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Measuring Emergency Electrical Loads in Commercial Buildings

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Abstract

Many commercial buildings were built decades ago. The electrical facilities in these buildings often do not meet the requirements of modern loads. Provision of emergency power was often used for little more than emergency lighting. This paper will discuss the remote measurement of electrical loads at various points in low and high rise commercial buildings. The loads that are measured include chillers, heating, air handling, lighting and various office equipment such as computers and servers. The measurements are taken on the main and emergency distribution systems. The data is remotely collected from various sites to **a** data centre where it can be analysed. These measurements will assist utilities, consultants and facilities management personnel to design, plan and modify emergency and normal building supplies.

Commercial Buildings

In most cities there is a mixture of commercial buildings from those recently constructed to those that are decades old. The 50 story high Carlton Centre, located in downtown Johannesburg, is Africa's tallest commercial building. This building with 72000m^2 of office space was completed in 1974 and at the time its electrical reticulation system represented the "state of the art". This has become outdated and is being refurbished to meet the challenges of the new millennium. This situation is not uncommon all over the world.

Carlton Centre, Johannesburg South Africa

The nature of electrical loads has also changed significantly over the years. Computers were located in centralized locations. Electric loads were continuous in nature and load profiles were more predictable as most companies only operated fixed hours “9 to 5”. Emergency power requirements were typically used for lighting and powering of equipment such as elevators.

Older buildings often have significant modifications made to their reticulation systems over time. Different standards of maintenance are applied when the ownership of the building changes. Documentation is often either not available or inaccurate as modifications are made without changes. The building knowledge is often known only to a few individuals and is lost when these people retire or move to other jobs.

Consequently building owners and managers are often unsure as to what normal and emergency capacity is available and how loads vary with time. This leads to uncertainty in operations and planning.

Emergency Power

Historically emergency power was usually provided for safety of personnel during a power failure. This included emergency lighting, ventilation and provision for evacuation using elevators. Many older buildings have no or very minimal emergency reticulation. In larger buildings the emergency supply was often centralized in a basement with a standby generator. Over time standby supplies and UPS equipment has been installed in various locations according to user requirements. This equipment is usually supplied by the tenants.

The modern business reality is a 24/7/365 operation. A loss of power is a significant loss of revenue Critical loads can now include

- Computers, servers, workstations, printers etc
- Networking and communication
- Point-of-sale equipment
- Lighting
- HVAC

In order to plan, improve and provide for the modern tenant, it is essential to understand the nature of loads in buildings.

Building Monitoring Considerations

A program of instrumenting and monitoring loads can be used as a systematic way to determine the current state of the loads in a building. Monitoring systems can be used to profile loads by:

- Building type
- Tenant
- Time of day
- Day of week
- Season
- Other factors (e.g. ambient temperature)

Prior to implementing the monitoring program it is essential to determine the monitoring objectives. A monitoring program could be required for one or more of the following:

- New tenant requirements
- Documentation
- Refurbishment
- Energy consumption
- Potential for savings
- Planning & research

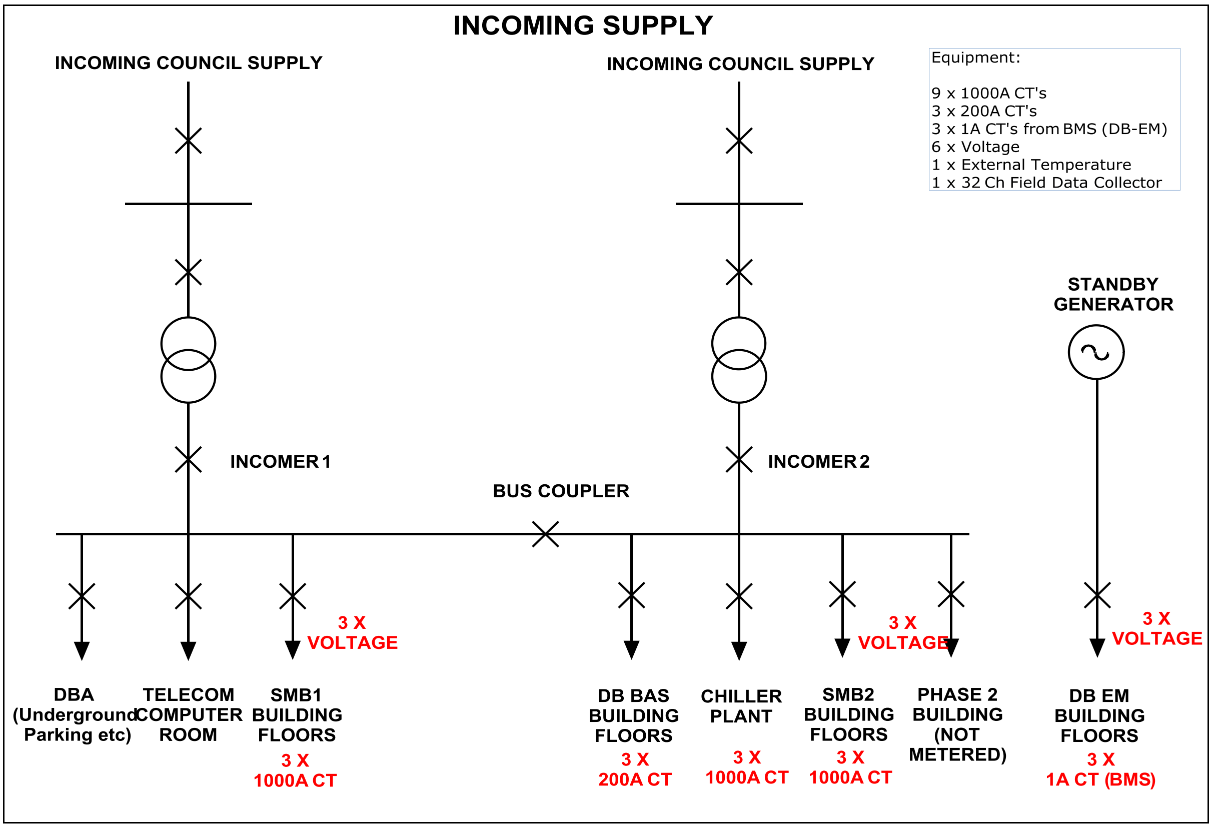
Once the objectives of the monitoring program have been determined, the monitoring plan can be devised based on these objectives. The ideal plan would include as much detail as possible by measuring as large as possible sample to provide a statistically valid result. The plan could require measurement of:

- Entire building
- Representative floor
- Specific office
- Particular load
- Some combination of the above

Depending on the monitoring objectives and size of the building, it will usually not be necessary to monitor every load. In some cases it is impractical to certain loads as there may be difficult to access the monitoring points. In such cases it is also possible to derive the value by measuring the feeder and the remaining loads and then determine the required value by summation. If there are a number of similar offices or tenants, a representative load profile can be determined by only monitoring one or a few of these.

Case Study: Low Rise Commercial Building

The following information is extracted from a monitoring study done on a 4 floor office building. The building houses a large electronic and print media company. The nature of its operation is 24/7. The incoming supply is shown below. The text in red indicates the monitoring points.



Incoming Supply to Low Rise Commercial Building

The client requested that the load profile of the entire building was measured. This comprises the main intake supply in the basement, two representative floors (operations) and the ground floor (catering, reception, security etc). Certain loads were identified as not important and excluded from the monitoring plan. The monitoring objective was to determine the load profile over a 12 month period. In addition the internal and external temperature was also measured. The incoming supply panel to the building was located in the basement. This is shown below.

Building Incoming Supply Panel

A number of challenges relating to the site were identified as:

- No up-to-date documentation was available
- The building power could not be interrupted to install monitoring equipment due to the nature of the business operation
- Only the building maintenance electrician could be used to install the equipment.

A detailed examination of where the loads could be measured was undertaken. Power measurement requires both voltage and current monitoring. The line voltage could be monitored at a number of points. These included the busbars, panel meter, building metering and unused circuit breakers. Panel meters and circuit breakers were used in this case

Panel Meters Used for Voltage Measurement

Current measurement options are usually limited to using existing current transformers (CT's) where possible and providing clamp-on or split-core CT's.

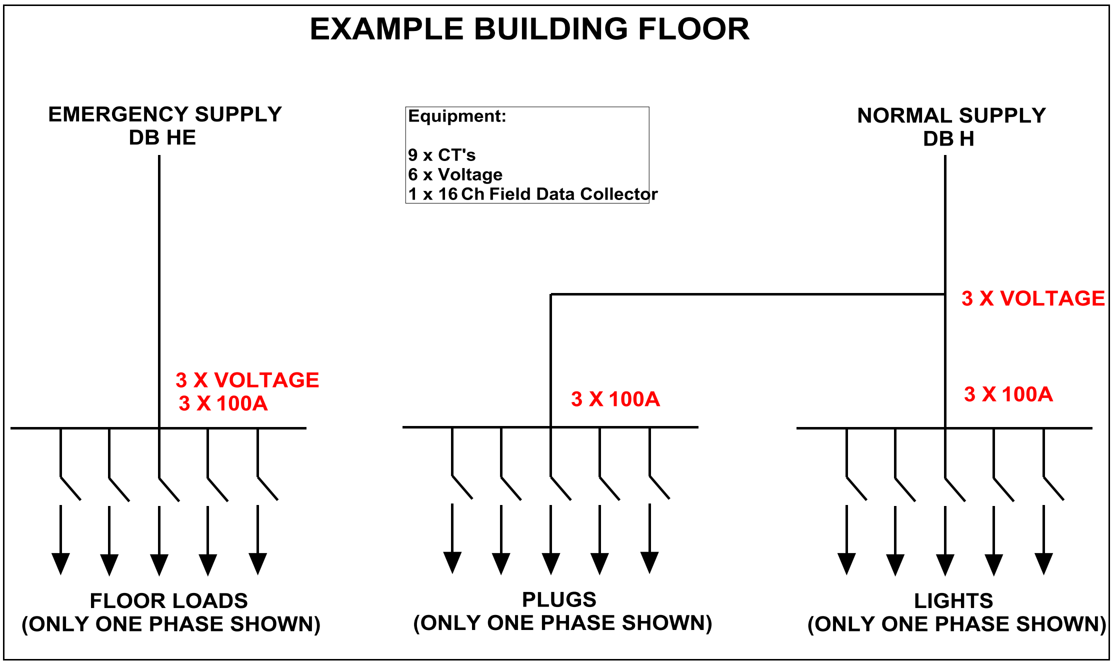
Split core CT's were used as these provided high accuracy with a low size profile. Installation did prove to be a challenge as the CT's had to measure load on multiple conductors per phase. This is shown below.

Clamp-On Current Transformer Installation Location

The monitoring equipment was installed at the top of the switchgear panel. A GSM link was used to remotely transmit the data back to a central database. This location provided adequate signal strength without the need for an external antenna. The installed monitoring system is shown below.

Monitoring System Installation

The building floor supply consists of an emergency feeder, a supply for the lights and one for the plugs. There is a distribution panel on the north and south side of each floor. The floor distribution supply is shown below.



Electrical Supply to Floor Loads

The emergency and normal supply panels are shown below.

Emergency Supply Panel

Normal Supply Panel

Installation access was difficult as the conductors required for load measurement were stiff and cable-tied together.

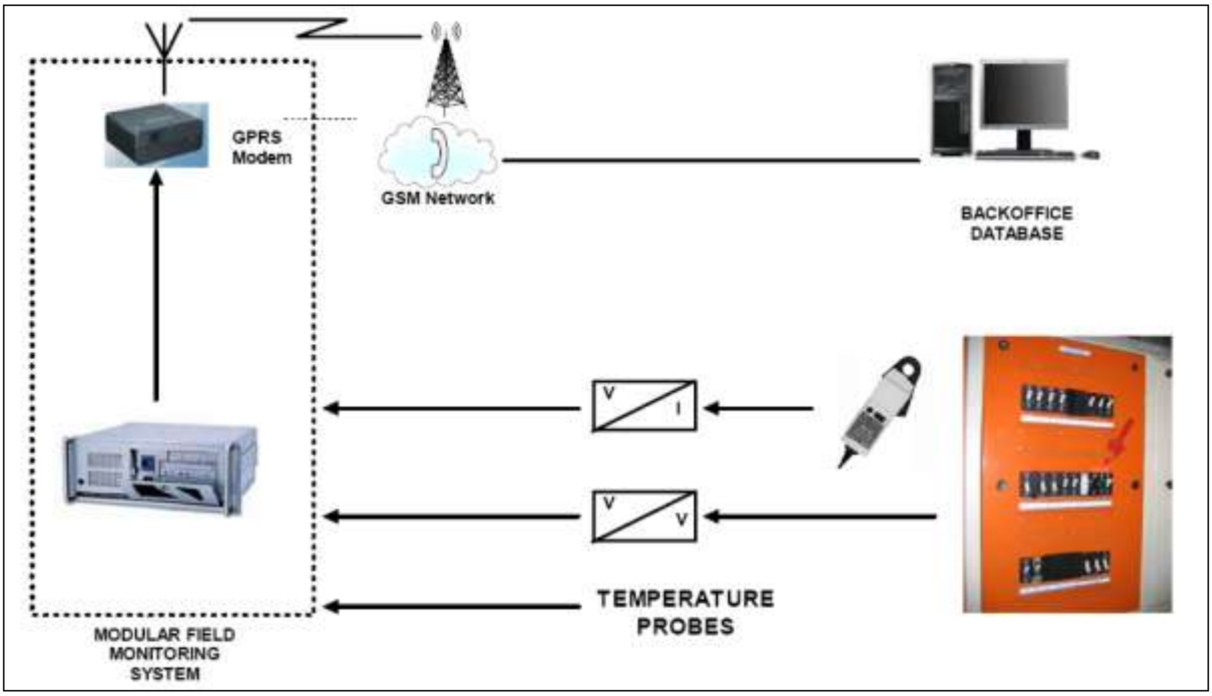
Data Acquisition System

The data acquisition system used for building monitoring was able to provide the following:

- Measure multiple voltage and current inputs (up to 32 channels)
- Calculate apparent power (kVA), active power (kW), power factor(pf), energy (kWh) and maximum demand (MD) from the phase current and voltage
- Measure single and three phase circuits. (Resist the temptation to measure only 1 phase as representative of a 3 phase load. There is often severe unbalance between phases.)
- Save readings at a selectable interval (usually 5 or 10 minutes)
- Better than 2% accuracy. (Accuracy does not need to be metering class – 5% is usually adequate)
- Data capacity for a minimum of 12 months of readings. This is non-volatile hard drive storage
- Local flat panel display and keyboard. This is used to configure the equipment on site. (Since the equipment is closed it does not necessarily need a local display. Configuration could alternatively be performed using a PDA or laptop)
- The equipment is mounted in a lockable enclosure to prevent tampering
- A backup power supply is provided for up to 3 hours to ride through during power outages. The power supply is connected to the emergency supply which is only out of service until the standby generator switches in.
- Remote data transmission using GSM/GPRS back to a central database

The data collected by the unit can also be manually retrieved using a memory stick or disk. It is recommended that where access is difficult, data should be transmitted to a collection point using a local area network (LAN) or a wireless technology such as GSM/GPRS, CDMA or WiFi. Remote data collection can also be used where data is required real-time or near real-time. There could however be cost restrictions where there are several monitoring points in the building. The data from each system could be centralized before the data is sent to the central data storage unit.

The data flow from system installed in the example building is shown below.



Measurement and Data Flow from Building Monitoring System

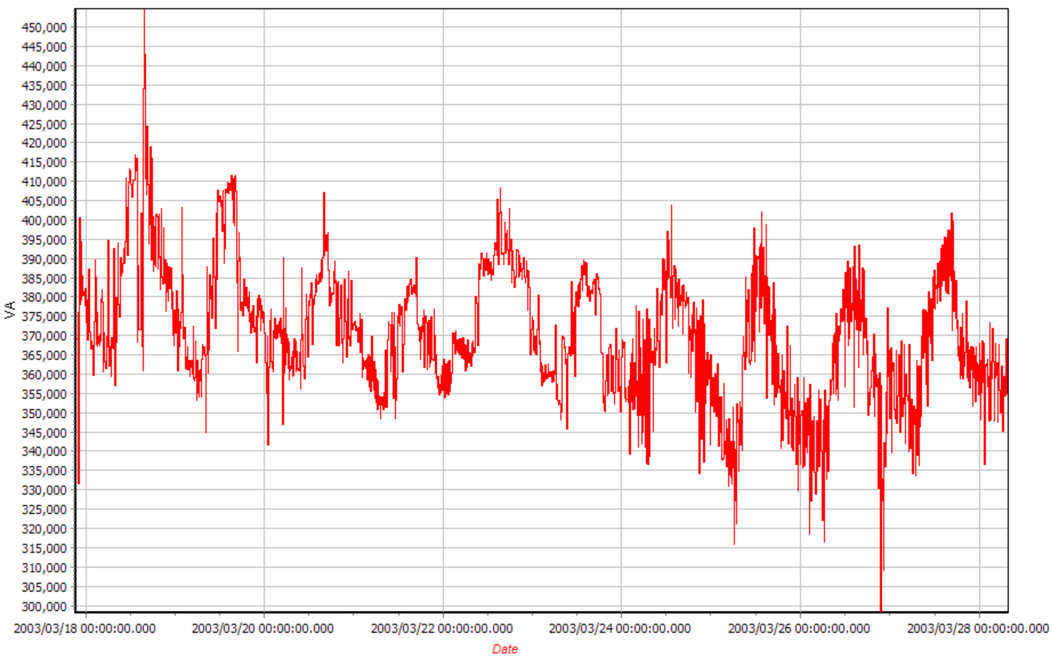
Data received from the monitoring system is stored in a database. The database is able to store data from the remote systems indefinitely. The database should ideally be based on an open standard where possible. MS Excel, MS Access and SQL are all commonly used for data storage. The reliability and integrity of the data was a critical requirement of the system. An example of an MS Excel database table is shown below.

	V1 1 V2 2 V3 3 I1 13 I2 14 I3 15						V1 4 V2 5 V3 6 I1 16 I2 17 I3 18		
	Irms	Vrms	S	P	Q	pf	Irms	Vrms	S
2003/03/18 04:40:00 AM	513.2682486	234.6668604	360.5032813	-329.7122813	-144.9536406	0.909041477	47.72169195	231.1289259	32.8796679
2003/03/18 04:50:00 AM	516.7119141	236.0798035	365.011	-333.0739375	-148.4141406	0.913447559	47.72379684	231.2458191	32.6561816
2003/03/18 05:00:00 AM	524.8422852	236.0332794	370.79325	-339.1861875	-148.9245	0.907932401	47.7306366	231.2414093	32.8837070
2003/03/18 05:10:00 AM	514.776801	235.7923737	363.3486875	-330.9161875	-149.2641094	0.911139727	47.73671722	231.2096252	32.9103632
2003/03/18 05:20:00 AM	513.8837891	235.0519867	361.6133125	-330.0797813	-146.9475	0.914894432	47.73864446	231.1459045	32.8997539
2003/03/18 05:30:00 AM	527.8717041	233.8376465	369.6667813	-339.0671563	-146.565375	0.910572112	47.73630472	231.037384	32.90
2003/03/18 05:40:00 AM	523.6688232	235.0948792	369.3037188	-336.684625	-150.969875	0.910737872	47.73046112	231.1934357	32.9267890
2003/03/18 05:50:00 AM	522.8496723	234.9373627	367.1684063	-335.01025	-149.5131719	0.909989476	47.74024963	231.1589813	32.9447304
2003/03/18 06:00:00 AM	558.4696845	235.9331512	394.51625	-357.6520938	-165.6816563	0.894282295	47.77004623	231.2069092	32.9983710
2003/03/18 06:10:00 AM	527.5650636	238.2341401	376.151125	-340.5378125	-158.8666719	0.905167699	47.76473618	231.3888183	32.989
2003/03/18 06:20:00 AM	510.7978516	236.7490846	362.1256625	-329.1002188	-150.2334063	0.908233623	47.77433777	231.2757874	33.0329453
2003/03/18 06:30:00 AM	520.4165039	235.6689301	367.1806875	-334.7392813	-150.1039844	0.909849524	47.78133392	231.1485334	33.0313984
2003/03/18 06:40:00 AM	517.5373535	234.2201691	363.9414063	-330.7670625	-148.9592344	0.912212253	47.7644043	231.0253143	33.0497929
2003/03/18 06:50:00 AM	514.4967041	233.2637634	359.33	-329.312375	-142.9931875	0.916061044	47.76666723	230.9532166	33.0189492
2003/03/18 07:00:00 AM	525.3282515	234.9160919	369.4478125	-337.9063125	-148.5046563	0.907366097	47.77374649	231.0759735	33.0361523
2003/03/18 07:10:00 AM	523.1549072	234.2494659	366.933	-335.1863125	-148.537875	0.914326251	47.76654434	231.0089417	33.0534023
2003/03/18 07:20:00 AM	524.9644166	233.1192627	366.5296938	-336.3933438	-144.8755	0.916269011	47.77369308	230.9366913	33.0316562
2003/03/18 07:30:00 AM	563.4713745	232.7196503	392.6894063	-358.8919688	-158.568375	0.910044909	48.11869512	230.9088593	33.2563164
2003/03/18 07:40:00 AM	545.1800537	232.3893433	379.5070313	-346.1987188	-154.812125	0.910042167	48.37207413	230.876799	33.4437343
2003/03/18 07:50:00 AM	511.7633667	232.9140254	356.9854375	-325.0308125	-144.6804844	0.909677429	48.06792999	230.9341125	33.2160460
2003/03/18 08:00:00 AM	543.5857666	233.0744324	379.2869375	-345.4571875	-156.6099844	0.912133336	47.80049133	230.9621277	33.0368164
2003/03/18 08:10:00 AM	547.0388353	232.0009918	379.880625	-347.7344375	-151.9762969	0.910969377	48.12971878	230.8823395	33.2575234
2003/03/18 08:20:00 AM	527.8416748	233.0713348	360.2815938	-336.3123125	-149.2064531	0.910430263	47.84362112	230.9793827	33.0602148
2003/03/18 08:30:00 AM	545.7442817	231.7888489	378.6574063	-346.3925625	-152.0779844	0.91473341	48.29156731	230.8687744	33.3768593
2003/03/18 08:40:00 AM	565.4728459	232.6805725	394.0504375	-359.5729063	-160.4156094	0.910652995	48.23240662	230.9512177	33.3319687
2003/03/18 08:50:00 AM	538.8591309	234.3310394	378.0214688	-344.3379063	-155.1711406	0.90951395	47.88804245	231.0716248	33.1246210
2003/03/18 09:00:00 AM	534.5517578	234.1141968	374.7122813	-341.6800313	-153.0755625	0.909999179	47.83281708	231.0418891	33.0809804
2003/03/18 09:10:00 AM	552.2381636	233.5876007	386.0622188	-351.9630938	-157.618	0.909545243	48.17088318	231.0184937	33.3156171
2003/03/18 09:20:00 AM	558.0183716	233.5824085	390.2802188	-355.6219063	-159.9913906	0.909023046	47.92377803	231.0827332	33.1532109
2003/03/18 09:30:00 AM	551.6176147	233.4936523	385.4870625	-351.3752813	-157.5827031	0.90992564	47.82373047	231.0779877	33.0616719
2003/03/18 09:40:00 AM	552.1459961	233.6006622	386.2345	-352.094875	-157.5965781	0.908877552	47.78728104	231.0829468	33.0234296

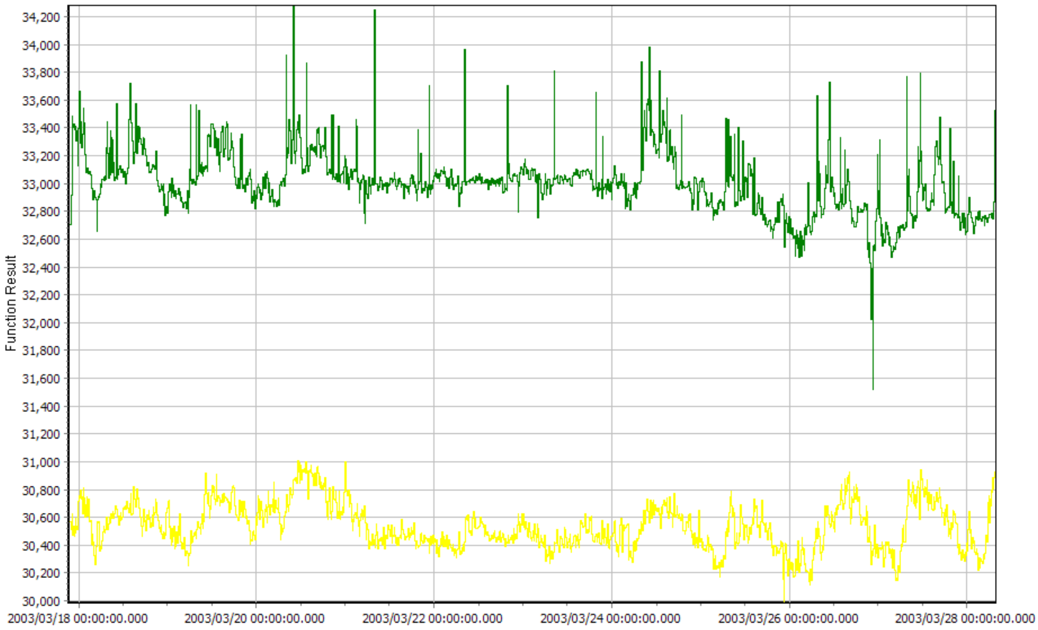
Example Database Data from Building Monitoring System

Results

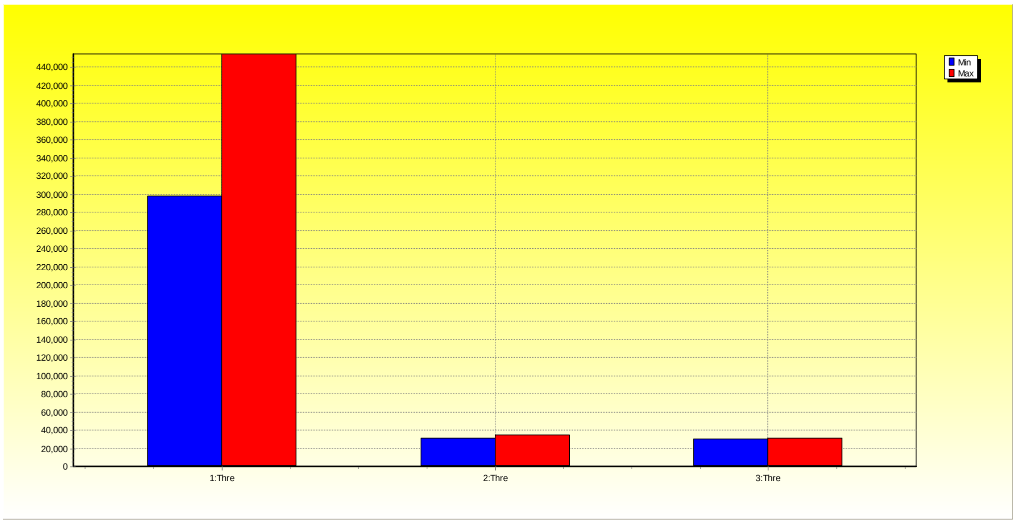
Results from the monitoring system are available in a graphical form. This includes waveforms, trends and disturbances. In addition summary statistics of mean, maximum, minimum values is provided. Common data can be used for different stakeholders – building management, maintenance, consultants etc. Consultants will normally require a more comprehensive data set. Some example building data are shown below.



Load Profile: Normal Supply



Load Profile: Emergency Supply



Load Profile: Minimum & Maximum

Data analysis was performed at fixed intervals during the measurement period. Analysis tools are able to select channels and dates of interest and perform cumulative measurements. Data is displayed in a simple format as shown above. Data can also be exported from the database for further analysis.

The conclusions drawn from the measurement are based on measurement objectives. This was to determine if the supply is able to meet current and future needs, what the diversity of the supply is to accommodate additional loads and what the potential is for increased capacity.

Conclusion

Emergency and normal electrical loads in commercial buildings can be measured reliably and cost effectively using remote monitoring equipment. These measurements will assist utilities, consultants and facilities management personnel to design, plan and modify emergency and normal building supplies.

References:

http://www.amethyst.co.za/JhbLandmarks/

Business Reliability Depends on On-Site Power, Randy Tipton, P.E. and Mark Pavelka, P.E., TXU, Energy and power Management, September 2001.

Eskom Demand-Side Management (DSM) Programme. Case Study: Carlton Centre, Johannesburg

QSR2000 Operating Manual, Rev 06J, Motswedi TLC Software (Pty) Ltd, November 2006