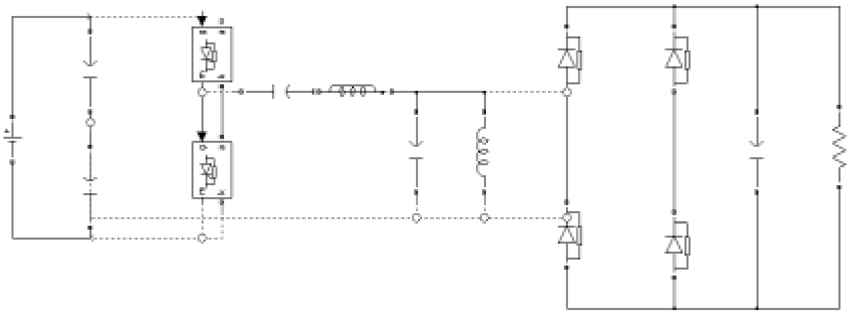
Thus for both m-derived low pass networks for a positive value of m(0<m<1),f α>f c. Equations (6) or (7) can be used to choose the value of m, knowing f_c and f_r .The variation of attenuation for a low pass m-derived section can be varied from $\alpha=2\ \cosh\text{-}1\sqrt{z1/4z^2}$ for $f_c<f<f_{\infty}$. For $z_1=j\,\omega\,L$ and $z_2=-j/\omega\,c$ for the prototype. $\alpha=2\cosh^{-1} m\, f/f_c/\sqrt{1-(f/f_{\infty})^2}$ $\beta=2\sinh^{-1} m\, f/f_c/\sqrt{1-(f/f_c)^2} * (1-m)^2$

In previous sections constant k-type filter has very low attenuation near cut-off frequency but as signal frequency is moved farther away from fc, attenuation increases. On the other hand , an m-derived filter has a very high attenuation close to cut-off frequency but at frequencies farther away from f α, attenuation decreases. Therefore, it is common practice to use one or more prototype and m-derived filter sections together in order to obtain best results. In addition to this, half sections are also included for impedance matching. The filter circuit so obtained is termed as composite filter. In order to get the best result composite filters should consist of One or more prototype constant-k section to produce cut-off or transition between transition band and the stop band at specified frequency f c. One or more m-derived section to give in finite attenuation at a frequency f∞ in the neighborhood of the cut-off frequency. Two terminating m-derived half section with m=0.6 to give reasonable constant input and output impedance. All these are joined in the ladder type. Such combinations give any desired characteristic, by choosing the proper value of m's.

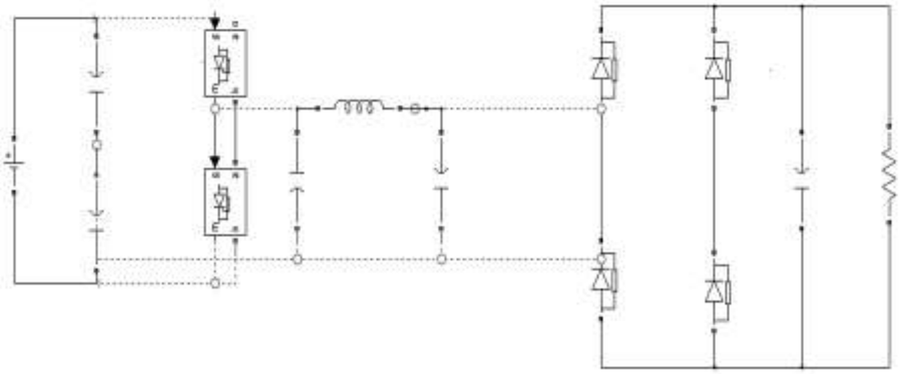
IV CIRCUIT DIAGRAM AND RESULTS



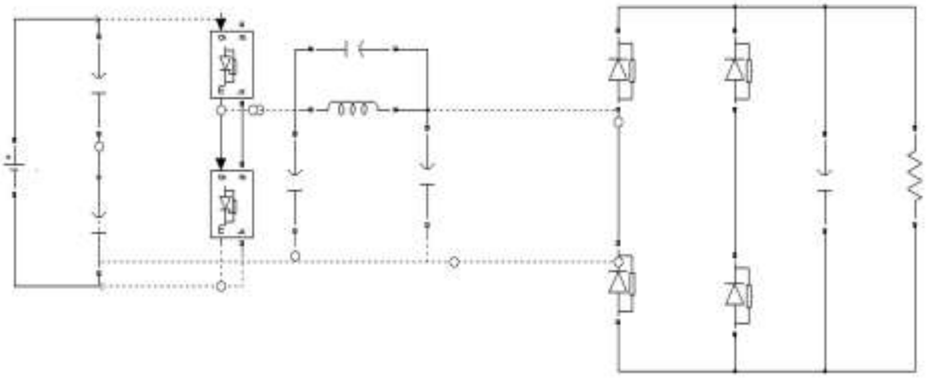
Fig(1) LCL & T type filter



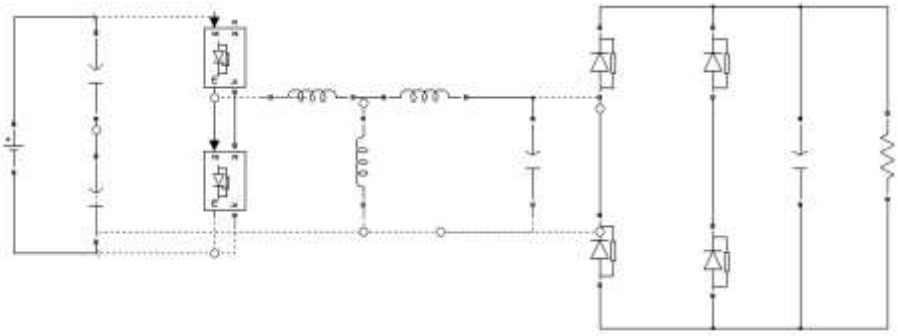
Fig(2) LLCC Type Filter



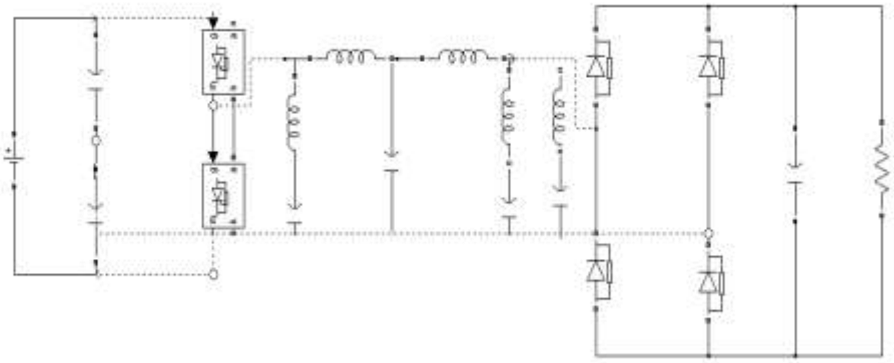
Fig(3) π Type Filter



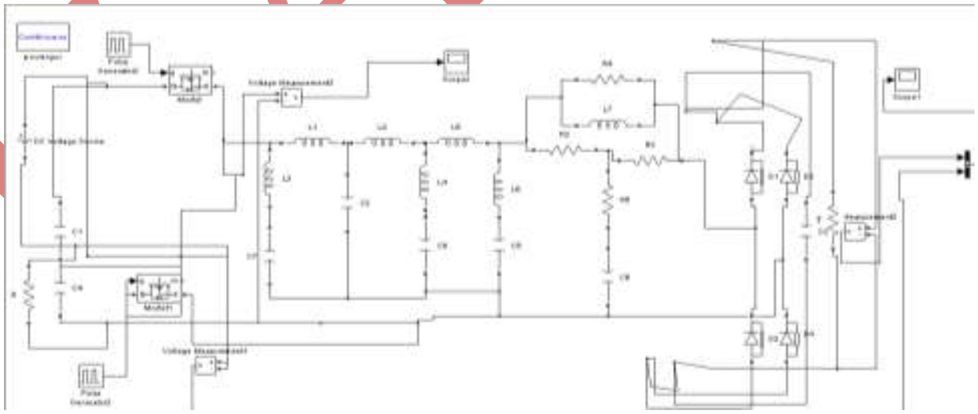
Fig(4) M-Derived T Type Filter



Fig(5) M-Derived π Type Filter



Fig(6) Composite Type Filter



Fig(7) Composite Attenuator Equalizer Filter

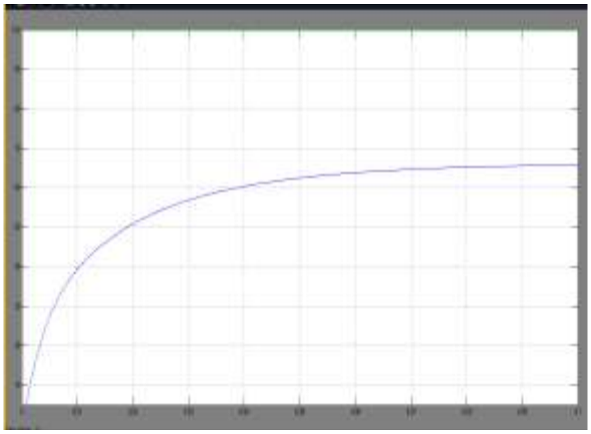


Fig 1) LCL Type Results

Fig2) π Type Result

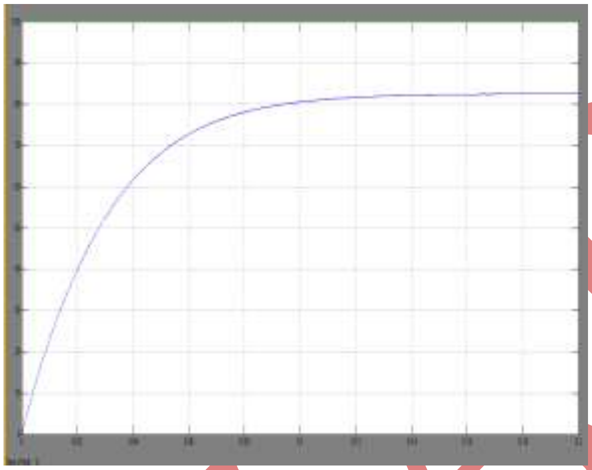


Fig3) LLCC Result

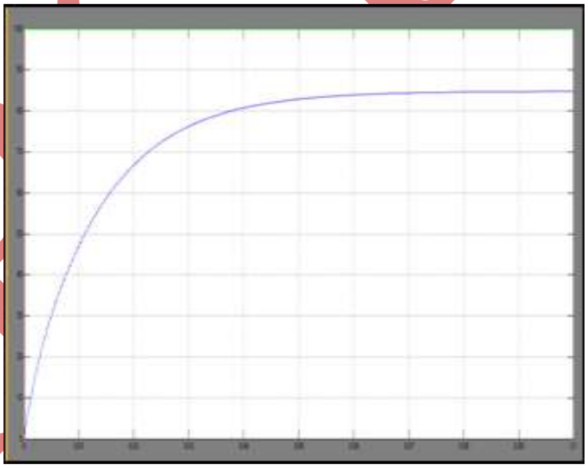


Fig4) M-Derived π Type Result

Fig5) T Type Result

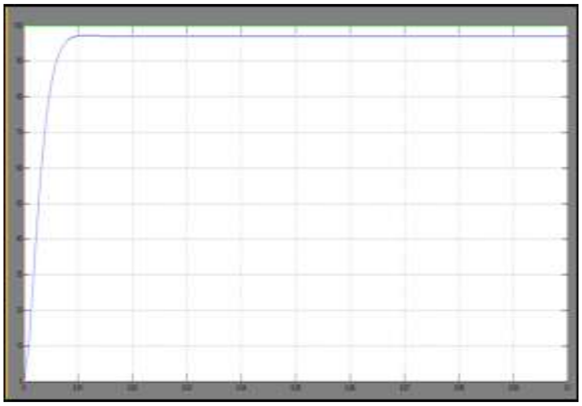


Fig6) Composite Type Result

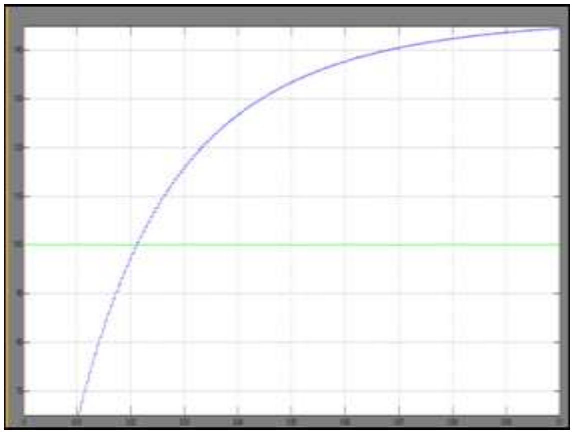


Fig7) M-Derived T Type Result

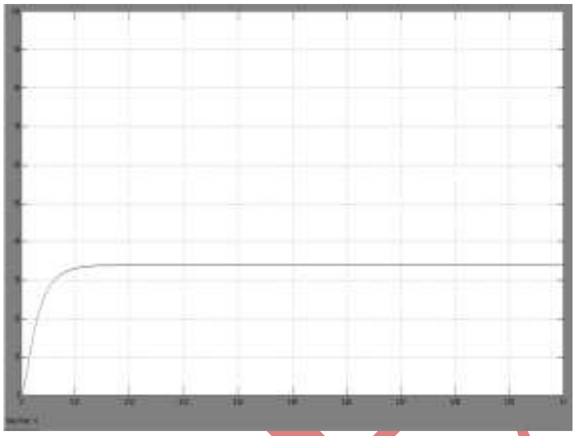


Fig8) Composite Attenuator Equalizer

V CONCLUSION

From the analysis and implementation of LCC,LLCC, T-type, π type , m type and m-Derived T-type, m-Derived π type and composite filters for Dc to Dc conversion, we can get the output of which is free from ripples and distortions, minimize stresses, high switching frequency, reduce switching losses and conduction losses and also the electromagnetic interference. By using the technique of attenuation, it is to remove a specified loss between source and a matched load without altering the impedance relationship ,while switching occurs and when the switching occurs equalizer could be remove the distortion when the signal passes to the electrical network ,so we get the ripple free output from all of the filters to convert DC to DC. It can be used for the applications of battery charging, un-interrupted power supply etc.,

REFERENCES

[1] W. Wongsaichua, W. J. Lee, S. Oraintara, C. Kwan, and F. Zhang, "*Integratedhigh-speed intelligent utility tie unit for disbursed/renewablegeneration facilities*," *IEEE Trans. Ind. Appl.*, vol. 41, no. 2, pp. 507–513,Mar./Apr. 2005.

[2] Z. Liang, R. Guo, J. Li, and A. Q. Huang, "*A high-efficiency PV moduleintegratedDC/DC converter for PV energy harvest in FREEDM systems*,"*IEEE Trans. Power Electron.*, vol. 26, no. 3, pp. 897–909, Mar. 2011.

[3] A. M. Rahimi and A. Emadi, "*Discontinuousconduction mode DC/DCconverters feeding constant-power loads*," *IEEE Trans. Ind.Electron.*,vol. 57, no. 4, pp. 1318–1329, Apr. 2010.

[4] R. Morrison and M. G. Egan, "*A new power-factor-corrected singletransformerUPS design*," *IEEE Trans. Ind. Appl.*, vol. 36, no. 1, pp. 171–179, Jan./Feb. 2000.

[5] Y. M. Lai, S.-C. Tan, and Y. M. Tsang, "*Wireless control of load current sharing information for parallel-connected DC/DC power converters*,"*IET Power Electron.*, vol. 2, no. 1, pp. 14–21, Jan. 2009.

[6] S. M. Lukic, J. Cao, R. C. Bansal, F. Rodriguez, and A. Emadi,"*Energystoragesystems for automotiveapplications*," *IEEE Trans. Ind. Electron.*,vol. 55, no. 6, pp. 2258–2267, Jun. 2008.

[7] F. Liu, J. Yan, and X. Ruan, "*Zero-voltage and zero-current-switchingPWM combined three-level DC/DC converter*," *IEEE Trans. Ind.Electron.*, vol. 57, no. 5, pp. 1644–1654, May 2010.

[8] Y. M. Chen, Y. C. Liu, and S. H. Lin, "*Double-input PWM DC/DC converter for high-/low-voltage sources*," *IEEE Trans. Ind. Electron.*, vol. 53,no. 5, pp. 1538–1545, Oct. 2006.

[9] C. Liu, A. Johnson, and J. S. Lai, "*DC/DC converter for low-voltage fuel cell applications*," *IEEE Trans. Ind. Appl.*, vol. 41, no. 6, pp. 1691–1697,Nov./Dec. 2005.

[10] R. M. Cuzner, D. J. Nowak, A. Bendre, G. Oriti, and A. L. Julian, "*Mitigating circulating common-mode currents between parallel soft-switched drive systems,*" *IEEE Trans. Ind. Appl.*, vol. 43, no. 5, pp. 1284–1294,Sep./Oct. 2007

.[11] M. Ilic and D. Maksimovic, "*Interleaved zero-current-transition buck converter*," *IEEE Trans. Ind. Appl.*, vol. 43, no. 6, pp. 1619–1627,Nov./Dec. 2007.

[12] Y. C. Chuang, Y. L. Ke, H. S. Chuang, and H. K. Chen, "*Implementation and analysis of an improved series-loaded resonant DC-DCconverter operating above resonance for battery chargers*," *IEEE Trans. Ind. Appl.*, vol. 46, no. 3, pp. 1052–1059, May/Jun. 2009.