Electronic Ballast(E-B) for HID Lamps

Design Considerations
for Robust and High Efficient Ballast

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HID Ballast & 4-axis CNC contr

High Intensity Discharge Lamps

HPS lamp
(high pressure sodium)

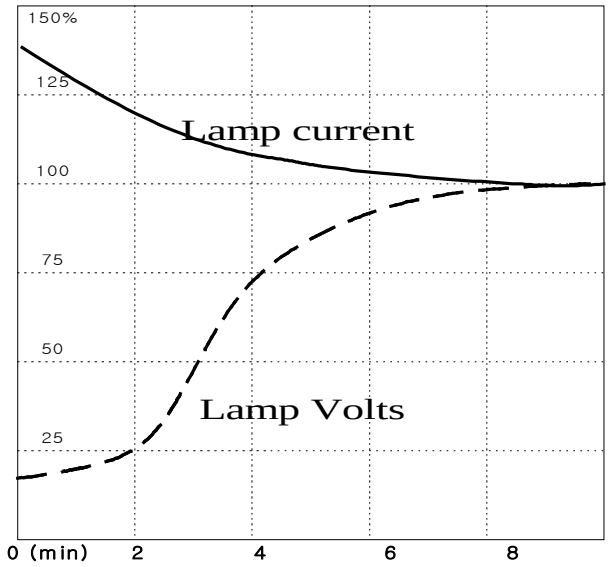
- **High efficacy:130 lm/W**
- **Warm-up time : 6 min.**
- **Ignition impulse :**
  2-4kV 1us
- **Yellow color**
- **Burning position free**

MH lamp
(metal halide)

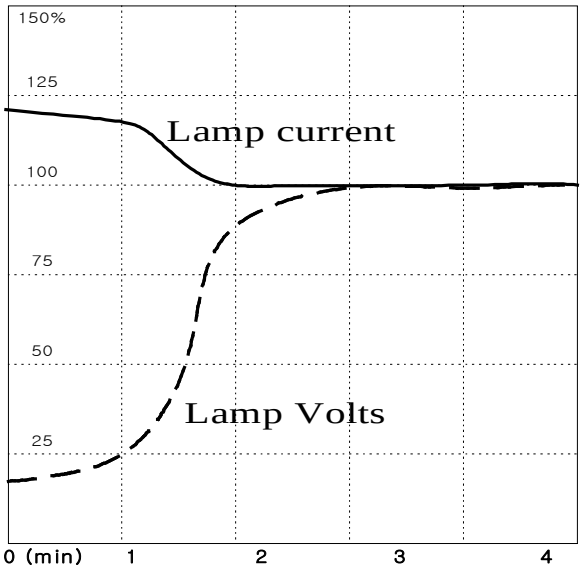
- **Efficacy : 90 lm/W**
- **Warm-up time : 3 min.**
- **Ignition impulse :**
  2+1 electrodes: 0.8~2KV 10us
  2 electrodes: same as HPS lamp
- **Excellent color rendering**

Different Warm-up process

- HPS lamp



- MH lamp



Core-Coil Ballast

- Simple and robust
- Big and heavy
- Much flicker
- High A_{THD}
- Much losses on Ballast (iron loss)
- Choke Coil type
  - low losses
  - output uncontrollable (reduction in life)
- Constant Wattage type
  - good regulation
  - much losses

Electronic Ballast

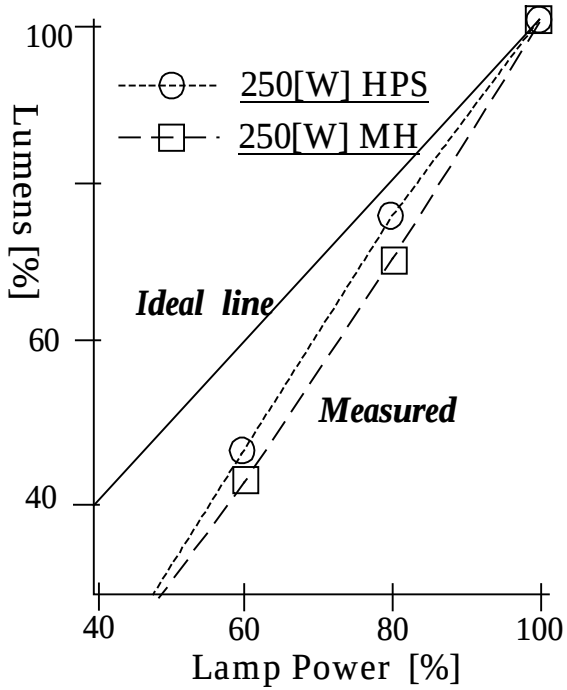
- Small and light weight
- Low Ballast losses
- Lower maintenance cost
- Flicker-free
- Extends the life-time more than 50%
  - -constant power
  - -less ignition energy
- Higher cost ?
- EMI ?
- Reliability ?

NO IMPROVEMENT OF LUMINOUS EFFICACY

ON A HID ELECTRONIC BALLAST

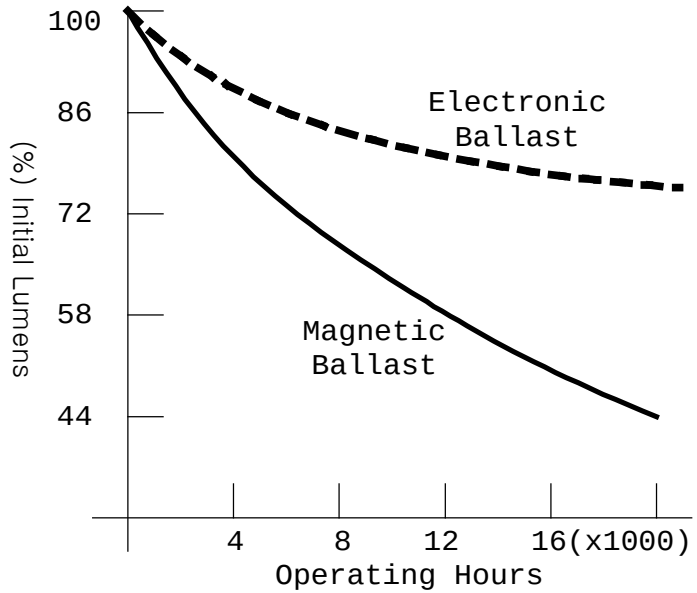
- DIMMING causes sputtering of emissive material from electrodes.
  - -Causes blackening
  - -Degrades lamp life

- Never do DIMMING for long time(> 5 hrs) and below 50% of rated power.



Extending Life-time of HID lamp

- At the end of life
  - increasing the lamp voltage
    (150% in HPS, 110% in MH)
  - decreasing the light output
    due to blackening
- The life time depends on
  1. Ignition impluse energy
  2. Warm-up process (at cold electrode)



ü At least, 150% of rated life-time can be achieved with E-B.

Structures of E-B

Lamp voltage goes up as lamp ages.

HPS lamp

- 80V(new) $\Rightarrow$160V(old)
  large variation
- Cycling at the end of life. Big problem !

- E-B for HPS : needs a variable V_{DCBUS}
  V_{DCBUS} = min. 300V
  max. 450V

MH lamp

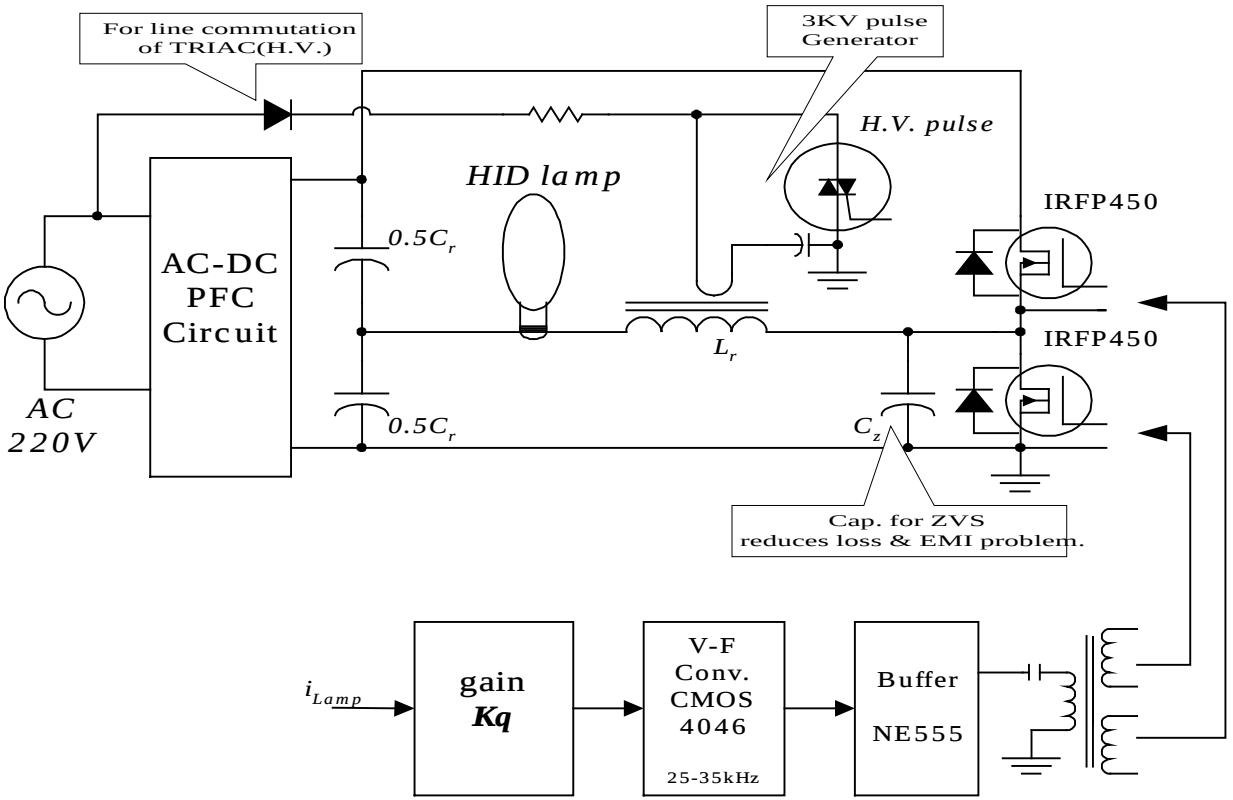
- 130V(new) $\Rightarrow$150V(old)
  small variation
- No cycling effect

- E-B for MH:
  fixed V_{DCBUS} = 380V
- But,Acoustic Resonance Problem !

Iginition : H.V. pulses (HPS)

HPS lamp : 3kV 1us

- Using the main L and SCR discharging circuit.

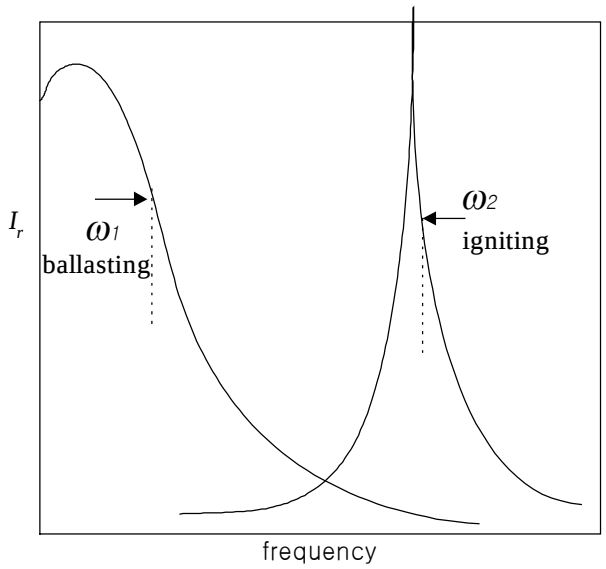


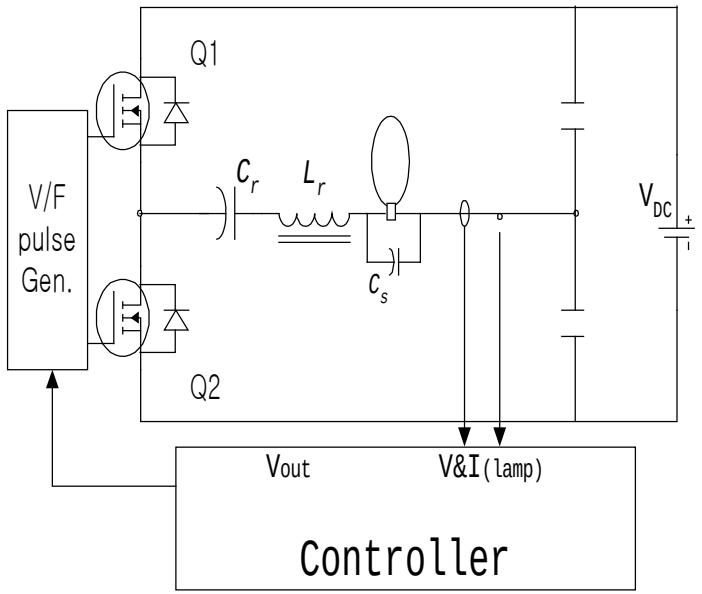
Iginition : H.V. pulses (MH)

MH lamp : 800V 1ms

- Using the main ***L*** and a small ***Cs*** in parallel with lamp.

ω1: at ballasting ω2: at igniting





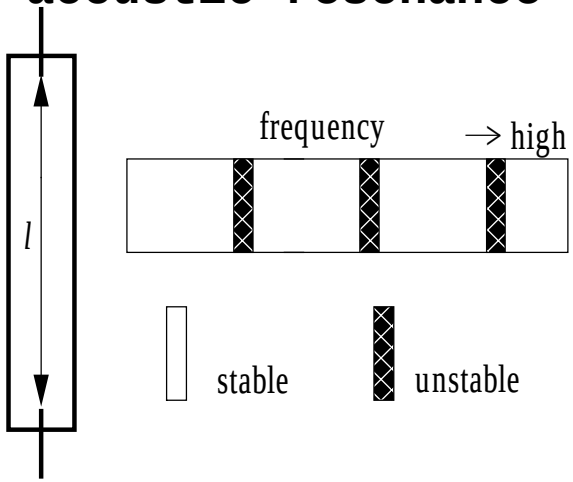
Acoustic Resonance(AR)

makes Sound or Unstable arc.

HPS lamp

- Narrow band AR

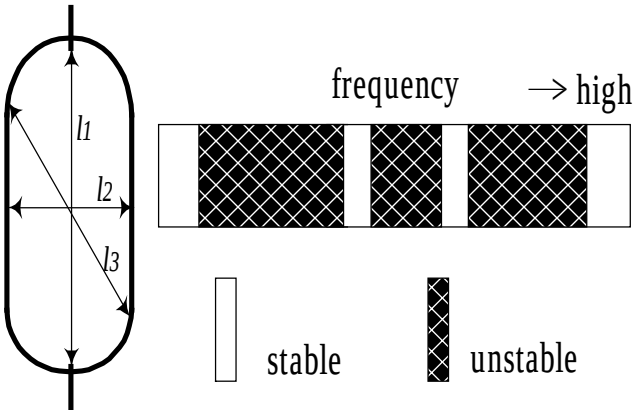
- bands of acoustic resonance



MH lamp

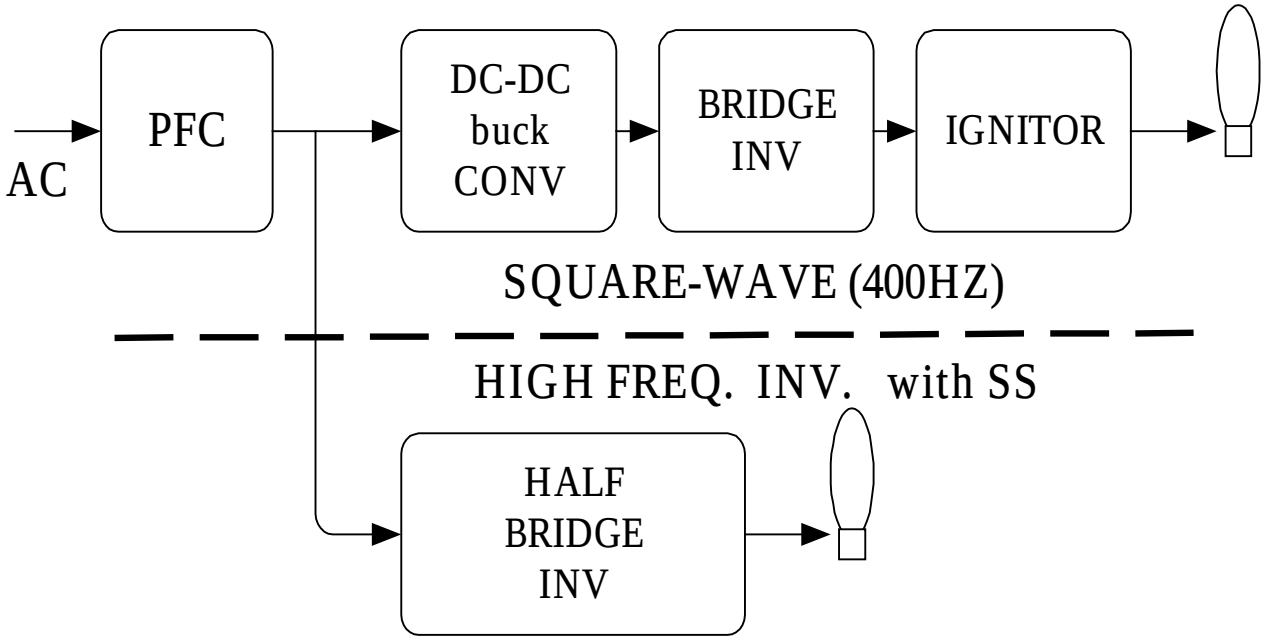
- Wide band AR

- bands of acoustic resonance



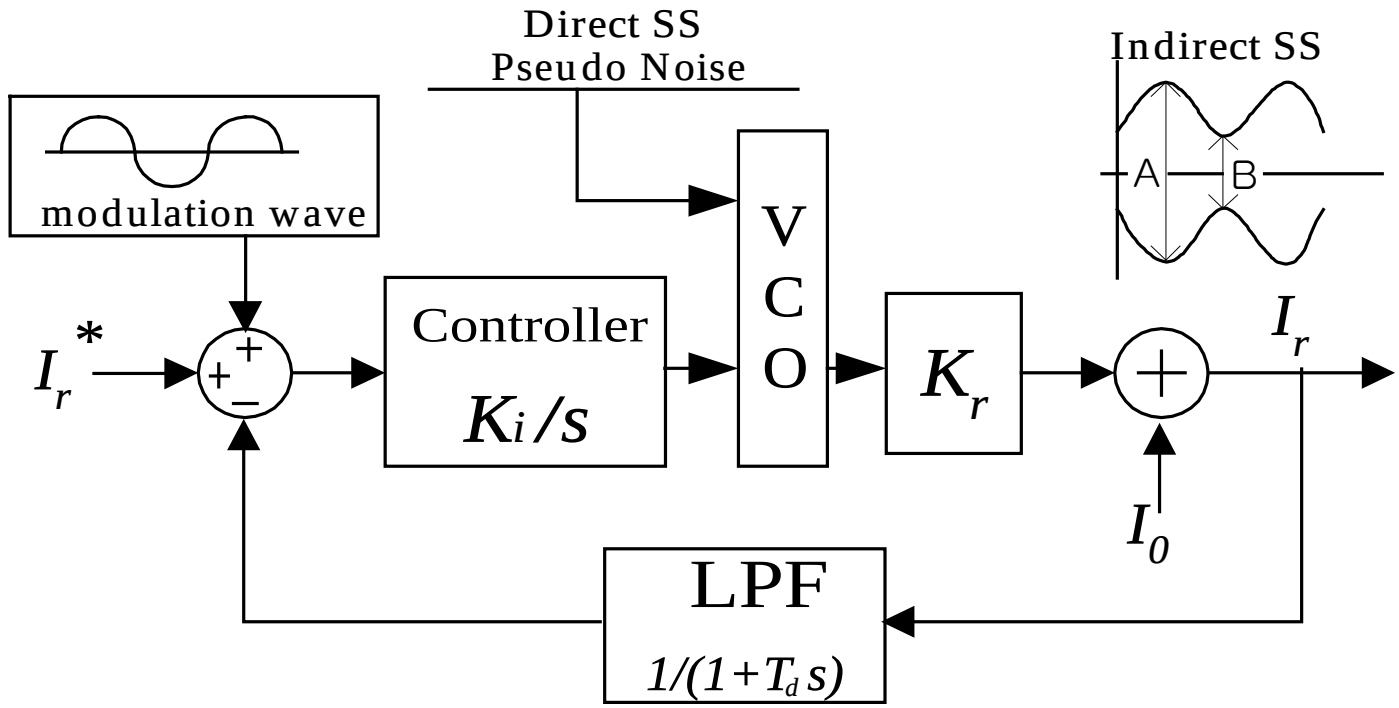
Removing AR by applying

- Square-wave driving(400Hz) : high losses, high cost
- Spread spectrum at High Freq. : low losses, low cost
  - operating freq. 20kHz < f < 100kHz
    Above 100kHz, Losses and EMI problem!

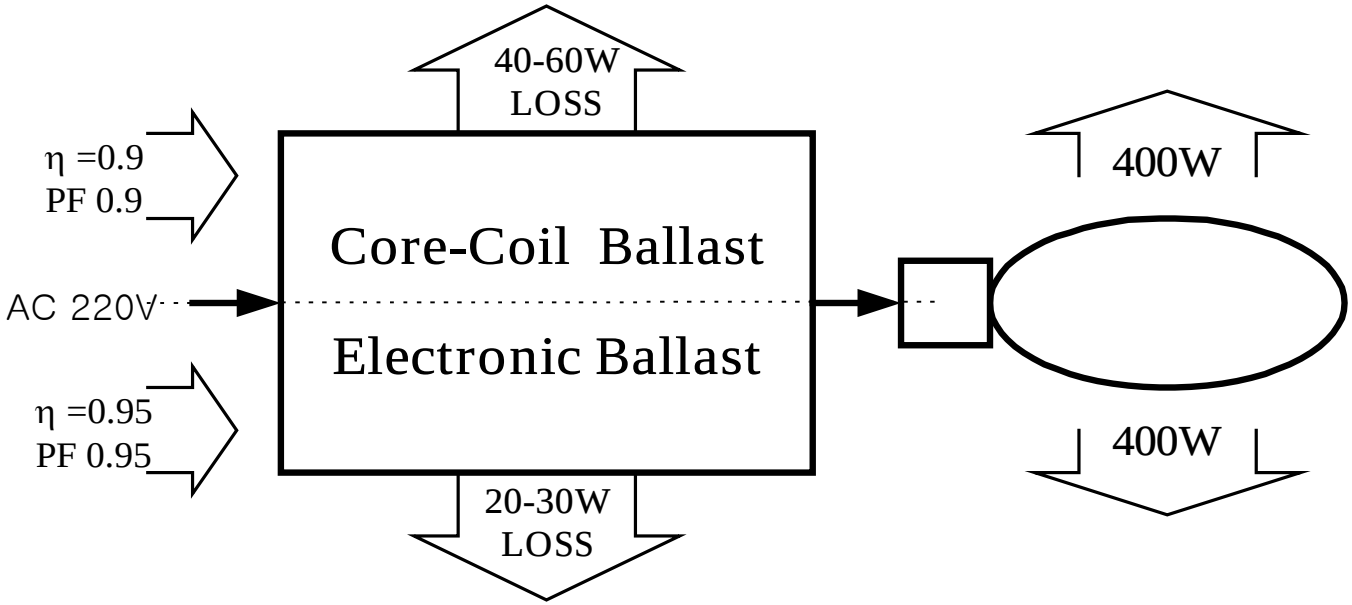


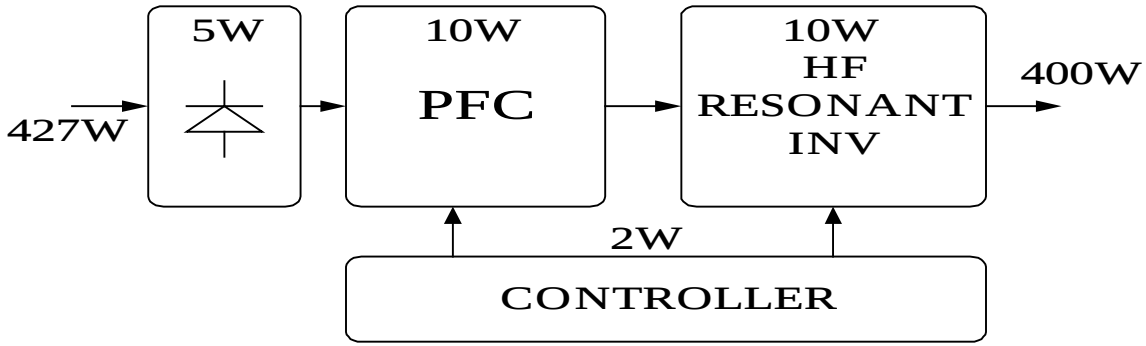
Spread Spectrum(SS) technique

1. By Amplitude Modulation(Indirect SS)
   - Ripple on the current (mod. index)
2. By Random Mod. (Direct SS)
   - No current ripple

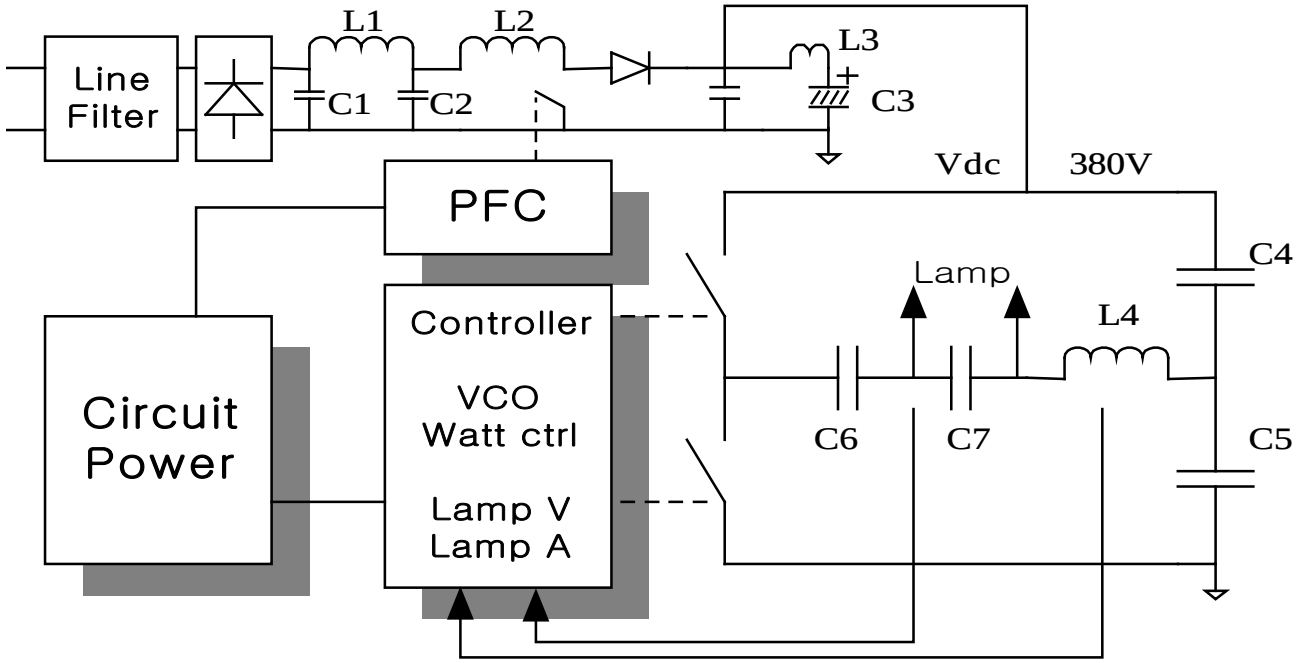


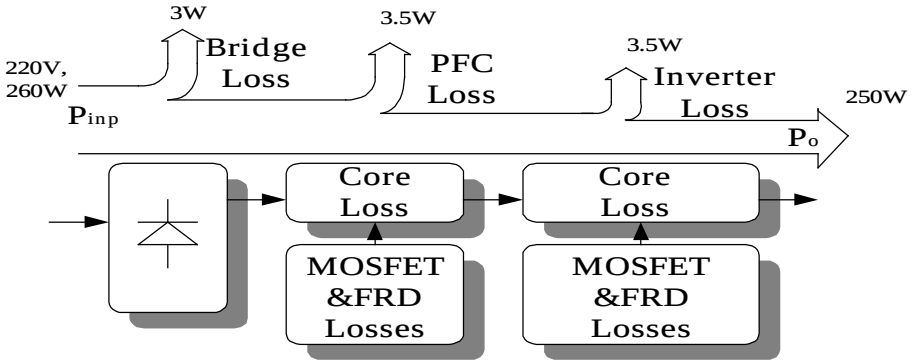
Ballast Losses (In case of 400W MHD)





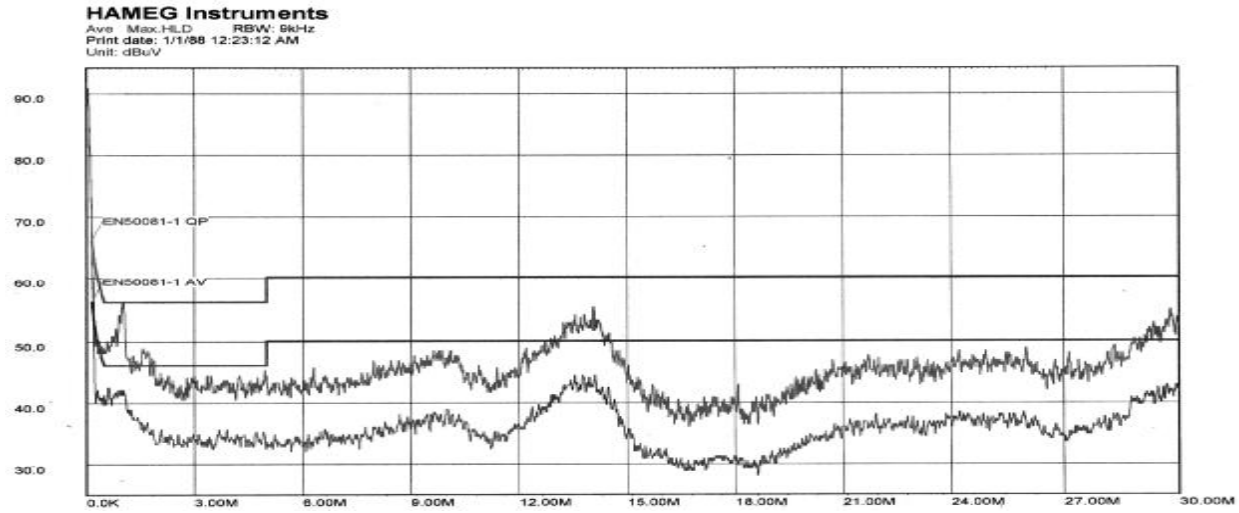
E-B for 250W MH lamp

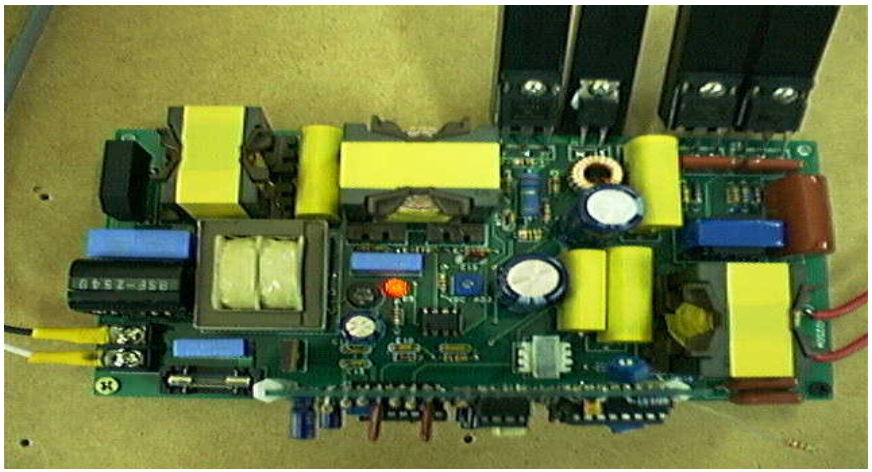




Ballast Loss:10W
P.F:0.99
A_{THD}:6%
Constant Output
Low EMI

EMI level of E-B(250W MH)





What I did and doing(since 1990)

- HPS lamps : 35W, 150W, 250W, 400W
- MH lamps : 250W, 400W
- HQI lamps: 150W, 250W