Energy Information System

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Abstract

Any organisation that practices Energy Management properly makes the operations more profitable. By practicing energy conservation in the context of an Energy Management program, the energy consumer becomes more conscious of how Energy is being used, and of the actual costs of energy waste.

1 Introduction

1.1 Objective

The objective is to develop an automated data collection and an information system that will support the decision making process of the Energy Management Team of Ceylon Tobacco Co. Ltd. The project would finally contribute to the vision of the Energy Management Team.

1.2 Scope

The Energy Management System, once implemented will automate the data collection; to the extent of availability of resources. EIS will provide facilities that will help the energy manager in planning and decision making. The system will provide a user friendly; data entering, viewing and summarising facilities.

1.3 Business Sponsor

The project is sponsored by the Ceylon Tobacco Company (Ltd.). The project will provide a basis for the automation of Energy Management at CTC. The Company would also provide facilities and available resources for the project.

The EIS will complement the Energy Managers tasks, mainly in the area of Energy data collection and analysis. And will help in the other areas as well.

2 Benefits

2.1 Automation

The data collection system would be fully/semi automated. This will lead to having a central system will all the necessary information, without having to manually collect and process data.

The system will also carry tools to do trend analysis and provide facilities to predict the future energy usage. The prediction of energy usage will allow the Energy Manager to disciple the energy usage, leading to total energy conservation.

2.2 Knowledge Base

The EIS would be a knowledge base for any future projects. It will complement any knowledge asset that will have details of any energy project.

The system, due to its user friendliness will support the decision making process, by providing access to quick information. This is not only for the Energy Manger but for all the departments and management teams, who are interested in such information.
Apart from supporting the strategic level decision making EIS will help the Energy Management Team to make day to day operational decisions in achieving company's energy targets.

3 Developments

Several improvements were suggested and carried out in place of the heavily manual based existing system.

The data collection was done manually. A person from the Workshop of the Engineering Department would visit all the Energy meters and manually read the data, which were entered to a stand-alone computer.

The existed three year based Energy consumption prediction system was proposed and replaced by a monthly prediction system which analyses sectional Energy consumption.

The prediction policy altered such that the sections which had less correlation to production were added up to give the average. Whilst the other sections ware used to get the best-fit linear graph. These two graphs were added to provide a final formula that was the base for Energy usage prediction.

4 The Energy Information System

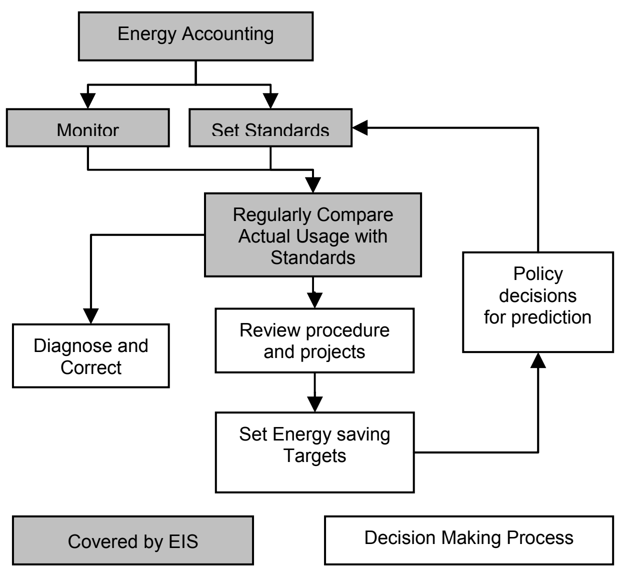


Figure 1: Process flow of the EMS and complementing tasks

Figure 1 shows the flow diagram of the Energy Management System. Energy Information System is intended to partly automate the Energy management system that would work to complement the decision making process.

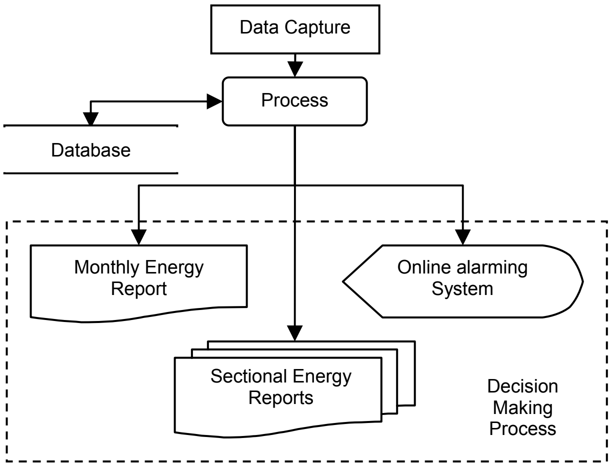


Figure 2: Context Diagram of EIS

5 Data Capturing Device

Design of watt-hour energy meter based on the AD7750

The AD7750 integrates two high resolution sigma-delta ADCs and the digital signal processing necessary to implement an electrical energy measurement IC. All signal processing is carried out in the digital domain. The AD7750 also incorporates two digital-to-frequency converters with a pulse output.

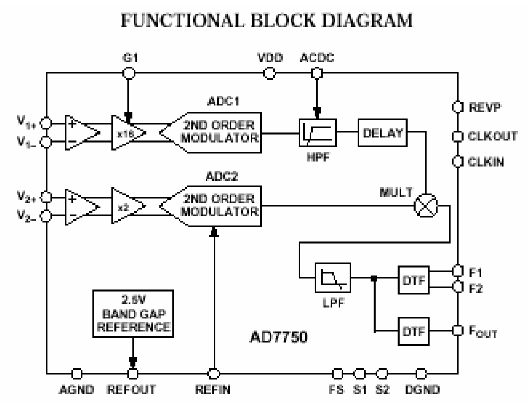


Figure 3: Functional Block Diagram of AD7750

5.1 Theory of Operation

The two ADCs digitize the voltage signals from the current and voltage transducers. A high-pass filter in the current channel removes any dc component from the current signal. This eliminates any inaccuracies in the real power calculation due to offsets in the voltage or current signals.

The real power calculation is derived from the instantaneous power signal. The instantaneous power signal is generated by a direct multiplication of the current and voltage signals. In order to extract the real power component (i.e., the dc component), the instantaneous power signal is low-pass filtered. Figure 4 illustrates the instantaneous real power signal and shows how the real power information can be extracted by low-pass filtering the instantaneous power signal. This scheme correctly calculates real power for non sinusoidal current and voltage waveforms at all power factors.

The output frequency (F_{out}) is proportional to the instantaneous real power. This is useful for system calibration purposes that would take place under steady load conditions.

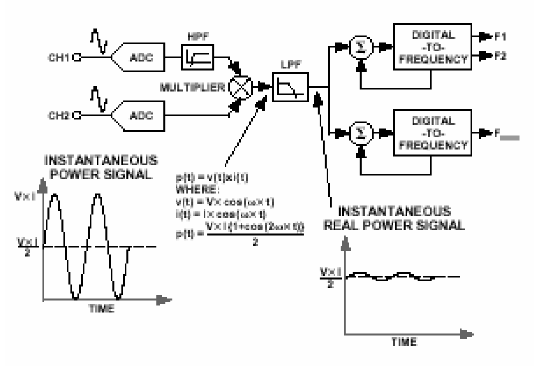


Figure 4: Real Power Calculation

5.2 Power Factor Considerations

The method used to extract the real power information from the instantaneous power signal (i.e., by low-pass filtering) is still valid even when the voltage and current signals are not in phase. Figure 5 shows the current signal lagging the voltage by 60º. If we assume the voltage and current waveforms are sinusoidal, the instantaneous power signal is given by:

$$p(t) = V\cos(\omega t) \times I\cos(\omega t - 60^{\circ})$$

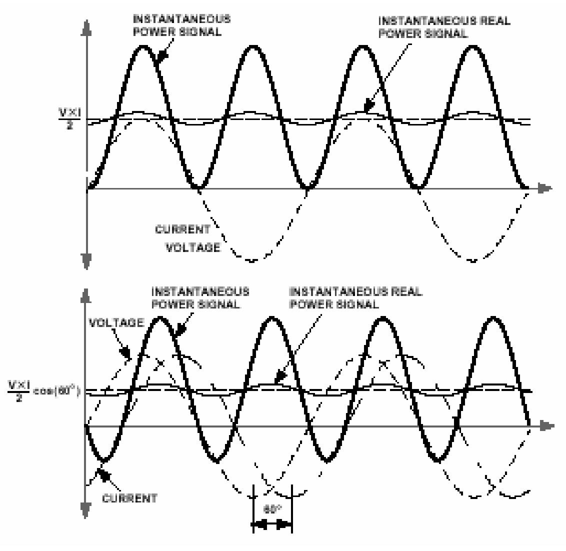


Figure 5: Effect of Channel Offsets on the Real Power Calculation

5.3 Non-Sinusoidal Waveforms

$$v(t) = Vo + \sqrt{2} \times \sum_{h \neq 0}^{\infty} Vh \times \sin(h\omega tt + \alpha h)$$

Where:

$v(t)$ is the instantaneous voltage

Vo is the average value

Vh is the rms value of the voltage harmonic h and

α h is the phase angle of the voltage harmonic.

$$i(t) = Io + \sqrt{2} \times \sum_{h \neq 0}^{\infty} Ih \times \sin(h\omega t + \beta h)$$

Where:

$i(t)$ is the instantaneous current

Io is the dc component

Ih is the rms value of the current harmonic h and

βh is the phase angle of the current harmonic

Using the above two equations, Real Power P can be expressed in terms of its fundamental real power (P_1) and harmonic real power (P_H).

$$P = P_1 + P_H$$

Where: $P_1 = V_1 \times I_1 \cos\varnothing_1$

$\varnothing_1 = \alpha_1 - \beta_1$

And $P_H = \sum_{h=1}^{\infty} Vh \times Ih \cos\phi h$

$\varnothing_h = \alpha_h - \beta_h$

5.4 Energy Meter Implementation

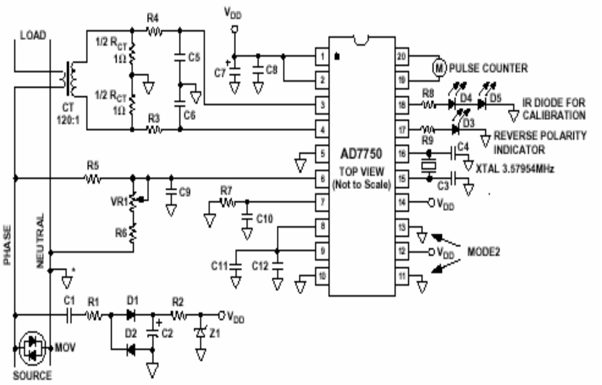


Figure 6: Energy Meter Implementation

The pulse output $F_{out}(18)$ is taken through an opto-coupler and the online instantaneous real power and Energy are displayed on the computer at a sampling rate of 2400BPS via the serial port. The RS 232 driver implementation is done using MAX 232 level converter.

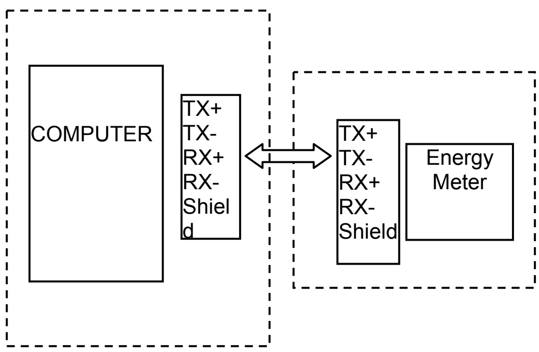


Figure 7.communication connection

6 The System Software

6.1 Processing

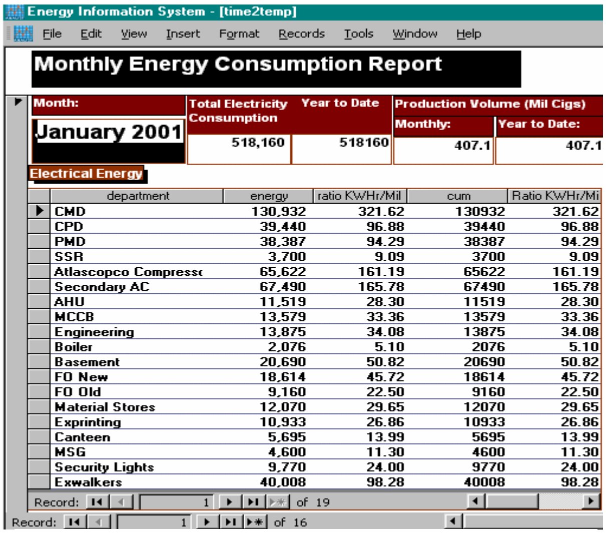
All energy related data are automatically maintained in a database, provided with manual feed in facilities.

The system would compose of a prediction system based on the data captured. This will involve the feedback received from the previous reports based prediction policies decided by the Energy Management Team.

6.2 Output

6.2.1 Monthly Energy Reports

The reports that will be used by the energy management team in planning and decisions making according to the set targets and also to revise policies for energy predictions.



Energy Information System - [time2temp]

Monthly Energy Consumption Report

Month:	Total Electricity Consumption	Year to Date	Production Volume (Mil Cigs) Monthly:	Year to Date:
January 2001	518,160	518160	407.1	407.1

Electrical Energy

department	energy	ratio KWHr/Mil	cum	Ratio KWHr/Mi
CMD	130,932	321.62	130932	321.62
CPD	39,440	96.88	39440	96.88
PMD	38,387	94.29	38387	94.29
SSR	3,700	9.09	3700	9.09
Atlascopco Compress	65,622	161.19	65622	161.19
Secondary AC	67,490	165.78	67490	165.78
AHU	11,519	28.30	11519	28.30
MCCB	13,579	33.36	13579	33.36
Engineering	13,875	34.08	13875	34.08
Boiler	2,076	5.10	2076	5.10
Basement	20,690	50.82	20690	50.82
FO New	18,614	45.72	18614	45.72
FO Old	9,160	22.50	9160	22.50
Material Stores	12,070	29.65	12070	29.65
Exprinting	10,933	26.86	10933	26.86
Canteen	5,695	13.99	5695	13.99
MSG	4,600	11.30	4600	11.30
Security Lights	9,770	24.00	9770	24.00
Exwalkers	40,008	98.28	40008	98.28

Record: 1 of 19

Record: 1 of 16

Figure 8: Monthly Energy Consumption Report

6.2.2 Sectional Energy Reports

Reports are generated on consumption of energy for individual departments of the company. These will be used in deciding on target setting.

6.2.3 Alarm System & Online Metering System

A warning will be created by the system when the energy consumption has increased beyond the set targets.

6.2.4 Analyzer Interface

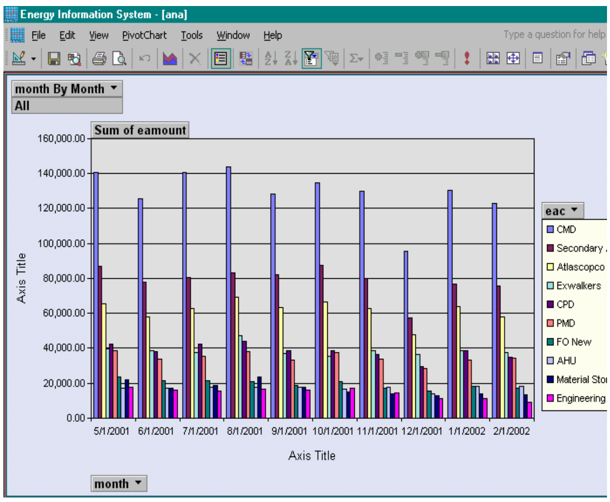


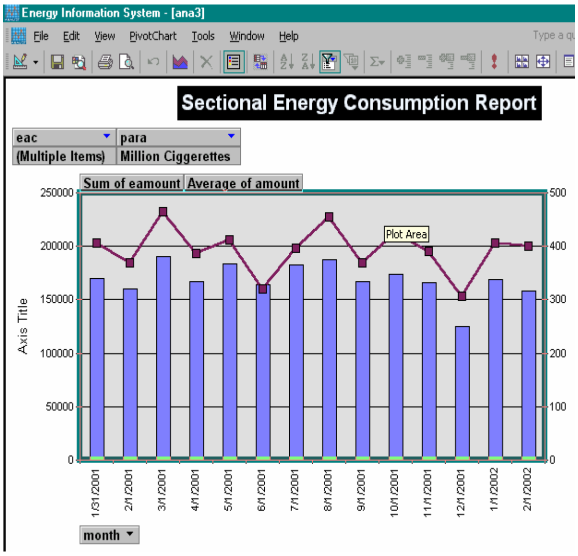
Figure 9: Sectional Energy Consumption Report.

The system provides the facilities to dynamically analyse data sets with pivot charts as per the requirement.

This platform lets filter data set and retrieve calculated results with selection of aggregate function

6.3 User Interface

- User friendly GUI enhances user interaction to enter, manipulate and analyze data.
- Appropriate user and grouping levels defines the access rights for the data base objects.



7 Conclusion

7.1 Constraints

7.1.1 Prediction Policy.

The system would use the prediction policies decided by the management to produce the trend line to suite changing policies. But system has the potential to suggest prediction formula based on historical data.

7.1.2 Accuracy and Reliability of Data Capturing Device Developed.

The accuracy of this developed capturing unit is acceptable and suitable for who seek low cost solution. But incompliance with industry standards prompted CTC to use more reliable data capturing devices.

7.2 Reviews and Possible Improvements

System is expected to be fully installed, tested and reviewed for debugging and possible improvements. Installation and delivery of industrial standard data capturing devices has delayed the proceedings.

8 Reference

Manuals & Books

- SLEMA – Energy Management Manuals
- Management Information Systems – Stevan Alter
- IC2000 series operations manual

Websites

- www.microchip.com
- www.analog.com

People and Places

Rotax (Pvt.) ltd.