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Frequency Controlled Protection Scheme to Protect the Theft of Electric Power at Distribution End

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Abstract: *This paper presents an advanced protection method to protect the theft of electric power at distribution end. The money power involved in the game of power theft is beyond imagination. Today power theft is all over the world. Electricity energy is cannot be seen to be taken. This makes the detection and bringing to book the culprits engage in illegal obstruction of energy really challenging. This paper focuses on the fundamental procedures of power theft and demonstrates a method to protect power theft. This proposed method is totally done by frequency variation in distribution system. Here distribution system model has been developed in frequency variation scheme. The operating principle, frequency variation method and effect of power theft on the illegal consumer have been analyzed in this paper.*

Keywords – *Cycloconverter, Frequency Controlled Scheme, Hooking protection, Power theft.*

I. INTRODUCTION

One fourth of the world population is deprived of the benefits of electricity, and African and Asian countries are the worse affected ones. A lot of investment is required in this field which cannot be agenda of these countries right now. Income is not the sole criterion for complete electrification in a country. In Chaina with 56% people still poor has manage to supply to electricity to 98% of its population. In Africa about 83% of the people in the rural areas do not get electricity. The slums all over the world survive mainly by meeting the energy needs from tapping electricity. Tapped and congested electric poles can be seen commonly in Indian cities. Huge amount of theft of power is done by tapping from line, or bypassing the energy meter. According to a study 80% of total theft detected all over the world is from dwelling places and 20 % from commercial and industrial premises. In this paper the proposed method protect mainly the direct tapping from line and meter bypassing type power theft, which is 80% of total theft detection. Power theft in individual premises is done 20%, today industrial premises energy meters are smart electronic meter. In smart energy meters Remote Meter Reading (RMR) system are there. Theft monitoring is very easy in RMR scheme. Now-a-days all distribution licensees lose a huge amount due to power theft at low tension over head lines by tapping illegally, or bypassing energy meters. The proposed system, described in this paper will be very effective for power theft basically tapping from low tension line and bypassing energy meters. The proposed method is frequency variation method where only legal and silenced consumer can use 50 Hz (60 Hz in USA) of frequency electricity. This method creates a obstruction for those who using electricity illegally by tapping from LT lines and bypassing energy meters. They cannot use 50 Hz (60 Hz in USA) of supply. For illegal people, consumed electrical frequency will be in the range of 8 to 10 Hz.

II. METHODOLOGY

In this system the frequency variation will take place in the distribution end. In existing system frequency is remain same throughout the system. In proposed system frequency will vary from distribution transformers, pole mounted substation's output terminals and consumer end. In between distribution transformer and pole mounted substation's output and consumer end frequency will keep 8 to 10 Hz range. The frequency will step down to 8 to 10 Hz range from 50 Hz at distribution transformer or pole mounted substations output terminal by stepped down Cycloconverter. And in the consumer premises consumers' electricity energy meter will contain a step up Cycloconverter, which step up the frequency 50 Hz range from 8 to 10 Hz range. The all Cycloconverters (step down Cycloconverter and step up cycloconverter) must be kept in sealed enclosure. The step down cycloconverter should be installed just attached to the distribution transformers secondary side bushing, and totally covered by sealed enclosure. And the step up cycloconverter should be kept in the energy meter. So those, who are not legal persons tapped or using electricity by bypassing energy meters will using 8 to 10 Hz of frequency. The effect of 8 to 10 Hz range frequency electricity energy to the load will be discussed in this paper.

III. PROPOSED MODEL OF DISTRIBUTION SYSTEM

At transformer end step down cycloconverter will be installed at secondary terminal of transformer. This step down cycloconverter step downs the frequency 8 to 10 Hz range. This step down cycloconverter will be fully enclosed and sealed, so that the output terminals of the transformer will be such that it contains bushings and cycloconverter which is attached with the out output lids.

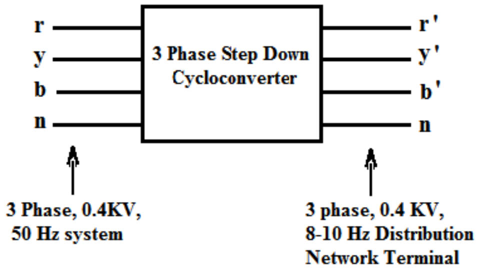

Figure 1: Step down Cycloconverter for stepping down frequency at distribution transformer end

Figure 1 show a step up cycloconverter, which will be attached to the output terminals of the distribution transformer. This figure is developed for 0.4 KV systems. Same will be done for any other voltage level at distribution end. This cycloconverter will step down the frequency 8 to 10 Hz from 50 Hz.

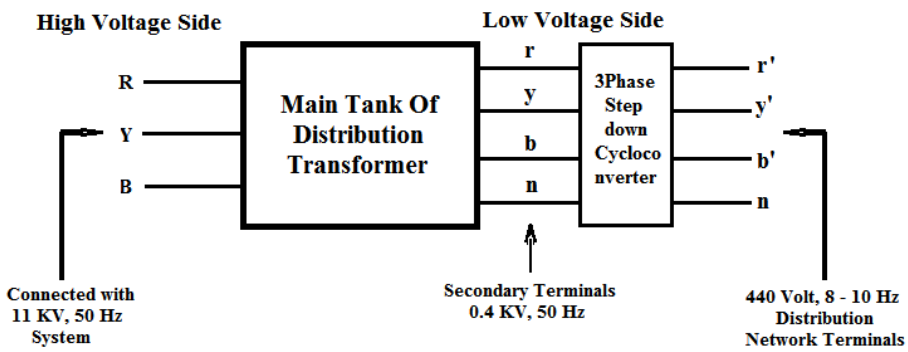

Figure 2: Step Down Cycloconverter arrangement at distribution transformer end

Figure 2 shows the distribution transformer incorporated with step down cycloconverter. Distribution primary side voltage is 11 KV and frequency 50 Hz. The output voltage will be 0.4 KV, 50 Hz, and it is connected with a step down cycloconverter, which step down the frequency 8 to 10 Hz from 50 Hz. The output terminals of the step down cycloconverter are termed as “Distribution Network Terminal” in this paper.

This position of step up cycloconverter should be in the energy meter, where incoming 8 to 10 Hz frequency electricity enters into the energy meter from distribution network. So cycloconverter step up that frequency to 50 Hz.

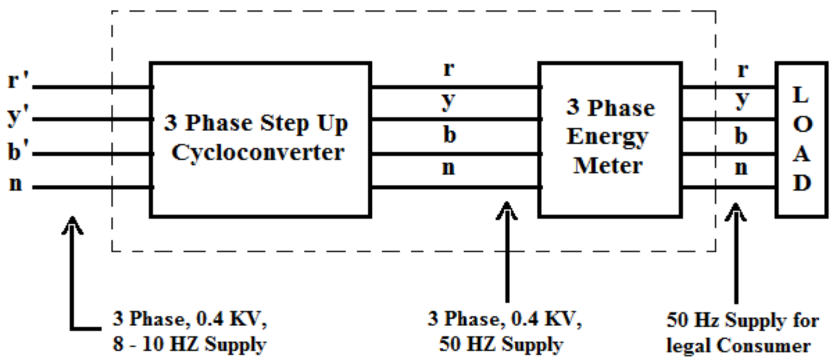

Figure 3: Step Up cycloconverter arrangement at 3 phase energy meter at legal consumer end.

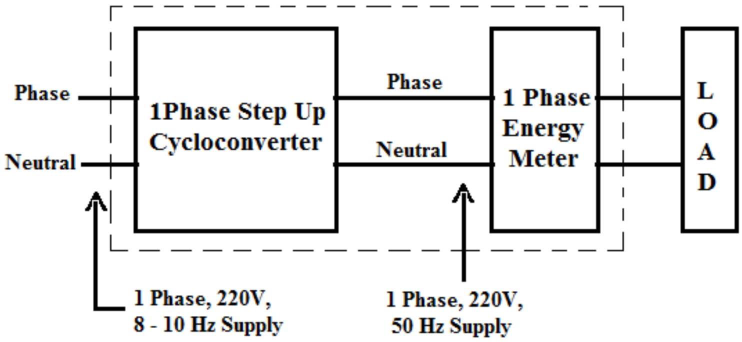

Figure 4: Step Up Cycloconverter arrangement in 1phase energy meter at legal consumer end

In the proposed model it is demonstrated that the cycloconverters' position. It is clearly understand that the distribution system frequency is kept 8 to 10 Hz range.

In the energy meter 8 to 10 Hz range frequency is stepped up to 50 Hz (60 Hz in USA). So only legal consumers can use 50 Hz healthy frequency system.

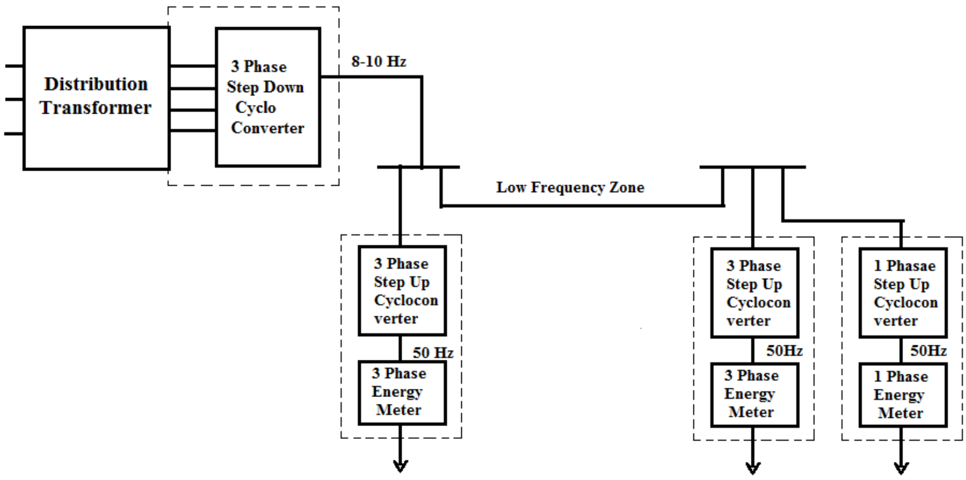

Figure 5: Distribution system model of proposed system

IV. OPERATING PRINCIPLE OF STEPPED UP AND STEPPED DOWN CYCLOCONVERTER

Working principle of cycloconverter is very common in power electronics. Though it is a very common topic, the working principle is discussed here. It is also discussed how 8 to 10 Hz frequency will be obtained from 50 Hz frequency system by using step down cycloconverter and how 50 Hz frequency will be obtained from 8 to 10 Hz frequency by using step up cycloconverter.

For Step down purpose 3 single phase cycloconverter is used for 3 phase connection due to better control purpose. In the figure it is seen that 'r', 'y', 'b' phases secondary terminal from distribution transformer are connected with 3 single phase cycloconverter respectively. Every single phase cycloconverter contain two terminals. One is phase and other is neutral. The lower frequency phase terminal is presented here as r', y', b' respectively. The supply for distribution purpose will be taken from output terminals of the cycloconverter. The output terminals of the step down cycloconverter are termed as "Distribution Network Terminal" in this paper.

The circuit diagram of step down cycloconverter incorporated with distribution transformer is described here. Figure 6 is the circuit diagram of a 1 phase step up cycloconverter connected with r phase of distribution transformer.

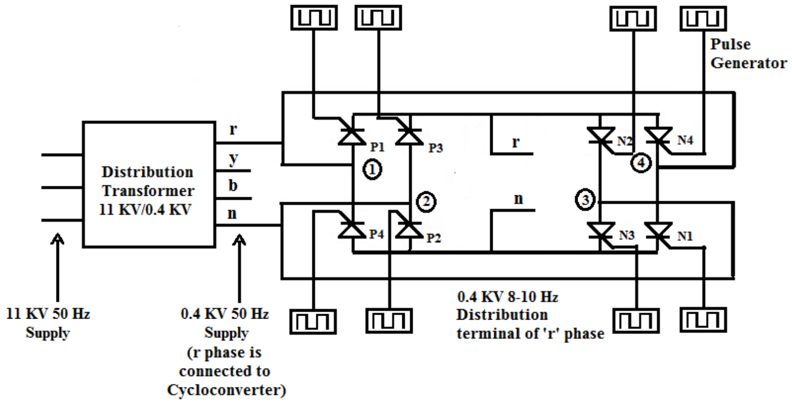

Figure 6: 1phase cycloconverter incorporated with distribution transformer 'r' phase.

Figure 7 is the circuit diagram of a 1 phase step up cycloconverter connected with y phase of distribution transformer.

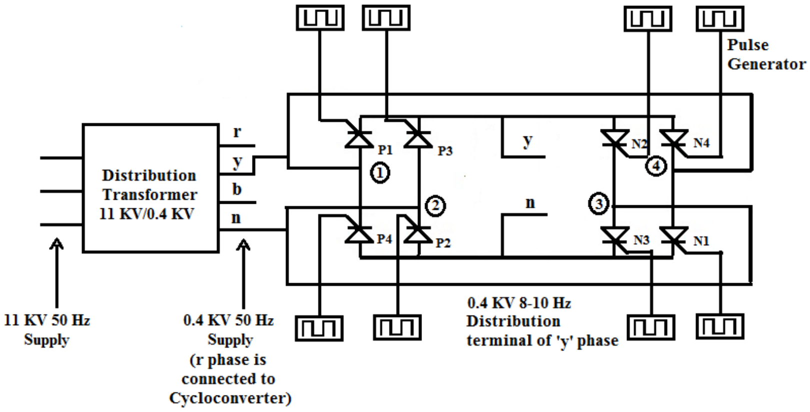

Figure 7: 1phase cycloconverter incorporated with distribution transformer 'y' phase

Figure 8 is the circuit diagram of a 1 phase step up cycloconverter connected with b phase of distribution transformer.

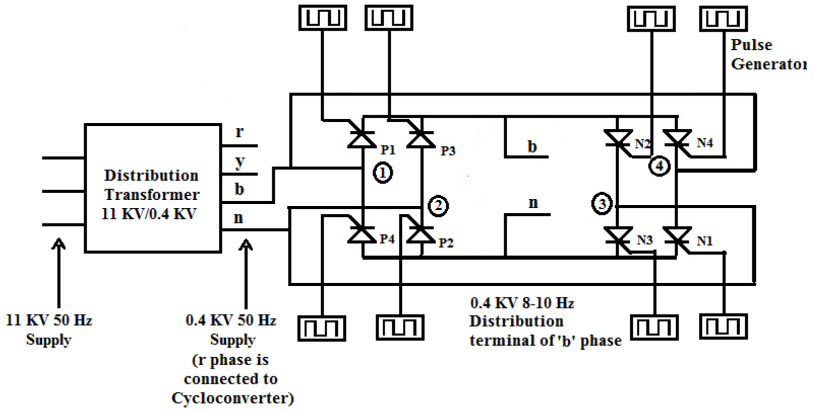

Figure 8: 1phase cycloconverter incorporated with distribution transformer 'b' phase

The 3 single phase cycloconverter connected with 3 phases of distribution transformer secondary terminals. The overall circuit diagram is given below.

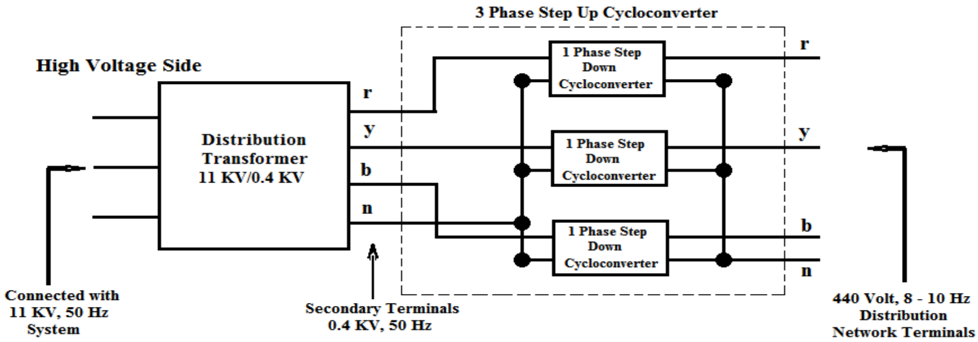

Figure 9: 3 single phase cycloconverter incorporated with distribution transformer's 3 phases

Figure 10 shows the operating waveforms for this step down cycloconverter with load terminal. The input voltage to the cycloconverter, Vs is an ac voltage at a frequency 50 Hz. Consider the operation of the cycloconverter to get one-fifth of the input frequency at the output.

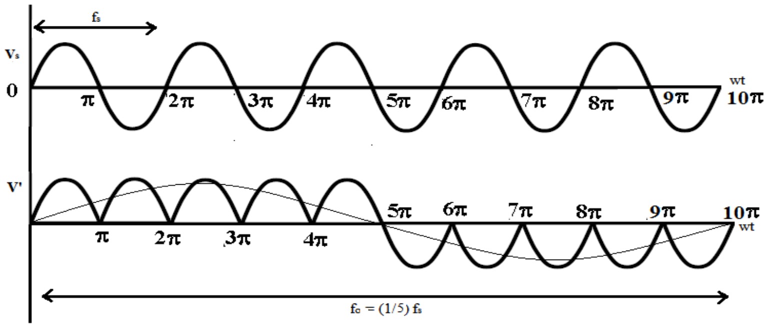

Figure 10: Output wave form of the step down cycloconverter

For the first five half cycles of Vs, the positive converter operates supplying current to the load. It rectifies the input voltage; therefore, the load sees 5 positive half cycles as seen in Figure 10. In the next five half cycles, the negative converter operates supplying current to the load in the reverse direction. The current waveforms are not shown in the figures Note that when one of the converters operates the other one is disabled, so that there is no current circulating between the two rectifiers. The frequency of the output voltage, V' in Fig. is 5 times less than that of Vs, the input voltage,

i.e. fo/fi =1/5. Thus, this is a step-down cycloconverter

For Step up purpose 3 single phase cycloconverter is used for 3 phase connection due to better control purpose. In the figure it is seen that r', y', b' phases are distribution network wire and are connected with 3 single phase cycloconverter respectively. Every single phase cycloconverter contain two terminals. One is phase and other is neutral. The 50 Hz frequency phase terminal for energy meter input is presented here as r, y, b respectively. The supply for energy meter input will be taken from output terminals of the cycloconverter.

The circuit diagram of step up cycloconverter incorporated with energy meter is described here. Figure 11 is the circuit diagram of a 1 phase step up cycloconverter connected with r phase of distribution transformer.

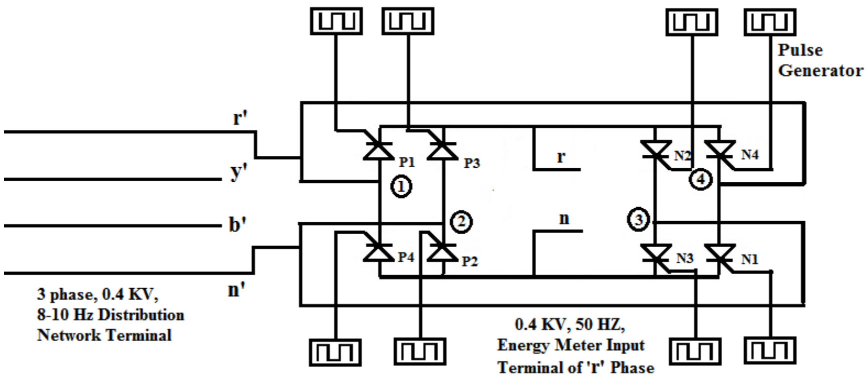

Figure 11: 1phase cycloconverter incorporated with distribution network terminal 'r' phase

For y and b phases will be like r phase. The 3 output terminals will be connected with the energy meter terminals.

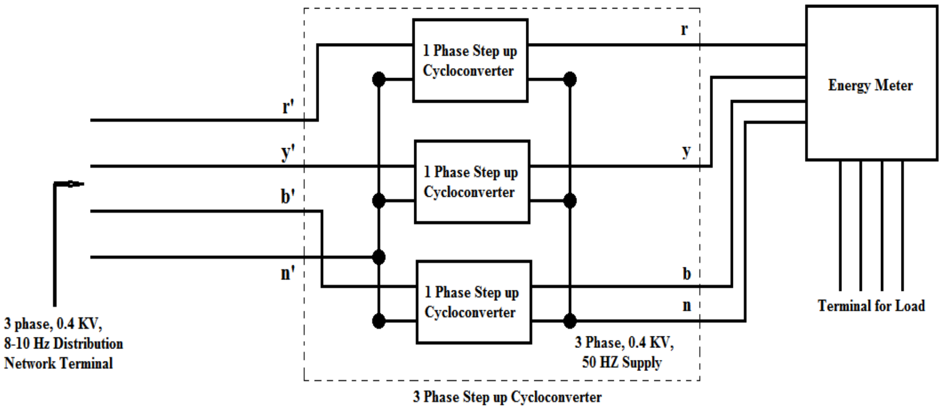

Figure 12: 3 single phase cycloconverter incorporated with 3 phase energy meter

Figure 13 shows the operating waveforms for this step up cycloconverter with energy meter terminal. The input voltage to the cycloconverter, V' is an ac voltage at a frequency 10 Hz. Consider the operation of the cycloconverter to get fifth times of the input frequency at the output.

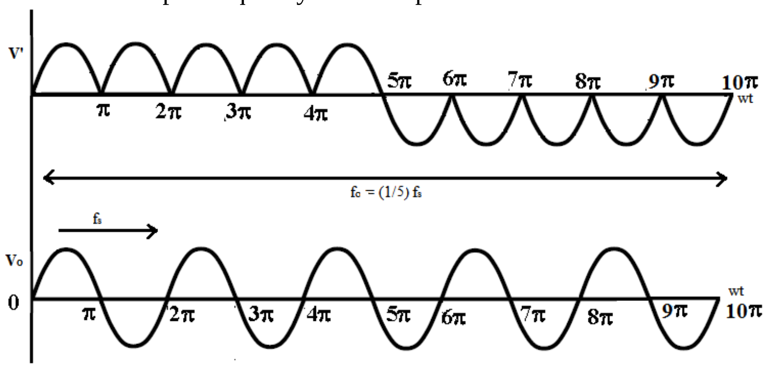

Figure 13: Output wave form of the step up cycloconverter

Figure 11shows the operating waveforms for this step up cycloconverter with energy meter terminal. The input voltage to the cycloconverter, V' is an ac voltage at a frequency 10 Hz. Consider the operation of the cycloconverter to get fifth times of the input frequency at the output of the step up cycloconverter.

It is seen from the figure that the step down frequency waveform contains 5 half cycles in positive half and 5 negative half cycle in the negative half. In case of stepping up the frequency, for the 1st positive half cycle in the positive half of V', the positive converter operates supplying current to the load. For the next positive half cycle of the positive half, negative converter operates supplying current to the load in reverse direction. Like that in every half cycle of whatever positive and negative half, positive and negative converter will operate one after one. So stepped up frequency will be obtained in this way.

V. CASE STUDY OF POWER THEFT IN PROPOSED SYSTEM

This proposed method of anti theft system is studied on the following types of load, and it is seen that, those who consumed electricity illegally by tapping or bypassing the energy meters, are drawing power in the range of 8 to 10 Hz frequency. This paper illustrates that effect of drawing such low frequency power to the loads.

Consumer use these type of loads

A) Lighting Loads

i) Incandescent lamp

ii) Florescent lamp

iii) Vapor lamp

B) Motor loads

C) Inductive loads

D) Small Transformer Oriented Instrument type load

If an Incandescent lamp is operated off a low frequency count, the filament cools on each half cycle of alternating current, leading to percentile change in brightness and flicker of the lamps; the effect is more pronounced with arc lamps; and mercury vapor and florescent lamps. Sometimes flickering of the lamps causes cut out of filament. So it will be damaged.

The effect on florescent lamp is slightly different, in fluorescent lamp contains a choke or ballast, which is a inductive load and it depends on frequency. In choke or ballast inductance $X = 2\pi fl$ (where l is the inductance of the ballast) provides reactance to limit the current through tube. If f will be f times lower reactance will be very low, causes destructive levels due to the tube's negative resistance characteristics.

When motor loads will be running at 8 to 10 Hz of range frequency the synchronous speed will be 1/5th, so rotor speed will become 1/5th. As the motor will connected to the mechanical load as per rating, this low frequency running motor draw more current from supply lines, so heat will be generated and motor will be burnt.

For inductive load inductance depends on frequency. So for lower frequency inductive load does not work properly.

For small transformer oriented instrument there will be a huge problem. Induce e. m. f. in transformer Proportional to frequency. So if this lower frequency will be applied to that type of instrument the induced e. m. f. will be very poor. So transformer cannot be operated properly and sometimes it will be a chance to damage.

There is another effect to the illegal consumer of electricity. The step down cycloconverter output voltage waveforms have complex harmonics. Higher order harmonics are usually filtered by the machine inductance, therefore the machine current has less harmonics but in this system due to lower frequency, inductance of the machine of illegal users of electricity are very low. So no filtration of harmonics has been occurred. The harmonics causes noisy operation, harmonic losses and torque pulsations in the instrument used by illegal persons and causes heat generation in the instruments. Sometimes it will burn the instruments.

At the legal consumer end the step up process occurs, but there will be no harmonic because the step down waveform is just stepped up in that end.

Note that in a cycloconverter, unlike other converters, there are no inductors or capacitors, i.e. no storage devices. For this reason, the instantaneous input power and the output power are equal.

VI. ADVANTAGE OF LOW FREQUENCY POWER DISTRIBUTION

A In this proposed method the distribution of power is done at 8 to 10 Hz of frequency range. The major advantage of the scheme is protection against power theft. Not only that this method has quiet advantage in distribution system.

As the frequency is low, at range of 8 to 10 Hz range, the inductance of the line will be $X_L = 2\pi fL$ is proportional to frequency, will be very low. The inductance of the line should be lower at 5 times than 50 Hz system.

Skin effect totally depends on frequency. So lower frequency causes lower skin effect, lower proximity effect. So power flow will maximize 5 times due to f times lower frequency.

Lower skin effect, proximity effect reduces resistance, cause lower distribution loss. Effect of corona loss should be reduced. In cable distribution system the alternation current causes sheath loss, due to lowering the frequency sheath loss will be lower.

For lower frequency the distribution capacitance of the line $X_C = 1/(2\pi fC)$ will be high. So good voltage profile will be obtained at distribution end.

VII. Conclusion

This paper demonstrates the method, protect the 80% of power theft which are done by tapping and meter bypassing. This proposed method will be very effective for distribution licensees. Here the models are done only at 11KV/0.4 KV 50 Hz system, although this scheme is valid for any other voltage level in distribution system. For distribution system this anti theft system of power can be considered as "Frequency Controlled Anti Theft System of Power"

The future research work will focus on control scheme of frequency variation in Frequency Controlled Anti Theft System of Power and its effect of distribution system as well as illegal consumers.

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