High frequency Electronic ballast for HID Lamps

**Technical Objective**

Electronic Ballast Systems Corp. has been working on the development of highly efficient (94%) electronic ballast for HID lamps (35W,...,400W) providing energy savings of up to thirty five percent (35%) as compared to the only available alternative, the standard core and coil HID ballasts currently on the market.

**Technical Approaches and Results**

The planned electronic ballast family belongs to the high frequency piecewise exponential class. The practical solutions are based on the high frequency switchmode converters, particularly on the switchmode half-bridge configurations. The high frequency switchmode half-bridge converter provides symmetrical square wave output voltage where the voltage to current source conversion is realized by an inductor connected in series with the lamp as it is shown in the following figure.

![Diagram of a high frequency Electronic ballast for HID Lamps](image)

It is also shown in the above figure that the ballast should have the following basic units:
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1. Power factor correction unit
   Planned technical parameters:
   a) efficiency: 96%
   b) power factor: > 98%
   c) THD: < 10%
   d) temperature range: -20°C --- +70°C

2. High frequency square wave inverter (including inductor)
   Planned technical parameters:
   a) efficiency: 95%
   b) symmetry: 50%
   c) frequency: ≈ 60 kHz (modulated)
   d) lamp power control: 3%
   e) temperature range: -20°C --- +70°C

3. Ignition unit
   For starting purposes, providing high voltage pulses (3000V, 1µs)

   A general technical description of high frequency ballast currents
   was published in 1992 (IAS '92).

A. Circuit solutions for the input unit:

   1. Low power range (35 W, ..., 150 W). An initial solution
      (95% efficiency) was developed by the Grantee in 1991 and it is
      technically described in 1992 U.S. Patent (No. 5,146,398). An
      improvement of the circuit solution was achieved in April-October
      1993. The technical parameters achieved were as follows:
      efficiency (≈96%), PF>98%, THD<5%.

   2. High power range (200 W, ..., 400 W). In the high power range a
      special dual solution was developed in 1994 (Jan.-May). This
      solution is based upon a dual half-bridge boost converter
      configuration (200 W) and the low power is achieved by two parallel
      connected units controlled by a common logic control unit (applying
      a "push-pull" control). Achieved technical parameters:
      efficiency (≈96%), PF>99%, THD<3%.
B. Circuit solution for the high frequency square wave inverter and ignitor:

1. *Master-Slave half-bridge inverter.* The initial solution was developed at the EBS Corp. in 1991/92 (US Patent No.: 5,097,183; 1992). A technical description of the solution was published in APEC '93. Frequency modulation was added to the basic solution in 1993 (October-December). Technical results: efficiency (=96.5-97%), power control 3%, frequency: 60 kHz (modulated) frequency modulation depth: 5 kHz (mod. freq. = 1 kHz). Since the frequency of the basic solution depends upon the temperature which can be considered as one of the most serious technical difficulties, a further development period was conducted in the last quarter of 1994, with promising results.

2. *Self-symmetrizing half-bridge inverter.* This cost effective solution was developed for the low power range (35 W, . . . , 150 W). US patent No. 5,229,927. Since this circuit solution has some drawbacks, it is presently unclear which solution shall be applied in the low power range. More experimental investigation and possible modifications may be needed.

Benefits To US Energy Conservation Efforts...

The electronic HID ballast could provide important benefits to the growth of the U.S. economy by reducing energy consumption, derived from the massive use of this lighting product. Energy conservation has already made more energy available to the U.S. economy than any other single source. In 1988 this country spent $440 billion on energy, which amounts to $5,000 per household. Moreover, by showing the growth in demand for new energy capacity, conservation could liberate ten percent (10%) of U.S. industrial investment capital for other uses. Already the rate of capital investment in new power plants has fallen sharply owing to energy conservation. In 1982 utilities spent $50 billion in industrial plant and equipment. In 1992 the amount invested had dropped to $17 billion.