International Journal For Technological Research In Engineering
Volume 2, Issue 7, March-2015 ISSN (Online): 2347 - 4718

ANALIYSIS OF FRONT-END CONVERTER WITH UNITY POWER FACTOR AND LOW INPUT CURRENT THD FOR TRACTION APPLICATION

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Abstract: The work presented in this thesis deals with the simulation, design & development of the front-end converter. Here front-end converter is AC/DC or DC/AC converter at the front end of the system. A suitable PWM technique is employed in order to obtain the required output voltage in the line side of the inverter. SPWM technique has been used for providing triggering pulse to the FEC and Inverter both in which IGBT is used as switch. It is very accurate method as it is concern with the modulation of the amplitude and frequency. By changing Modulation index (ma) amplitude of the output voltage and current can be controlled. The main advantage of this approach is that the total harmonic distortion (THD) in line and phase voltage decrease as the value of the modulation index increased. The value of fundamental component in line and phase voltage is increased with the increase in modulation index. PWM is one of the best methods for the controlling the output voltage especially SPWM because it make it possible to control frequency and magnitude both in traction Induction motor. It is also used for the reduction of the harmonics from the system. FEC has advantage of drawing balanced supply even in the unbalance supply form Utility. Using Matlab simulink this operation will be shown with the details like THD analysis, output voltage, output current, triggering signals for switching. Total circuitry controlling will also be developed in the Matlab.

I. INTRODUCTION

Traction means a driving force or an electric traction means a locomotion in which the driving force is obtained from electric motors. One of the practical application of the electricity which enters into everyday life of many of us, is its use trains, trolley buses, and tram cars in traction we have AC and DC drives. AC induction motor is referred as AC Drives; it offers advantages like low cost, low maintenance, smaller size and reliable operation. Some other prior application areas are fans & conveyer belts, robotics, overhead cranes, paper mills, textile mills, etc. In general for better control and lesser losses in motors. We need to adopted a advanced method which provides desired regulation and it have became more flexible after combining with power electronics; different kind of AC/DC, DC/AC and AC/DC/AC configurations are used to provide desired output of traction induction motor. Since it is very important to control output voltage of different electrical equipments. And for that control purpose FEC (front-end converter) are used at the front-end of the system.

II. FRONT END CONVERTER

Front end converters are becoming and interesting solution for power factor correction and low frequency current harmonic elimination in static power conversion systems. The term Front End Converter refers to the power converter system consisting of the line-side converter with active switches such as IGBTs, the dc link capacitor bank, and the load-side inverter. The line-side converter normally functions as a rectifier. But, during regeneration it can also be operated as an inverter, feeding power back to the line. The line-side converter is popularly referred to as a PWM rectifier in the literature. This is due to the fact that, with active switches, the rectifier can be switched using a suitable pulse width modulation technique. The PWM rectifier basically operates as a boost chopper with ac voltage at the input, but dc voltage at the output. The intermediate dc-link voltage should be higher than the peak of the supply voltage. This is required to avoid saturation of the PWM controller due to insufficient dc link voltage, resulting in line side harmonics. The required dc-link voltage needs be maintained constant during rectifier as well as inverter operation of the line side converter. The ripple in dc-link voltage can be reduced using an appropriately sized capacitor bank. The active front-end inverter topology for a motor drive application is shown in Figure for a constant dc-link voltage; the IGBTs in the line-side converter are switched to produce three-phase PWM voltages at a, b, and c input terminals. The line-side PWM voltages, generated in this way, control the line currents to the desired value. When dc link voltage drops below the reference value, the feed-back diodes carry the capacitor charging currents, and bring the dc-link voltage back to reference value.

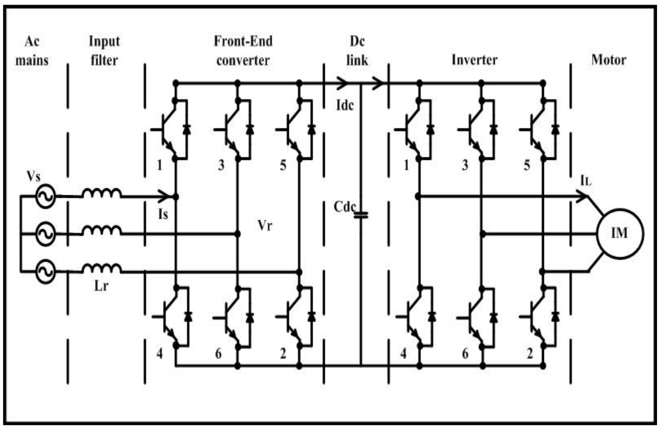

Figure: 1 Basic Circuit Diagram of Front End Converter.

III. PULSE WIDTH MODULATION TECHNIQUE

Pulse width modulation is a technique in which a fixed input dc voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is most popular method of controlling the output voltage and this method is termed as pulse width modulation technique. PWM is an internal control method and it gives better result than an external control methods. There are number of PWM methods for variable frequency voltage-sourced inverters. A suitable PWM technique is employed in order to obtain the required output voltage in the line side of the inverter. A Sinusoidal Pulse Width Modulation technique is also known as the triangulation, sub oscillation, sub harmonic method is very popular in industrial applications. In this technique a high frequency triangular carrier wave is compared with the sinusoidal reference wave determines the switching instant. When the modulating signal is a sinusoidal of amplitude Am, and the amplitude of triangular carrier wave is Ac, then the ratio m=Am/Ac, is known as the modulation index. It is to be noted that by controlling the modulation index one can control the amplitude of applied output voltage.

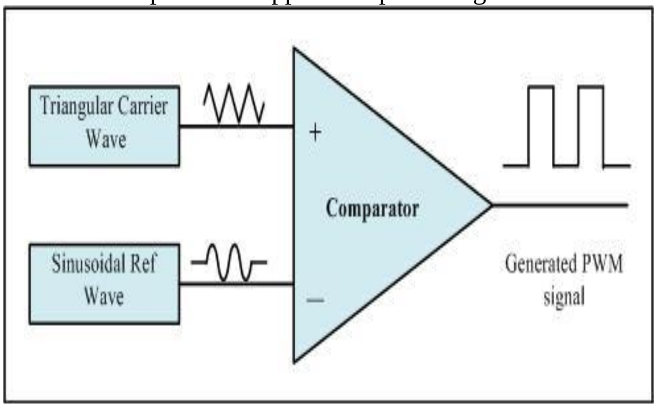

Figure: 2 Block diagram of Basic PWM Generator.

For wide variation in drive speed, frequency of the applied AC voltage needs to be varied over a wide range. The applied voltage also needs to be varying almost linearly with the frequency. The harmonic content in the output of the inverter can be reduced by employing pulse width modulation (PWM).

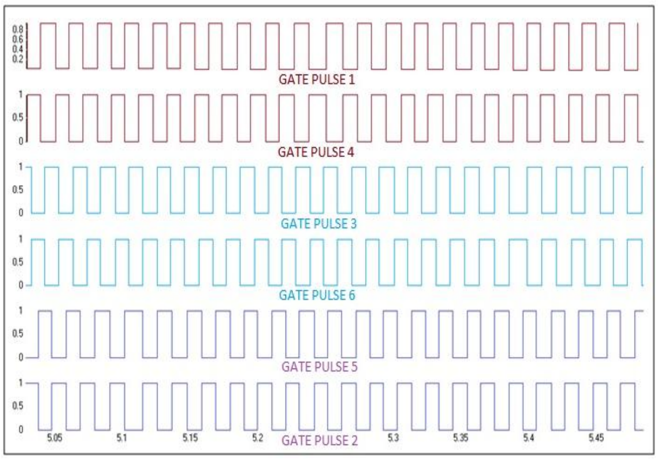

Figure: 3 PWM generated signal.

Sinusoidal PWM (SPWM) is affecting in reducing lower order harmonics while varying the output voltage and gone through many revisions and it has a history of three decades. Some of the following constraints for slow varying sinusoidal voltage be considered as the modulating signal are:

(1) The peak magnitude of the sinusoidal signal is less than or equal to the peak magnitude of the carrier signal. This ensures that the instantaneous magnitude of the modulating signal never exceeds the peak magnitude of the carrier signal.
(2) The frequency of the modulating signal is several orders lower than the frequency of the carrier signal. For example 50 Hz for the modulating signal and 20 KHz for the carrier signal. Under such high frequency ratio's the magnitude of the modulating signal will be virtually constant over any particular carrier signal time period.
(3) A three phase Sine-PWM inverter would require a balanced set of three sinusoidal modulating signals along with a triangular carrier signal of high frequency.

IV. SIMULTION RESULTS

Here we prepare the simulation of front-end converter with controlled and uncontrolled mode with their appropriate results; the controllable converter can be operated as a rectifier as well as an inverter too. The switching pulse of Inverter is provided by the PWM generator. The simulation of the proposed circuit is prepared with uncontrolled diode rectifier in line side and inverter controlled with six pulse pwm generator at load side. IGBT is used here as switch and to triggering that we can apply the pwm generator. The Capacitor is connected in parallel for removing fluctuations from the DC Bus Voltage. And there related waveforms are given below. Nominal fixed load torque of 11.9 N-m is given to the motor. The output speed of the motor will given in angular terms (ωm) hence to get the rpm a gain (block) speed converter is used uses the below expression for converting speed.

$$\text{rpm} = \frac{\omega m * 60}{2 * \pi}$$

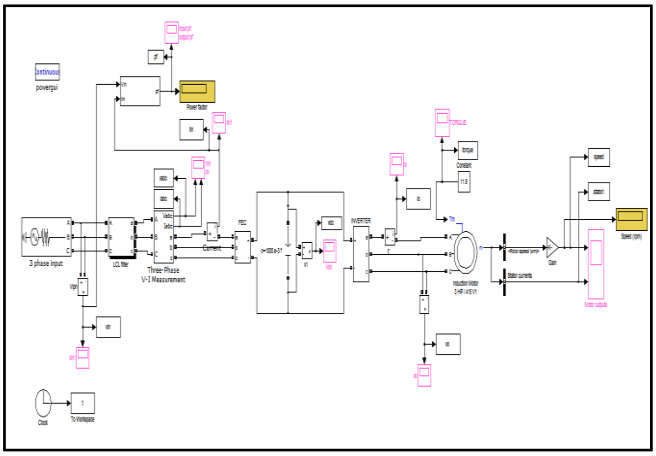

Figure: 4 Simulation of The Proposed Circuit (uncontrolled).

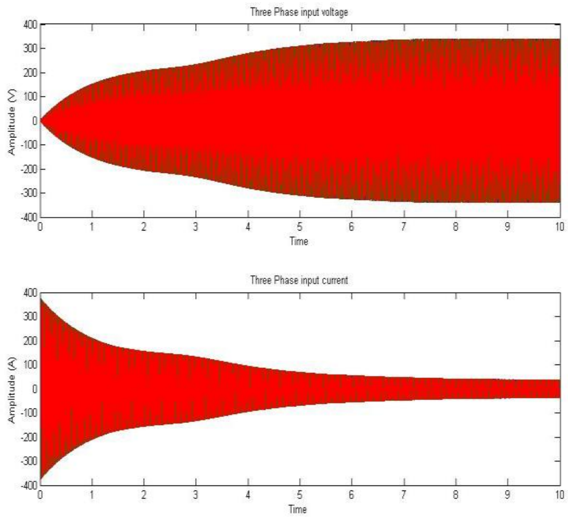

Figure: 5 Three phase input voltage and current waveform.

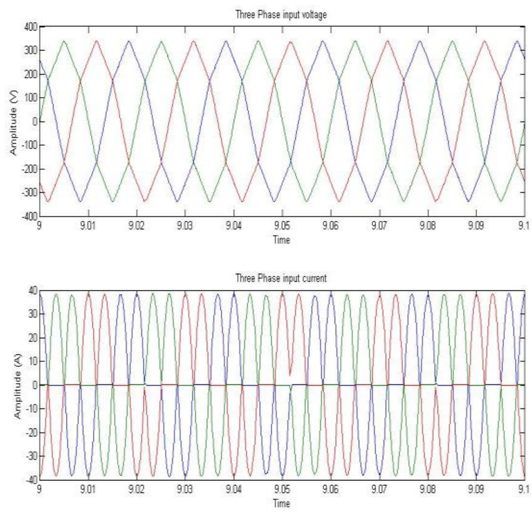

Figure: 6 Three phase input voltage and current scaling waveform.

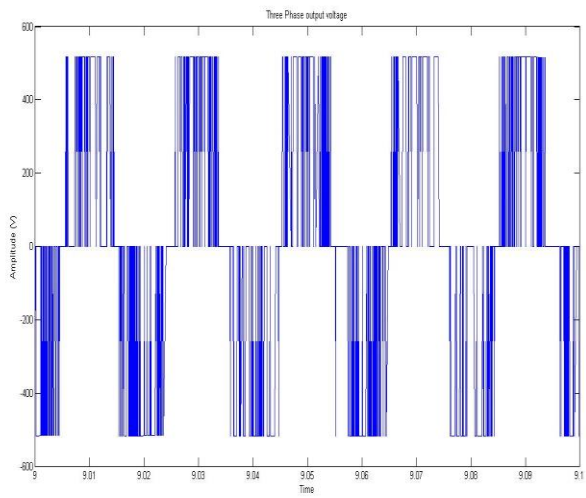

Figure: 7 Three phase output voltage waveform.

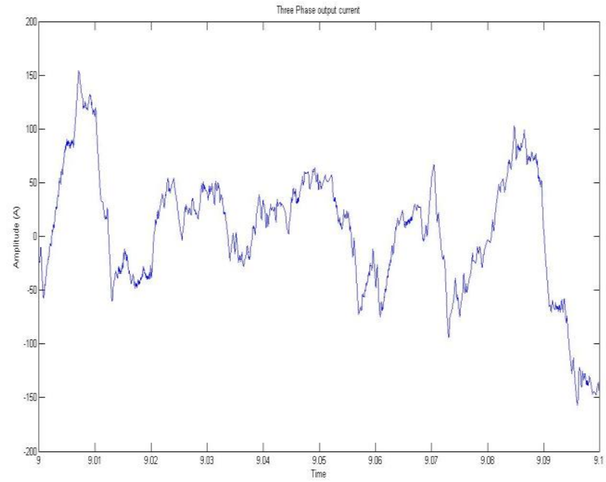

Figure: 8 Three phase output current waveform.

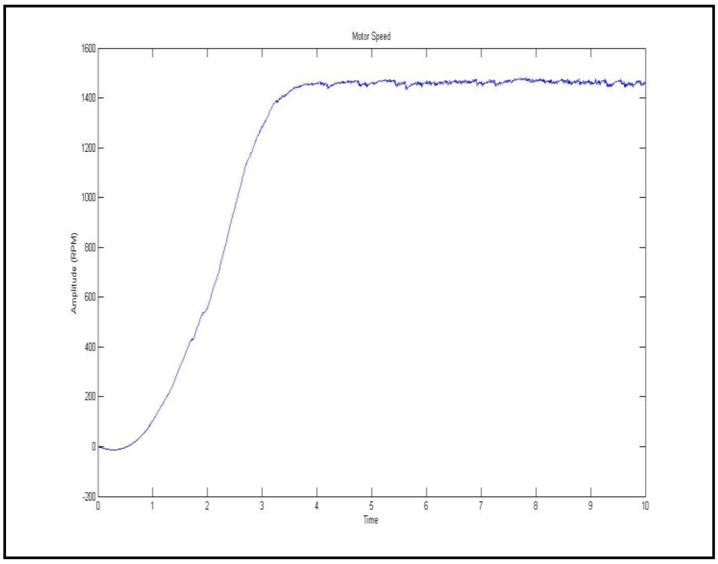

Figure: 9 speed of motor.

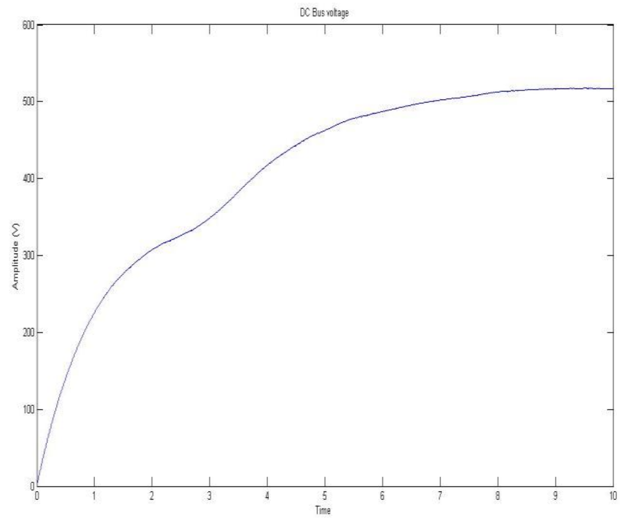

Figure: 10 voltage at dc link

MODULATION INDEX	THD I/P CURRENT	THD O/P CURRENT	THD I/P VOLTAGE	THD O/P VOLTAGE
0.2	3.71	19.99	24.59	149.08
0.4	3.74	14.88	25.23	110.45
0.6	3.98	2.93	26.69	119.23
0.8	3.89	2.38	26.38	60.52
1	3.86	3.83	26.35	18.28

Table: 1 Modulation Index and its effects on THD in uncontrolled system.

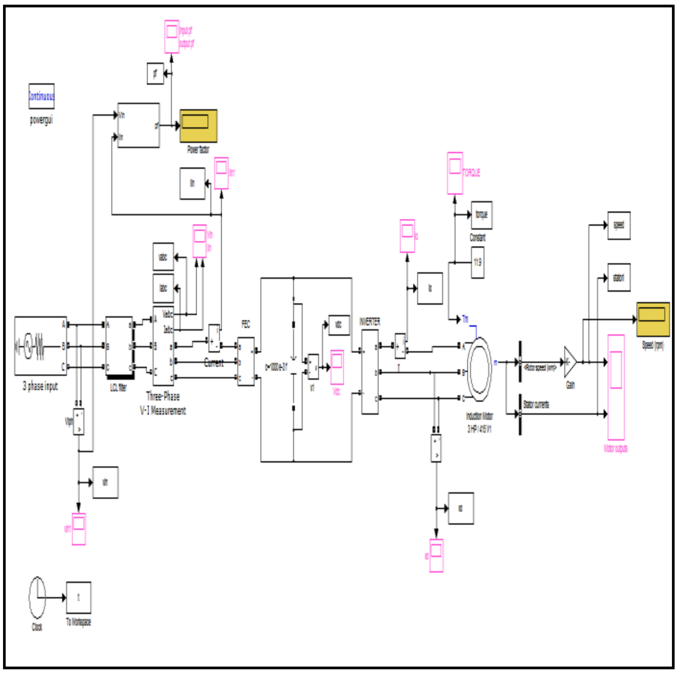

Figure: 11 Simulation of The Proposed Circuit (controlled).

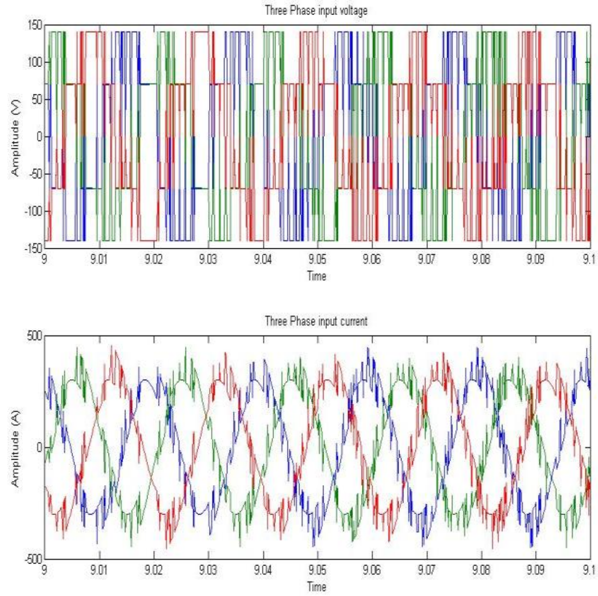

Figure: 13 Three phase input voltage and current scaling waveform.

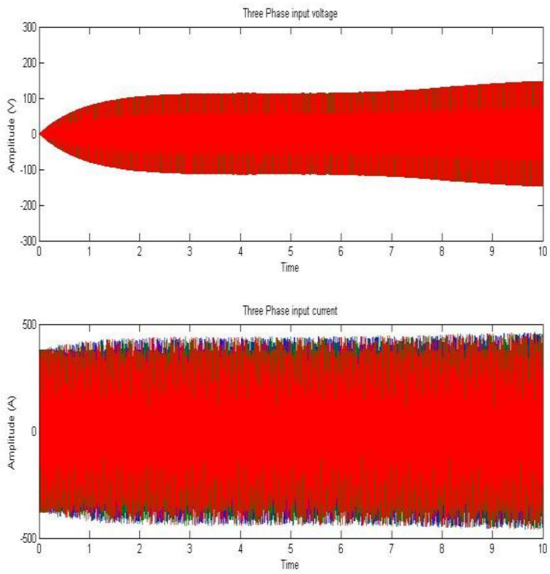

Figure: 12 Three phase input voltage and current waveform.

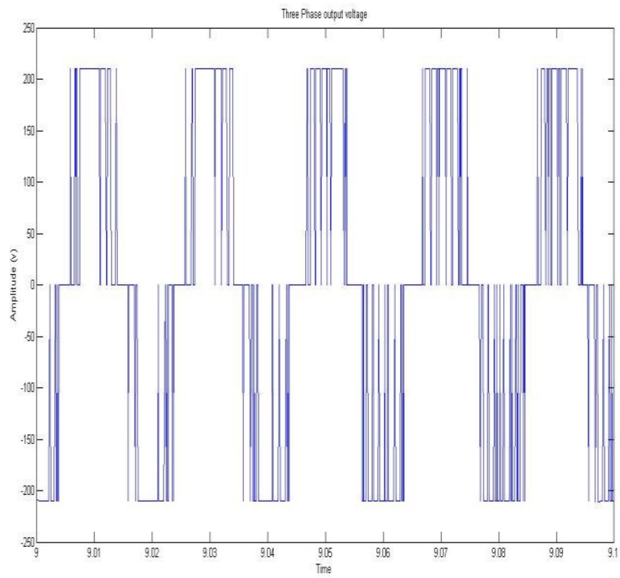

Figure: 14 Three phase output voltage waveform.

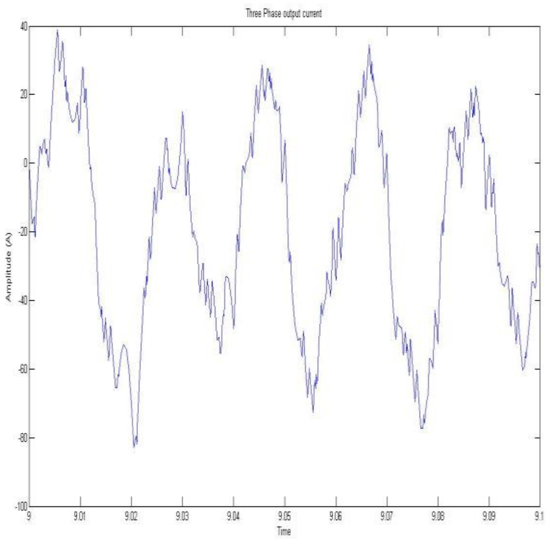

Figure: 15 Three phase output current waveform.

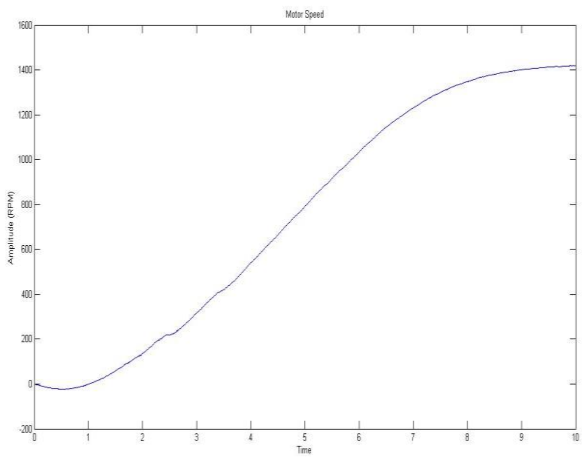

Figure: 16 speed of motor.

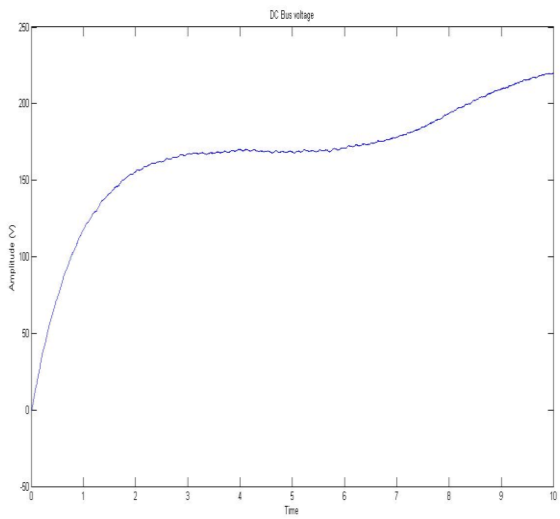

Figure: 17 voltage at dc link.

MODULATION INDEX	THD I/P CURRENT	THD O/P CURRENT	THD I/P VOLTAGE	THD O/P VOLTAGE
0.2	0.13	9.79	13.35	8.59
0.4	0.11	13.28	38.33	190.11
0.6	0.28	5.28	47.64	44.99
0.8	1.03	3.96	29.68	33.41
1	1.14	3.73	23.86	178.9

Table: 2 Modulation Index and its effects on THD in uncontrolled system.

Here in above session we can seen the different results of the uncontrolled and controlled proposed circuit with their analysis. And measure the THD of the both system with different modulation index.

V. CONCLUSION

Generally there are different control strategies to operate the traction motor as load. But with different strategy we always try to get the maximum output, and for that we included power electronics in the system. With a help of power electronics we can convert the AC/DC, DC/AC power at controllable mode. Earlier the AC is converted to fixed DC through uncontrolled rectifier using power diodes; a capacitor is used to filter the distortion and the pure DC is fed to an inverter for converting fixed DC to variable AC. Now a day controllable switch in converter is used as it is actively participating in the switching time. On the other hand a front – end converter is controllable device in line side converter for controlling the regular dc input in dc link. Front End Converter working in bidirectional mode which can fed the power back to the grid. Moreover if any kind of harmonic is present in the DC link than it will not be fed back into the grid when bidirectional power flow through FEC is considered. The controlled technique i.e. switching will however inject some harmonics. The Front End Converter is used here for solves the problem of poor power factor and it also help to achieve the better THD profile especially in controllable switching modes using PWM Generator.

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