REMOTE METER READING OVER POWER DISTRIBUTION LINES.

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INTRODUCTION

With the rapid developments of new housing, industrial and commercial installations in Sri Lanka, the number of consumers of electricity has been increased in the distribution network during last few decades. Therefore the utility is looking for solutions to overcome the difficulties arisen and to provide reliable and controllable service to the consumers.

One of the best solutions is Remote Meter Reading, which transmits data from meters at consumers' premises over a communication channel to a central monitoring computer at a remote central location. This offers more prospective benefits and long term cost savings to an electric utility and customers than traditional metering system.

Mainly it eliminates the possibility of human errors, missed readings and estimated readings on the part of a meter reader. Employees can be protected from hazardous situations and also prevented to reach difficult areas to read the meters. In addition, Remote Meter Reading reduces operating costs, save critical amount of money and eliminating the much of paper work by reducing the number of meter readers required.

Also the facility of Remote Meter reading is usable to communicate with the customers frequently to provide archive information to help resolve billing disputes and to provide flexible billing options such as billing on a requested date. “Read to bill” time is also reduced. Maintenance engineers also use information to size transformers, identify power outages, and detect line problems before they become serious and cut line losses.

DATA TRANSMISSION ON POWER DISTRIBUTION LINES

Remote Meter Reading requires a good communication link to transfer data between each consumer and the central computer. This needs the metering device to be equipped with communication hardware. The crux of the whole process is the establishing of a successful and reliable communication link. The power distribution system itself is an ideal option for the communication link, [1],[2],[3] when applied with a reliable data transmission strategy. The work described in this paper uses this transmission link.

Basically the system involves the components of Remote Transponder Unit (RTU), Communication channel and Data Collection Unit (DCU), as in figure 1.

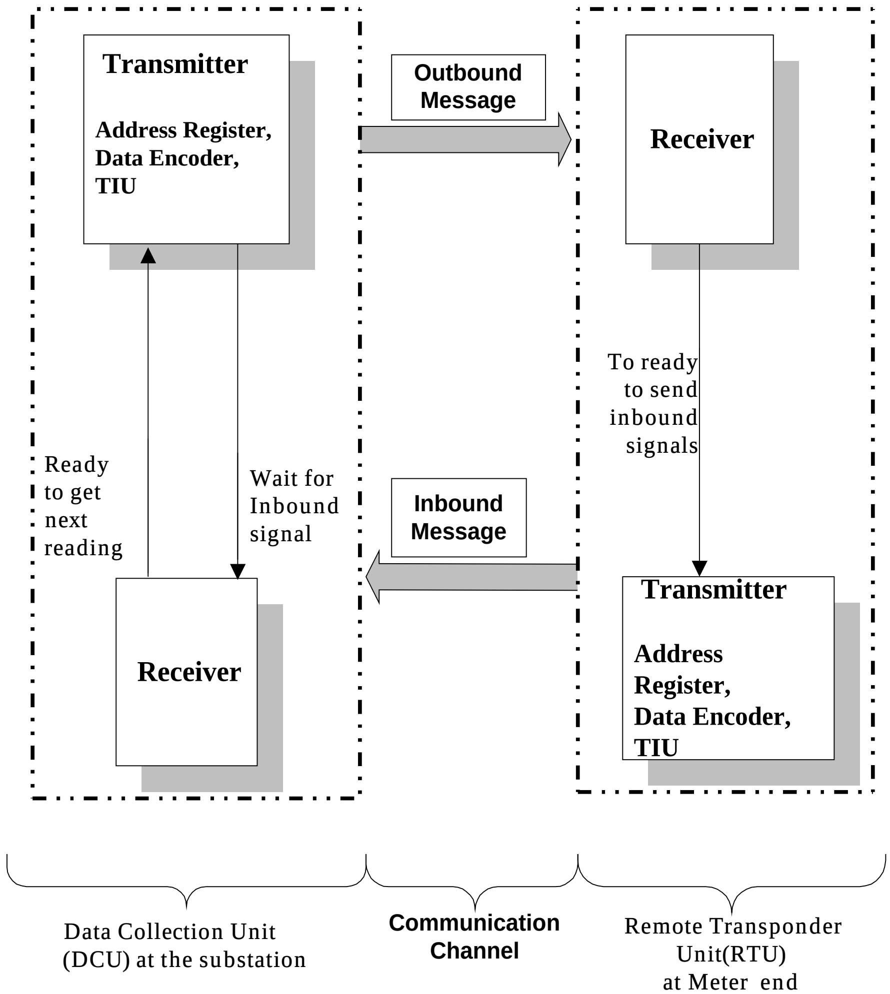

Figure 1 Components of the Basic Communication System

Remote Transponder Unit (RTU) consists of a transmitter and a receiver. The transmitter consists of a Meter register data encoder and Telemetry Interface Unit (TIU). Meter register contains the energy consumption data. Data Encoder Unit produces stream of data for transmission. Telemetry Interface Unit (TIU) converts the stream of data to the corresponding current pulses to be sent over the channel. The receiver consists of a front side filtering unit and a data decoding unit. Data Collection Unit (DCU) consists of a transmitter and a receiver, having similar functions.

To exchange messages between consumers and the computer at the remote central station, initially, an address message is sent from the central station (Master station) to a meter requesting data. Then the meter sends data to the central station. In communication terminology this is ***master-slave communication*** of ***half-duplex transmission mode***.[4], [5]

DATA TRANSFER CONCEPT

Basic concept of this research for data transmission is the change of voltage and current wave at the supply end and the load end respectively of the power system.[6] Voltage pulses and current pulses are superimposed with the line voltage and line current at the supply and load end respectively.

Outbound signal

The superimposed voltage pulses transmitted from the substation, is an outbound signal that addresses the consumer for requesting data. These pulses are detected and converted into real data at the consumer end by means of a suitable band pass filter and a processing technique. That is, The meter is polled from the substation.

Inbound signal

The superimposed current pulses transmitted from the consumer end, is an inbound signal that responds to the message from the substation. These pulses are detected at the supply end by means of a suitable band pass filter and converted to corresponding data by a processing technique.

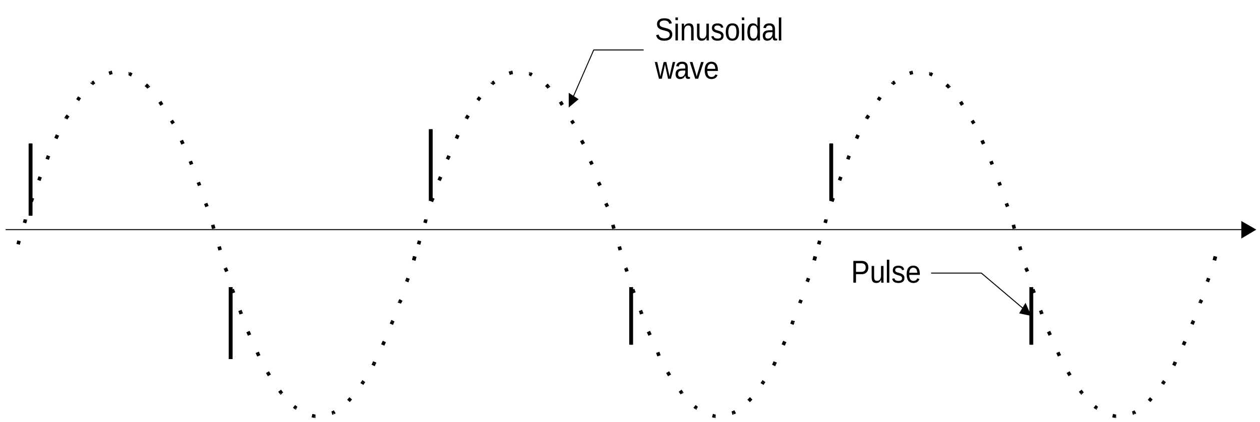

Figure 2a Superimposed pulses with sinusoidal wave of Voltage/Current at the transmitter

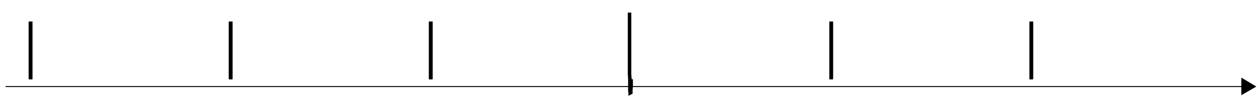

Figure 2b Detected pulses at the receiver

The superimposed pulses with sinusoidal wave of current/voltage at the transmitter and the detected pulses at the receiver can be shown as in figure 2(a) and 2(b).

Main role of this research is to select most suitable pulse when it transmits over distribution lines and step down transformers. The magnitude of the peak currents and the pulse width must have detectable strength with least interference to the system.

STRUCTURE OF THE SYSTEM USED IN THE STUDY

A 33KV feeder emerging from Ratmalana grid-substation is chosen for this study. This feeder serves industrial, commercial and large number of residential loads. The University of Moratuwa is also connected to this feeder, and this has been chosen as the RTU.

The Data Collection Unit (DCU) is at the 33KV feeder input. Other feeders emerge from the same substation also have similar DCUs.

The Central Reading Unit (CRU) may be located else where, and data from each DCU is sent to the CRU via a second communication link. This may be a conventional telephone link, or similar power line based communication link. [7] The structure of this overall system is given in figure 3.

COMMUNICATION PROTOCOL

A Data transmission protocol is necessary for successful communication between the substation and the consumer.[5] Flow charts in figure 4a and 4b simply describe the protocols at the substation and the consumer end.

Outbound messages of the substation contain POLL/ADDRESS, NACK and ACK messages while inbound messages at the consumer contain DATA, NACK and ACK messages. Each message block is encoded in ASCII. Fields for start, stop and error detection and correction are contained in each message block as is common in many data communication protocols. Structure of outbound and inbound message blocks, are shown in Figure 5a and 5b.

START OF FRAME	**OPERATION CODE**	**DATA/ACK/ NACK CODE**	**ERROR DETECTI ON CODE**	**ERROR CORRECTION CODE**	**END OF FRAME**

Figure 5a Structure of Inbound Message

START OF FRAME	**OPERATION CODE**	**ADDRESS/A CK/NACK CODE**	**ERROR DETECTI ON CODE**	**ERROR CORRECTION CODE**	**END OF FRAME**

Figure 5b Structure of Outbound Message

A series of 'pulse' and 'no pulse' patterns emit from the transmitter, according to each code. The presence of a pulse indicates a '1' and the absence indicates a '0'. Hence the message length and the time taken for metering can be decided by defining time between pulses.

METHODOLOGY

Development of a power system model

Having obtained the physical data of the selected part of the distribution system, a three-phase electrical circuit diagram is designed for simplifying the communication system analysis. Voltages at different points and currents in each branch of the circuit are calculated in the steady state condition of the system. A prototype system based on the above simplified method, is designed for analyzing data transmission over distribution lines.

Simulation studies

A computer simulation is carried out using MATLAB to investigate the possibility of data transmission and receiving at both ends.

Hardware development

A prototype model is available as a laboratory model to understand the exchange of data experimentally. Generating and formatting of pulses corresponding to the data, to be sent is done by the 8051 micro-controller and the associated circuitry. These pulses are injected to the system through power interface unit and thyristor circuit arrangement at the transmitting end.

Measurements

Series of measurement have been taken from the grid substation at Ratmalana to observe the harmonic contents in the feeder. The measured data are used to decide on a suitable data pulse, which will have minimum interference from the power line signal. It is also used to decide a suitable time for data frame. A band-pass filter and a level detector is designed to detect the pulse at the receiving end.

OBSERVATIONS AND RESULTS

According to the data samples obtained for frequency analysis of current wave, ratio of magnitude of the significant harmonics to the fundamental is around 0.1% during daytime. Significant harmonics are found below 4.7kHz during daytime and below 3.3kHz at night. But this ratio is around 0.03% in night. Figures 6a and 6b show the frequency spectrum graphs in daytime and night respectively.

According to the observations it can be concluded that the frequency range from 3.3kHz upwards could be suitable for data pulse insertion at night.

It is also observed that the power of a sinusoidal pulse of 50 micro-second width is in the frequency range of 0 - 20 kHz.
Using computer simulation, sinusoidaly shaped 50 microsecond pulses are injected at 400V side and detected at the 33KV side by means of 5 - 10kHz band pass filter. It shows that the positions of the detected pulses are the same as the positions of the injected pulses. This is illustrated as in figure 7.

According to the turns ratio of transformers used in the system 1.2% of load current appears at the supply end. Therefore the magnitude of the current pulse is in the range of 10 - 20A is enough to detect at the supply end at any frequency range above 3.3kHz during night. The effect of the pulse to the equipment connected to the consumer can be eliminated by means of a suitable passive low pass filter.

CONCLUSION

This paper outlined a simple and cost effective concept of remote reading of energy meters specially via low voltage distribution lines. Sine wave distortion method of voltage and current is used for inbound and outbound signal transmission respectively. A polling technique is used for this purpose The rate of metering is considerably higher than the traditional metering. Signal transmission is possible during mid night period and detection can be done at frequencies above 3.3kHz. The signal transmission and detection techniques are to be further developed including the effects due to the system oriented harmonics caused by such action as capacitor switching, operation of switch mode power supplies, load changes etc. The effect on the power system of the harmonics generated by the sine wave distortion technique and methods of minimizing such effects are also to be studied.

ACKNOWLEDGEMENT

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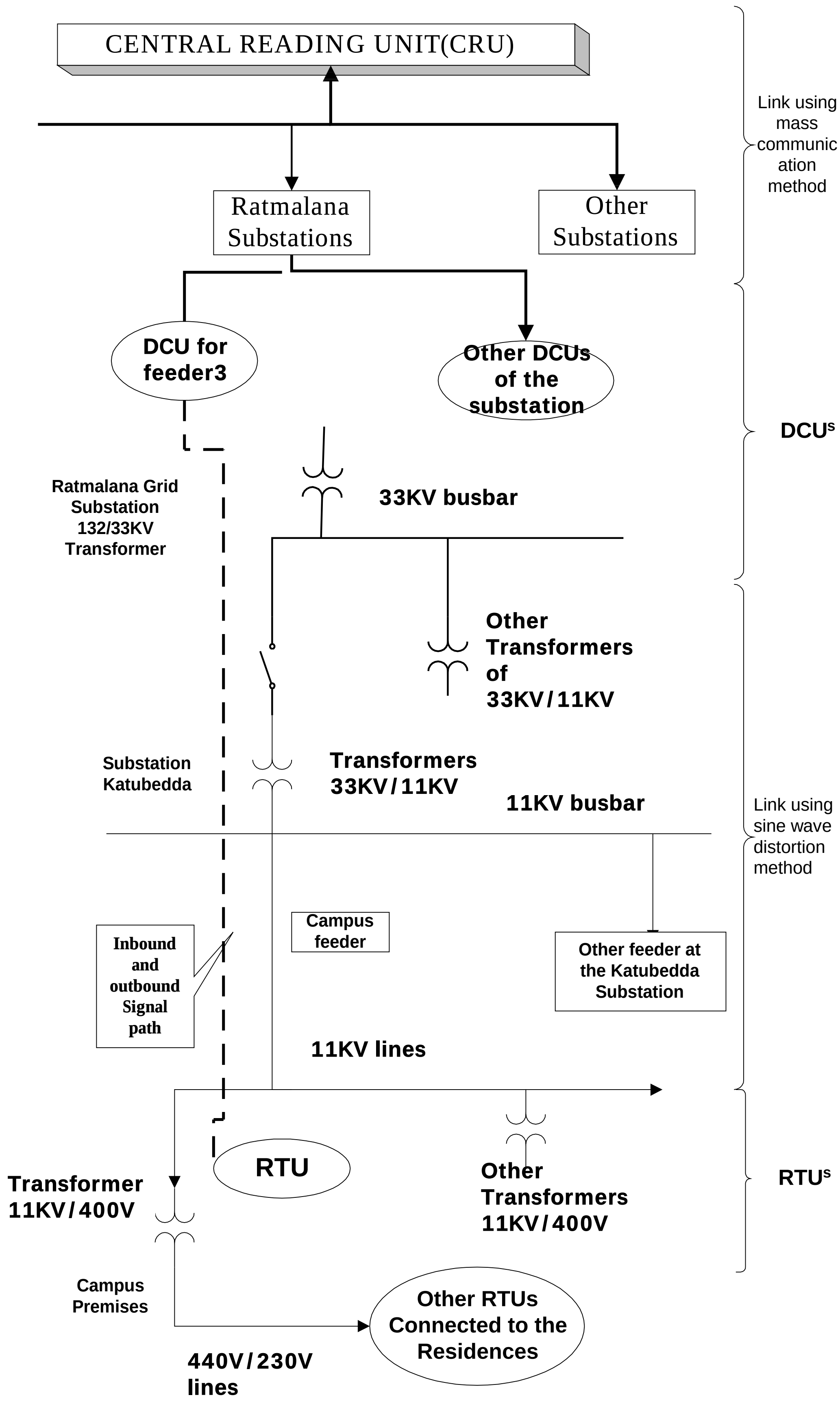

Figure 3 Communication link between RTU & CCU in distribution system

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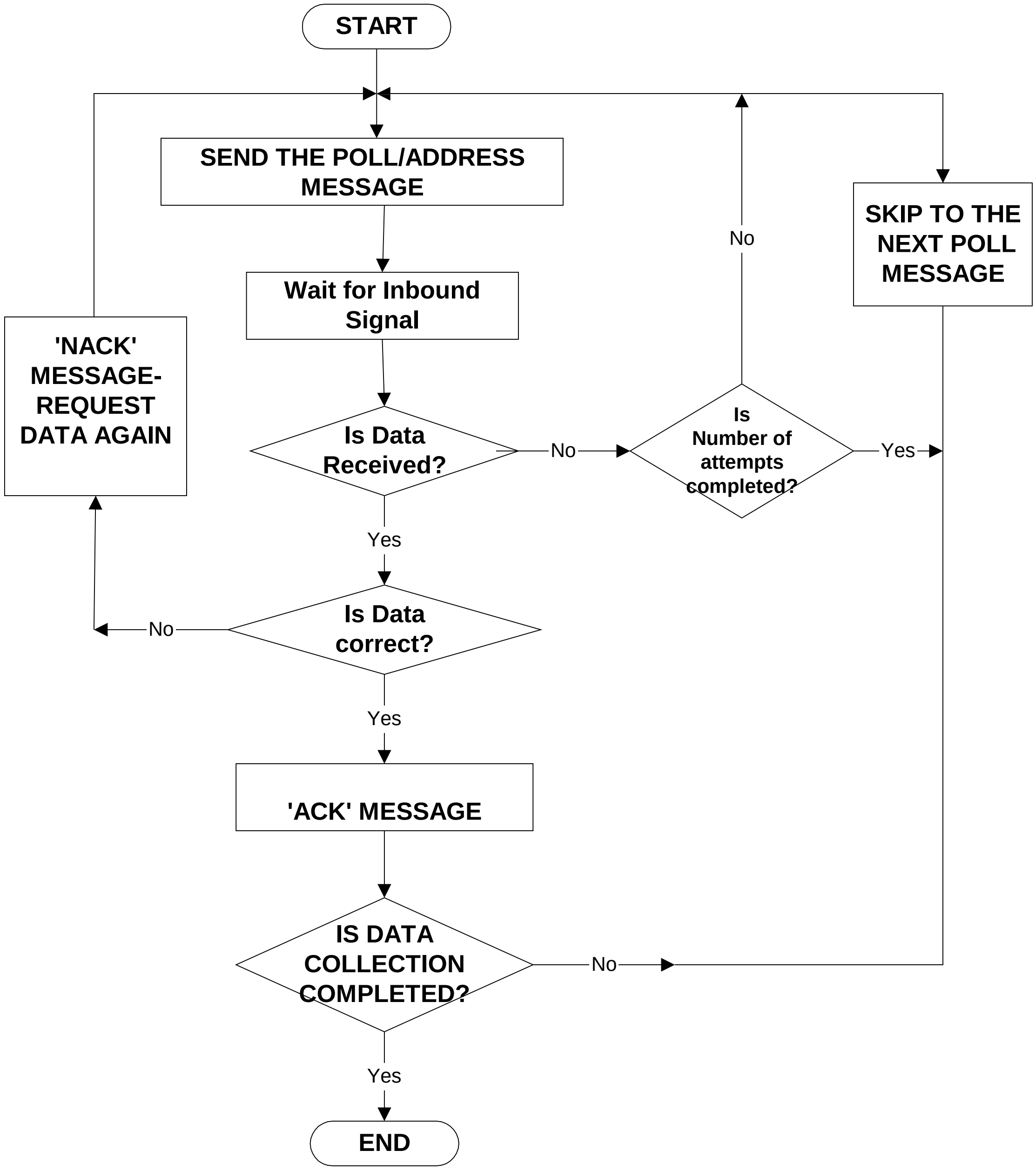


Figure 4a

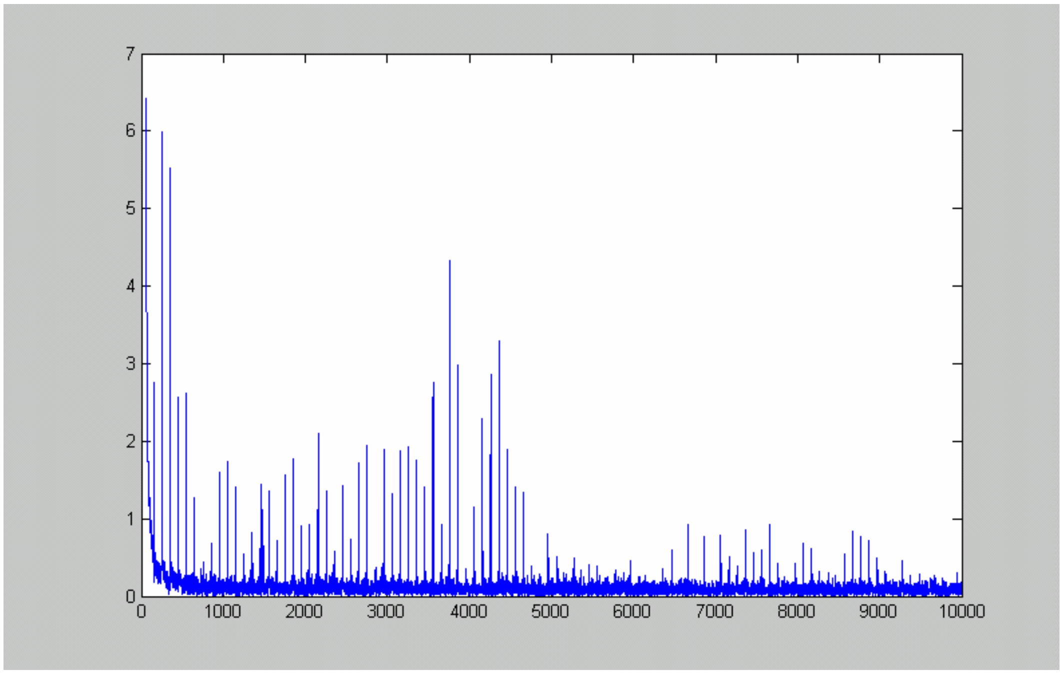


Figure 6a Frequency spectrum graph in day time (from 100 to 10000 Hz)

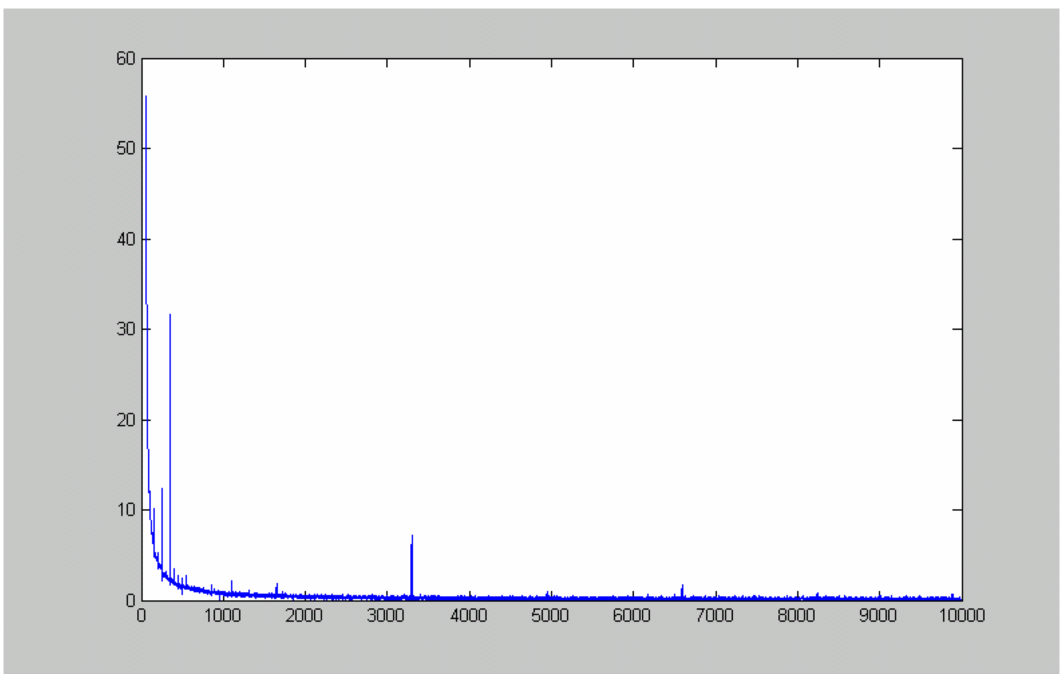
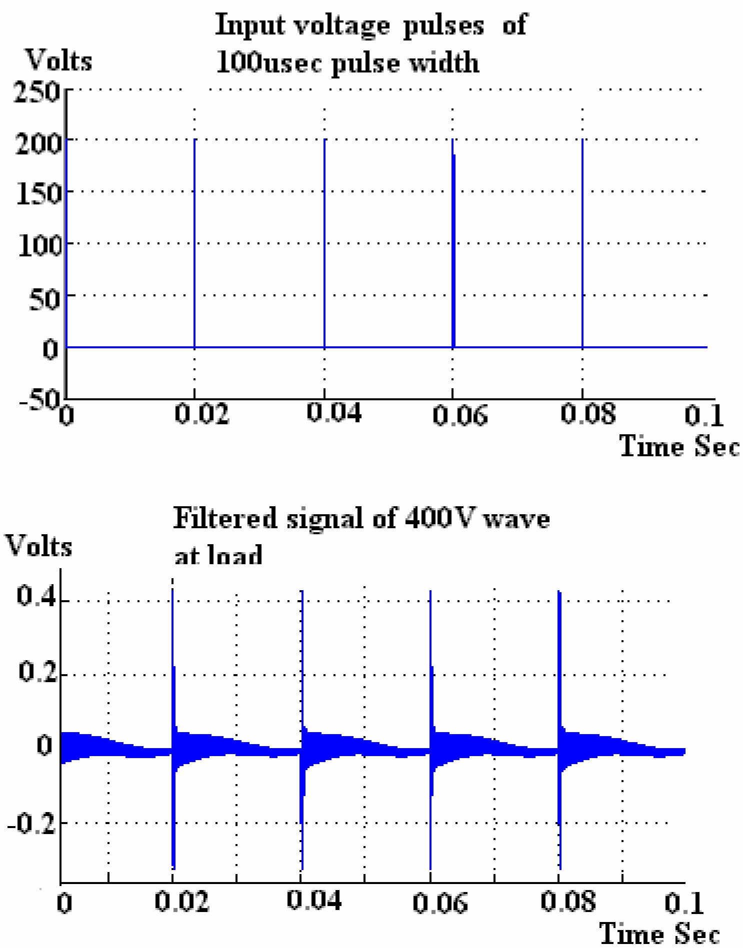


Figure 6b Frequency spectrum graph in night time(from 100 - 10000Hz)



Input voltage pulses of
100usec pulse width
Volts
250
200
150
100
50
0
-50
0
0.02
0.04
0.06
0.08
0.1
Time Sec
Filtered signal of 400V wave
at load
Volts
0.4
0.2
0
-0.2
0
0.02
0.04
0.06
0.08
0.1
Time Sec

Figure 7