Promoting the Use of Mainland Energy Efficient Equipment in Hong Kong

1. Energy Efficient Lighting Products

Lighting consumes about 20-40% of the total energy consumption in commercial buildings in Hong Kong. There are many opportunities for energy savings in lighting, such as:

- the use of more energy efficient lamp/ballast systems;
- the use of more efficient luminaire reflector/louver systems;
- the installation of dimming or on/off control systems for the maximum utilization of available daylight; and
- the use of occupancy detectors to switch off or dim down the lamps in unoccupied zones.

The use of electronic ballasts to replace conventional electromagnetic ballasts in fluorescent luminaries is very common nowadays (Fig. 1). The basic construction of typical electronic ballast involves a low-pass filter, rectifier, buffer capacitor and a high frequency oscillator (Fig. 2). Although the electronic ballast system is integrated into one single unit, its different functions and requirements can be divided into a number of individual blocks. The basic operation principle is that after passing a low-pass filter, the mains voltage at 50Hz power frequency is rectified in an AC/DC converter. This converter also contains the buffer capacitor, which is charged with a DC voltage. In the HF power generator this DC voltage is transformed into a HF voltage, which provides the power for the lamp controller. The ballast controller controls all these functions.

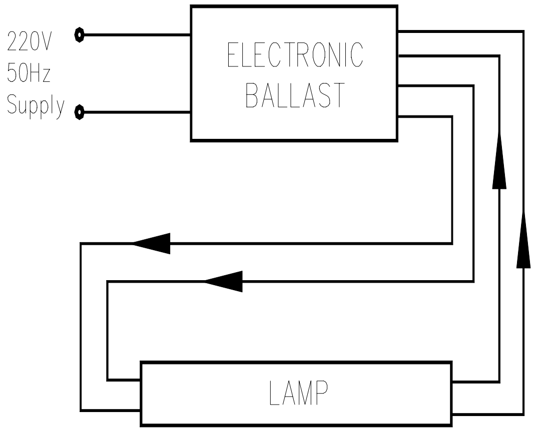

Fig. 1 Lamp circuit using electronic ballast

The ballast takes advantage of the characteristic of fluorescent lamps whereby greater efficacy is obtained at high operating frequency above 20kHz (Fig. 3). The overall lighting system efficacy can be increased by 20 to 30 percents due to three main factors:

1. Improved lamp efficacy at high frequency operation.
2. Reduced circuit power losses.
3. Lamp operates closer to optimum performance in most enclosed luminaires.

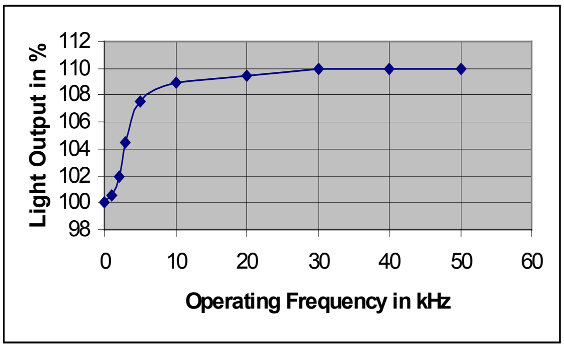

Fig. 3 Luminous flux of fluorescent lamp as a function of supply frequency at constant power

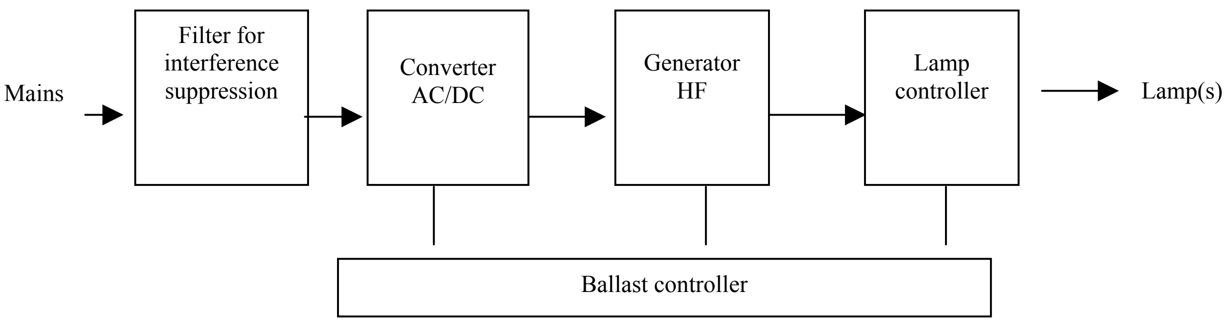

Fig. 2 Block diagram indicating main functions of electronic

Efficacy due to high frequency operation is increased by about 10% thereby enabling the lamp to be operated at a lower input power than at 50Hz mains power frequency. For instance, a 36W 1200mm T8 lamp normally consumes a circuit power of 47W with conventional ballast, can now be run at 36W for the same light output. The net effect is that same useful light output is maintained at lower power input in a typical luminaire.

Ballast losses are reduced compared to electromagnetic ballast, as the solid-state circuit contains no conventional copper windings. In the case of a twin 1200mm 36W lighting circuit the losses can be reduced from 24W to a mere 6W when using electronic ballast. The overall achievement in a suitable luminaire, therefore, is an energy reduction in the region of 20% to 30%. These energy saving features enable lighting levels to be maintained with a dramatic cut in electricity costs. With less heat generated, the cooling load on air conditioning equipment will also be reduced.

Other benefits electronic ballast offered include:

- Rapid or instant starting of lamp without flickering.
- Single ballast can be designed to drive one, two, three or even four lamps.
- Increased lamp life due to lower lamp operating current.
- Quiet operation without audible noise.
- Dimmable version is also available.
- No visible flicker during operation.
- No stroboscopic effect and HF operation.
- Most modern design has lower total harmonic distortion (THD) than conventional ballast with or without power factor correction capacitor.
- High total power factor due to low THD and cosθ.
- Cooler ambient temperature inside luminaires for optimum operation of lamp, control gear, capacitor and batteries for emergency lighting.
- Low operating temperature and reduce carbonisation and blackening to luminaire and decoration in the vicinity.
- Less effect on variation of luminous flux due to mains supply voltage fluctuations.
- Much lighter in weight.

As far as energy efficiency lamp is concerned, a new generation of T5 fluorescent lamp with a diameter of 16mm (5/8”) and G5 base (Fig. 4) has recently been introduced into Hong Kong. T5 lamps have been available with outputs of 4W, 6W, 8W and 13W for over 30 years. These lamp types were mainly used for furniture, signage and table lighting in the past. A few year ago, however, new T5 lamps with higher wattage were developed, which, owing to their superior luminous efficiency outputs (efficacy about 100 lm/W), represent serious competition for the classical T12 or T8 fluorescent lamps. The standard wattage of the new T5 lamps is 14W, 21W, 28W and 35W. Enhanced economy is achieved by high frequency operation with electronic ballasts, which are specified in principle for these new lamp types. Owing to their slim shape, the new T5 lamps permit innovation in luminaire design as a further reduction in luminaire casing dimensions. In addition, the lamp length of all T5 lamp types is 50mm shorter than their T12/T8 counterparts and T5 luminaires could then be dimensioned to enable them to fit exactly into the usual metric grid (600mm and 1200mm) of suspended ceilings.

Fig. 4 Physical size of T12, T10, T8 and T5 fluorescent lamps (Top to buttom)

For fluorescent luminaires with T5 lamps, the most effective means of optical control is parabolic reflection.

The parabola is the most commonly used reflector contour: it is defined by the equation $y^2 = 4ax$ where a is the shortest distance of the focal point to the reflector. The most important optical property of the parabolic reflector is that if a line source is placed at its focus a parallel beam of light is obtained. In practice the ideal line source is difficult to obtain from fluorescent tube and the shape of the distribution curve depends on the size of the source in relation to the focal length and mouth width of the reflector. As the diameter of T5 tube is much smaller than its T8 and T12 counterparts, and is more closer to a line source, optical control of luminaires with T5 lamps and parabolic reflector can be more precise and efficient.

Several pilot projects in office lighting using the above-mentioned technologies have been tried out in the following Government buildings.

2. Pilot Project using Mainland's Electronic Ballasts at Harbour Building

Harbour Building at Central District was selected in 1997 for Phase I Pilot EMO Implementation Programme in Government buildings. The retrofit project carried out in this building includes the replacement of the conventional ballasts with electronic ballasts (manufactured in Shanghai) for the existing fluorescent luminaires (Fig. 5) in the Labour Department Office (15/F and 16/F) as well as the replacement of fluorescent luminaires in all staircases. The luminaires involved are shown as follows:

- 192 nos. of 1 x 18W staircase lighting using electronic ballasts
- 574 nos. of 2 x 36W electronic ballasts for replacement in offices
- 11 nos. of 2 x 30W electronic ballasts for replacement in offices
- 4 nos. of 2 x 18W electronic ballasts for replacement in offices
- 175 nos. of 1 x 36W electronic ballasts for replacement in offices
- 170 nos. of 1 x 18W electronic ballasts for replacement in EXIT signs

The project sum was about HK$470,000. Installation commenced on site in November 1997 and the project was completed in May 1998.

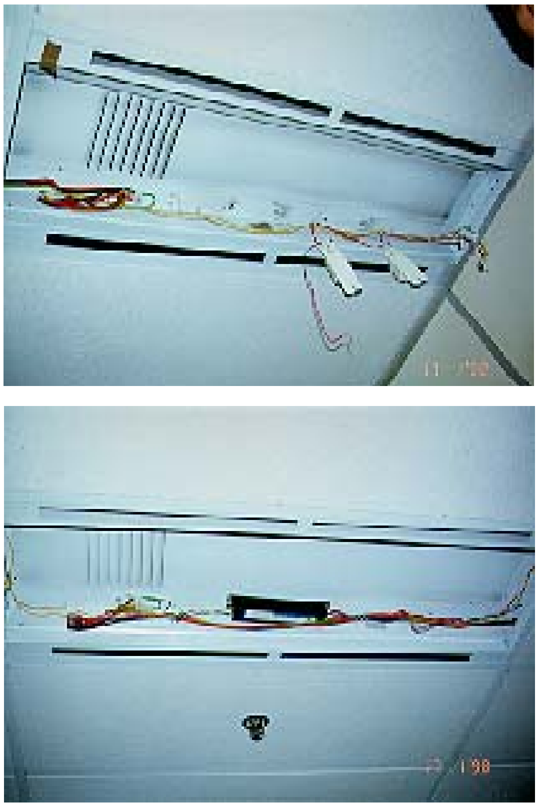

Fig. 5 Replacement of 2 nos. 36W Conventional Ballasts by 1 no. Electronic Ballast in Luminaire at Harbour Building

Separate kWh meters were installed in the meter rooms on 15/F and 16/F of the buildings. The power and energy consumption of the lighting installations before and after the retrofit work was recorded. Individual sample ballasts (conventional and electronic) were also taken from site for spot-checking, testing and measurement. There were some improvements in power factor and THD of the lighting circuits after the retrofit. Illumination level in staircase areas was increased substantially with the new luminaires and electronic ballasts. The result of this pilot project is summarised in Table 1 below.

Table 1: Summary of Ballasts Replacement Works in Harbour Building

Measured kWh Saving for 1 week	Anticipated Annual Energy Saving	Anticipated Annual Cost Saving @$0.9/kWh	Estimated Payback Period	Unit Cost of Electronic Ballast (Supply & Install)
1,372 kWh	68,600 kWh	$62,000	7.5 years	$490

The above Shanghai made electronic ballasts have now been operating continuously for more than 3 years and no serious defect was reported so far. We have confidence that they will keep performing for at least another 7 years as specified. This is the first pilot project using Mainland's product in 1997 when the cost of electronic ballasts was high. Price drops rapidly since then with quality improvement as well. Following the successful implementation of electronic ballasts in Harbour Building, we had also tried in some other Government buildings, other brands of electronic ballasts manufactured in Nanjing, Shenzhen, Fujian, etc. with similar encouraging results.

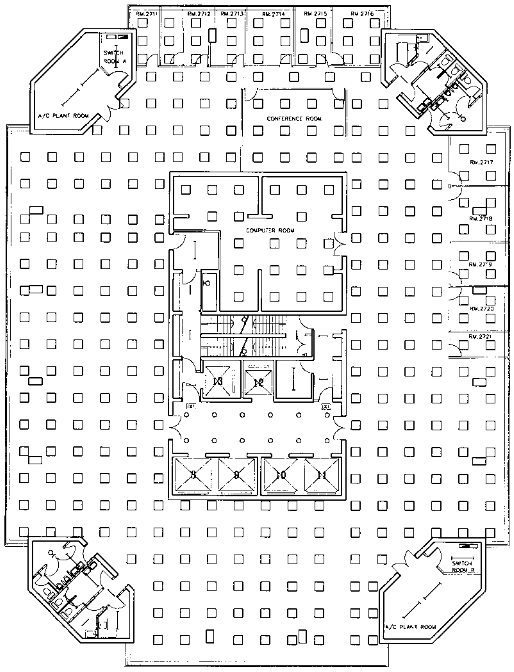

Fig. 6 Lighting layout at 27/F, Arsenal House

3. Pilot T5 Lighting Project at Arsenal House

The pilot project completed in 2000 included the replacement of the existing 320 sets 3 x 18W T8 600mm x 600mm recessed modular fluorescent luminaires in the office areas on 27/F, Arsenal House, with new 3 x 14W T5 600mm x 600mm recessed modular fluorescent luminaries, complete with electronic ballasts (1 for 3 lamps type) and parabolic reflector reflectors designed to CIBSE LG3, Cat. II. The complete set of luminaire including T5 lamps was made and assembled in Zhejiang Province. The lighting layout of the floor and the new luminaire used are shown in Fig.6 and 7.


Fig. 7 New 3x14W T5 Luminaire used at Arsenal House

Table 2 and Fig. 8 below show the test data of the existing 3x18W T8 luminaire removed from site.

Table 2 Electrical parameters of the old 3x18W T8 luminaire

			Voltage	Current
Frequency	49.99Hz	RMS	223.4V	0.754A
Power:		Peak	312.7V	1.095A
W	90W	DC Offset	0.2V	-0.02A
VA	168VA	Crest Factor	1.4	1.45
var	142var	THD Rms	2.23%	8.80%
Peak W	244W	THD Fund	2.23%	8.84%
Phase	58^{o}lag	HRMS	5.0V	0.66A
Total PF	0.53	KFactor		1.51
DPF	0.53			

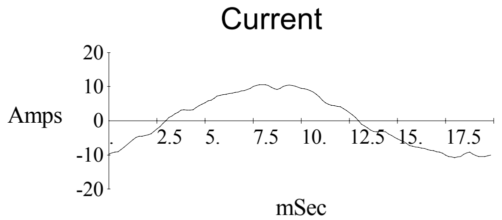

Fig. 8 Current waveform of the old 3x18W T8 luminaire

Table 3 and Fig. 9 below show the test data of the new 3x14W T5 luminaire used in the project.

Table 3 Electrical parameters of the new T5 luminaire

			Voltage	Current
Frequency	49.94Hz	RMS	221.8V	0.22A
Power:		Peak	308.5V	0.316A
W	48W	DC Offset	0.0V	-0.03A
VA	49VA	Crest Factor	1.39	1.44
var	7var	THD Rms	2.30%	8.60%
Peak W	98	THD Fund	2.30%	8.63%
Phase	8°lead	HRMS	5.1V	0.19A
Total PF	0.99	KFactor		1.19
DPF	0.99			

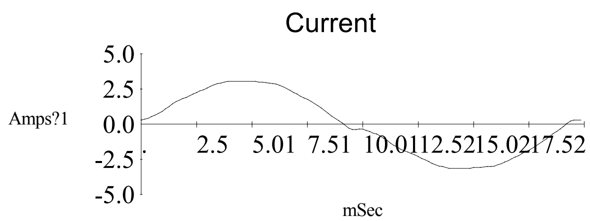

Fig. 9 Current waveform of the new T5 luminaire

Measurement on site before the lighting retrofit indicated that the floor had a total lighting load of 28kW and an average daily energy consumption of 470kWh. Each of the existing 3x18W T8 luminaire consumed 90W at a power factor of 0.53. The low power factor was mainly due to the under designed of the capacitors inside the luminaire (only one 5.5 uF capacitor was used for the whole luminaire). Table 4 below summarises the performance of the new T5 lighting installation as compared with the old lighting system.

Based on the information above, the following observations could be drawn for this pilot T5 lighting retrofit project:

- The average daily lighting energy consumption measured on site before retrofit was 470 kWh. The average measured daily lighting energy consumption after retrofit was 270 kWh. An annual energy saving of 55,000 kWh is anticipated per floor.

Table 4 Summary table for the lighting retrofit at 27/F Arsenal House

	Existing T8 Lighting System	New T5 Lighting System	% difference
Active Power (kW)	28 kW	16 kW	- 42%
Power Factor.	0.53	0.99	+ 87%
T.H.D.	11%	8.6%	- 21.8%
Apparent Power (kVA)	52.8 kVA	16.2 kVA	- 69%
Reactive Power (kvar)	23.7 kvar	2.3 kvar	- 90%
Average Illuminance	450 lux	500 lux	+11%
Lighting Power Density	30 W/m^2	18 W/m^2	-40%

- The power factor of the lighting circuits was greatly improved from 0.53 to 0.99, resulting in lower circuit current, less reactive power, smaller distribution loss and possible saving in demand charge.
- The reduction in reactive power of the lighting load in this floor is 21.4 kvar. The reduction of reactive power for the whole building will be 642 kvar if all 30 stories of offices/workshops are retrofitted with new T5 luminaires. This would eliminate the requirement to add extra capacitor banks at the main distribution board for power factor correction.
- The average lighting power density before retrofit was 30 W/m^2, which exceeds the maximum 25 W/m^2 as stipulated in the Lighting Energy Code. The new lighting power density after retrofit was 18 W/m^2.
- There was also a slight reduction in Total Harmonic Distortion (THD) of current, causing fewer problems to the power quality of the building
- Due to improvement in the design of parabolic reflector and the more linear T5 light source, the utilisation factors of the new luminaire is higher. The average illuminance measured after retrofit was 500 lux, which was 11% brighter than the original lighting installation (Fig. 10).

Fig. 10 Lighting after retrofit with new T5 luminaires

4. Conclusion

Taking the lead to use energy efficiently and to bring in competition for lower equipment cost are the major objectives of EEO. We have been actively involving in promoting the use of Mainland energy efficient equipment in Hong Kong since 1996. Equipment tested in many Mainland's testing authorities are also recognised by EMSD. We invited tenders from local agents of Mainland products to bid for our pilot projects. We had also discussed technical and detailed requirements with them for quality products that comply with our specifications. With the advantages of cheaper labour cost and the shifting of production to more automation in the Mainland, the cost of the products is becoming more and more competitive in Hong Kong.

Other than lighting equipment, Mainland's energy efficient products for use in construction industry include Variable Speed Drives (VSD) for motors, Variable Voltage Variable Frequency (VVVF) lift drive systems, water-cooled air conditioning equipment, absorption chillers, etc. Public and private sectors are promoting all these products hard for their wider application in Hong Kong. With the continuous increasing market share for these Mainland's products, it will surely help Hong Kong to achieve her sustainable development and improve our environment.