IR1150S: µPFC™ IC

High Density, Cost Effective CCM PFC from 75W to 4kW+

September 2005

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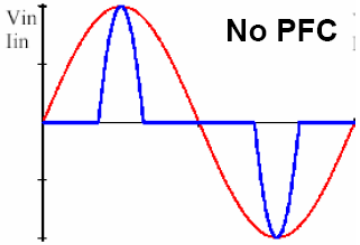
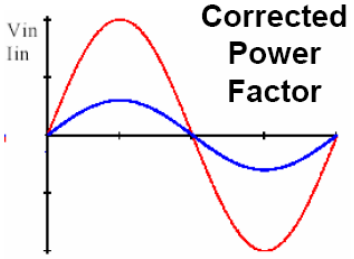
Power Factor Control

- "Power Factor"
  - Relationship between voltage and current waveforms
  - Measure of "power quality" that affects transmission network efficiency

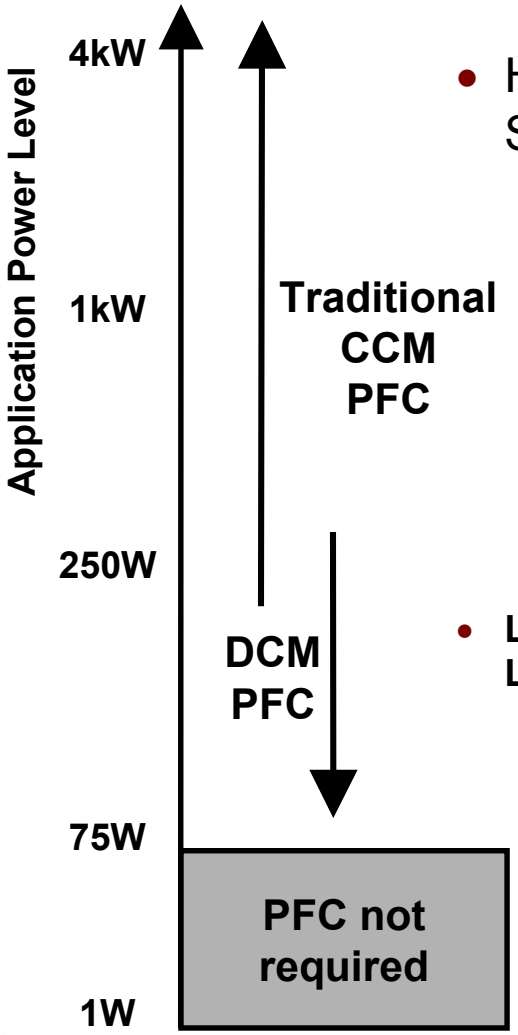
$$PF = \frac{\text{real power}}{\text{apparent power}} \qquad \text{Real Power} = \frac{1}{T}\int_0^T V_{IN} I_{IN} dt$$





- **PFC regulations apply to:**
  - **China : China Compulsory Certificate (CCC)**
  - **Europe : IEC 1000-3-2**
  - **Japan : JIC C 61000-3-2**
    - **For products >75W (>26W for lighting applications)**

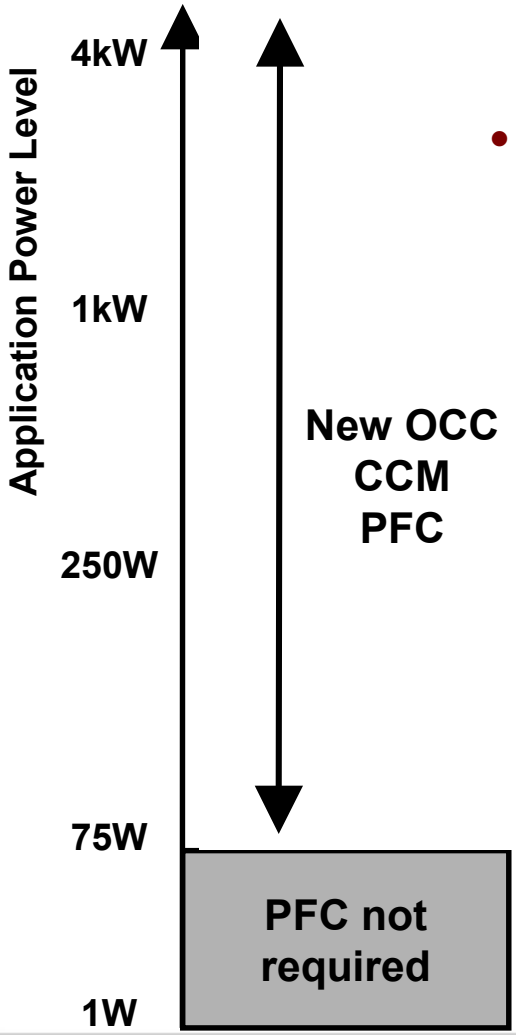
Traditional Solutions:
Compromise on Performance or Complexity



- High Power (>250W) Applications:
  Server SMPS, Telecom Rectifier, PDP TV, etc.
  - Used 'Multiplier' techniques for Continuous Conduction Mode (CCM) PFC:
    - Complex, many design stages
    - High component count
    - $$ Expensive

- **Low Power (<250W) Applications:**
  Laptop / LCD TV / Printer Adaptors, Home Theatre, etc.
  - **Used Discontinuous Current Mode (DCM) PFC:**
    - **Expensive and large size >100W (high peak currents, large EMI filters)**

New µPFC™ IC
= One solution, No Compromise



- **New CCM µPFC™ IC: IR1150S**
  - **CCM PFC for high efficiency**
  - **Easy design, small SO8**
  - **Low component count**
  - **Cost effective system design across application power range**

Background of One Cycle Control

- Proprietary ONE CYCLE CONTROL technique is a general PWM control Method developed in 1991
- One Cycle Control Technique is adapted for PFC control in 1994 with full implementation in Boost PFC circuits in 1997
- Motivation was to simplify conventional PFC solutions using Multipliers and Line Sensing
- Low Cost (Competitive w/ Discrete solution)

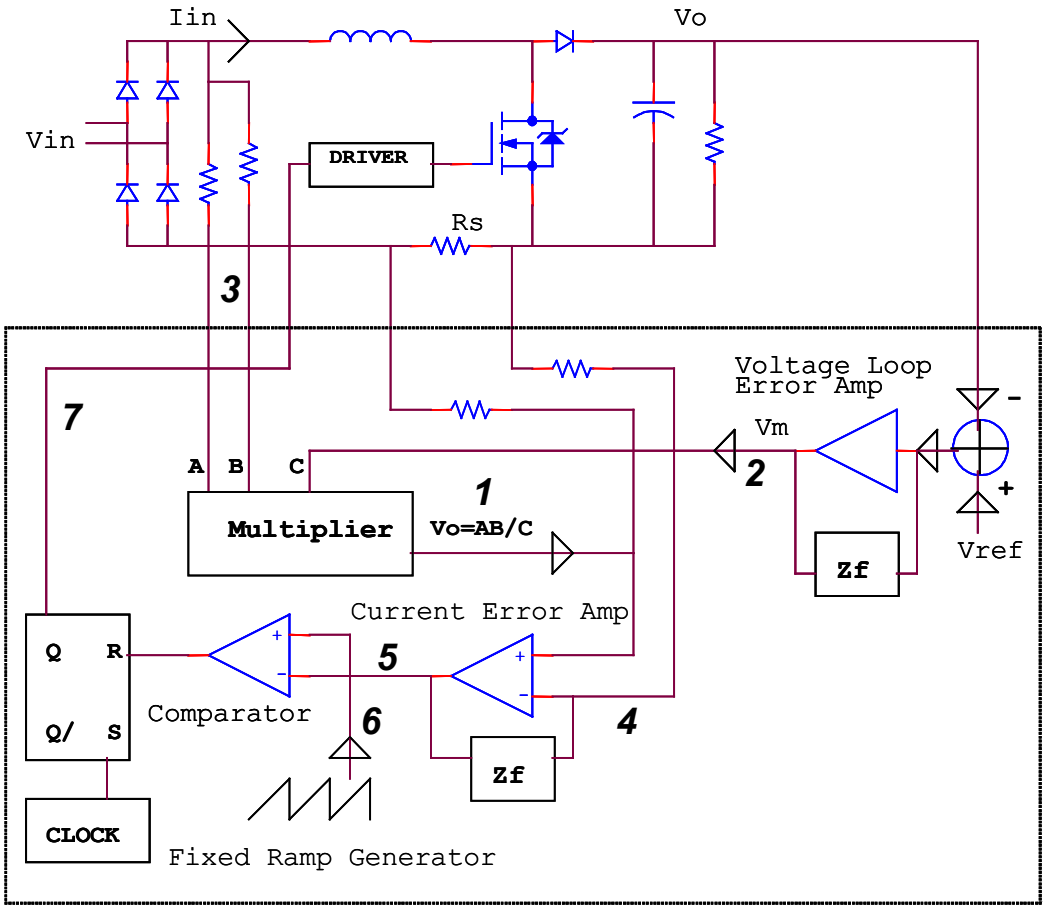
One Cycle Control

- IR has exclusive patent rights under US Patent 5,278,490 titled “One-cycle controlled switching circuit”. The license agreement is between IR and The California Institute of Technology. It is exclusive to *all single phase switch mode AC/DC power supplies and motor drive applications using the One Cycle Control technique.*

- In addition to these patent rights, IR successfully continues to invest its own patents in the One Cycle Control area.

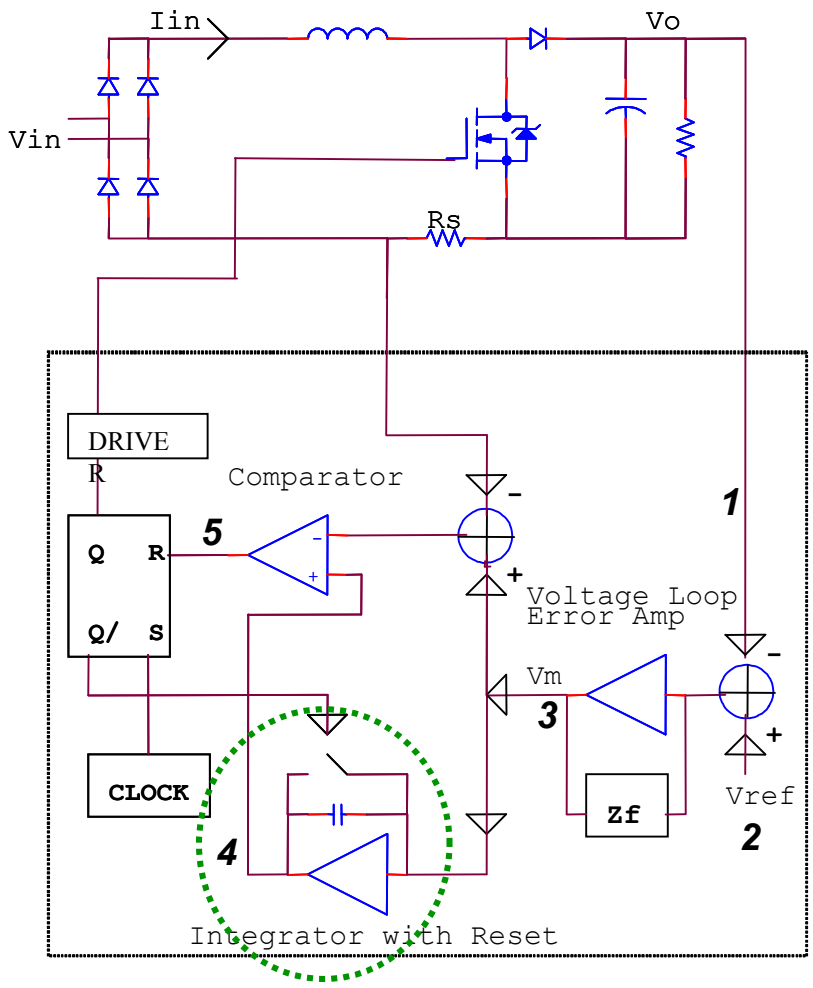
- Single Cycle Control is an old denomination not in use anymore.

Traditional 'Multiplier' CCM PFC



- Output of the analog multiplier (1) is the current programming signal created by multiplying the voltage error amplifier (2) output signal by the rectified line voltage signal (3)
- The voltage has the shape of input voltage and average amplitude proportional to output of voltage error amplifier, which controls the output voltage of the converter
- This programming signal is then summed with a current proportional to the average inductor current (4) and introduced at the current amplifier non-inverting input
- Output of current amplifier (5) is compared to a fixed oscillator ramp at PWM input (6) to become the gate drive signal (7).

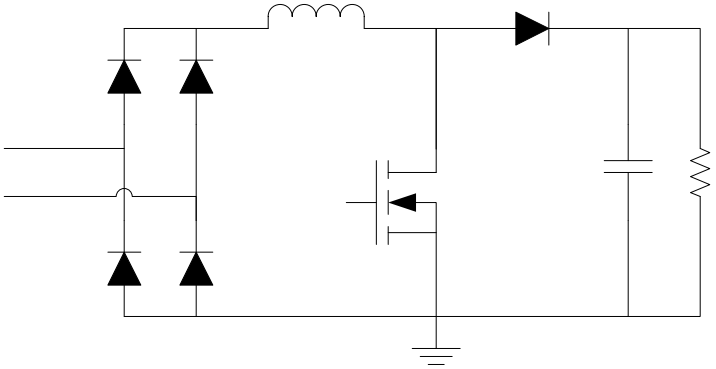
One-Cycle Control CCM PFC: Circuit



- The bus voltage (1) is compared to a reference (2) and the error (3) is integrated over one switching cycle to generate a variable slope ramp (4).
- This variable ramp is compared at the PWM input to a current programming signal (5) derived from the error amplifier output subtracted of the current sense signal
- 'Integrator with Reset'
- OCC looks at the bus voltage and return current to optimize the gate drive in just *'One Cycle'* of the IC switching frequency (based on selectable 50kHz-200kHz)

- Reference: Professor Keyue Ma Smedley, University of California Irvine, USA[13]

One-Cycle Control "Integrator with reset'

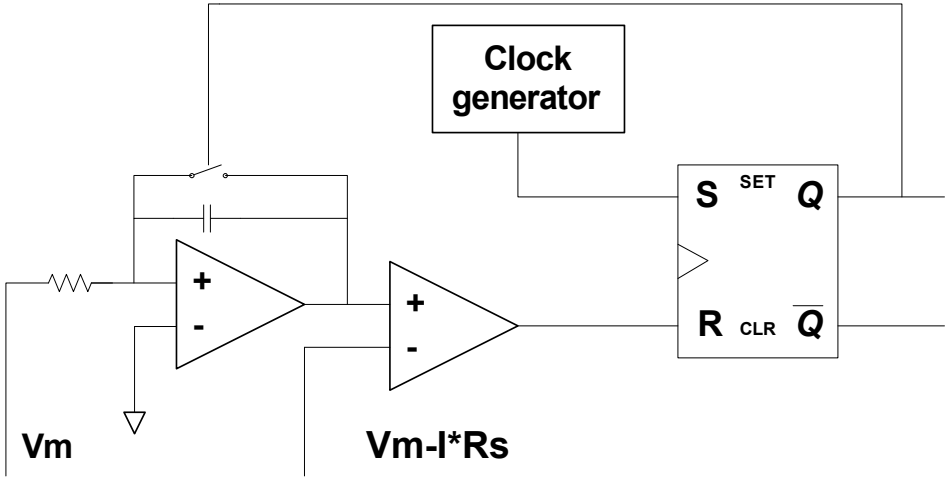


$$V_{in} = V_o(1-D)$$

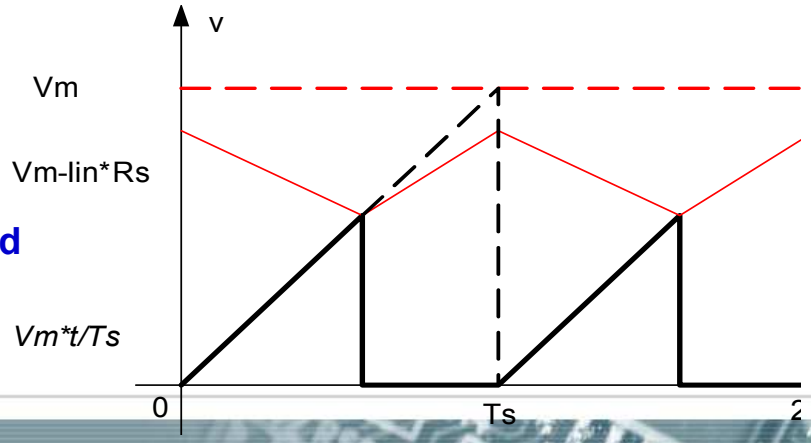
$$V_m \cdot D = V_m - I_{pk} \cdot R_s$$

$$I_{pk} \cdot R_s = V_m(1-D)$$

$$I_{pk} \cdot R_s = V_m \cdot V_{in} / V_o$$

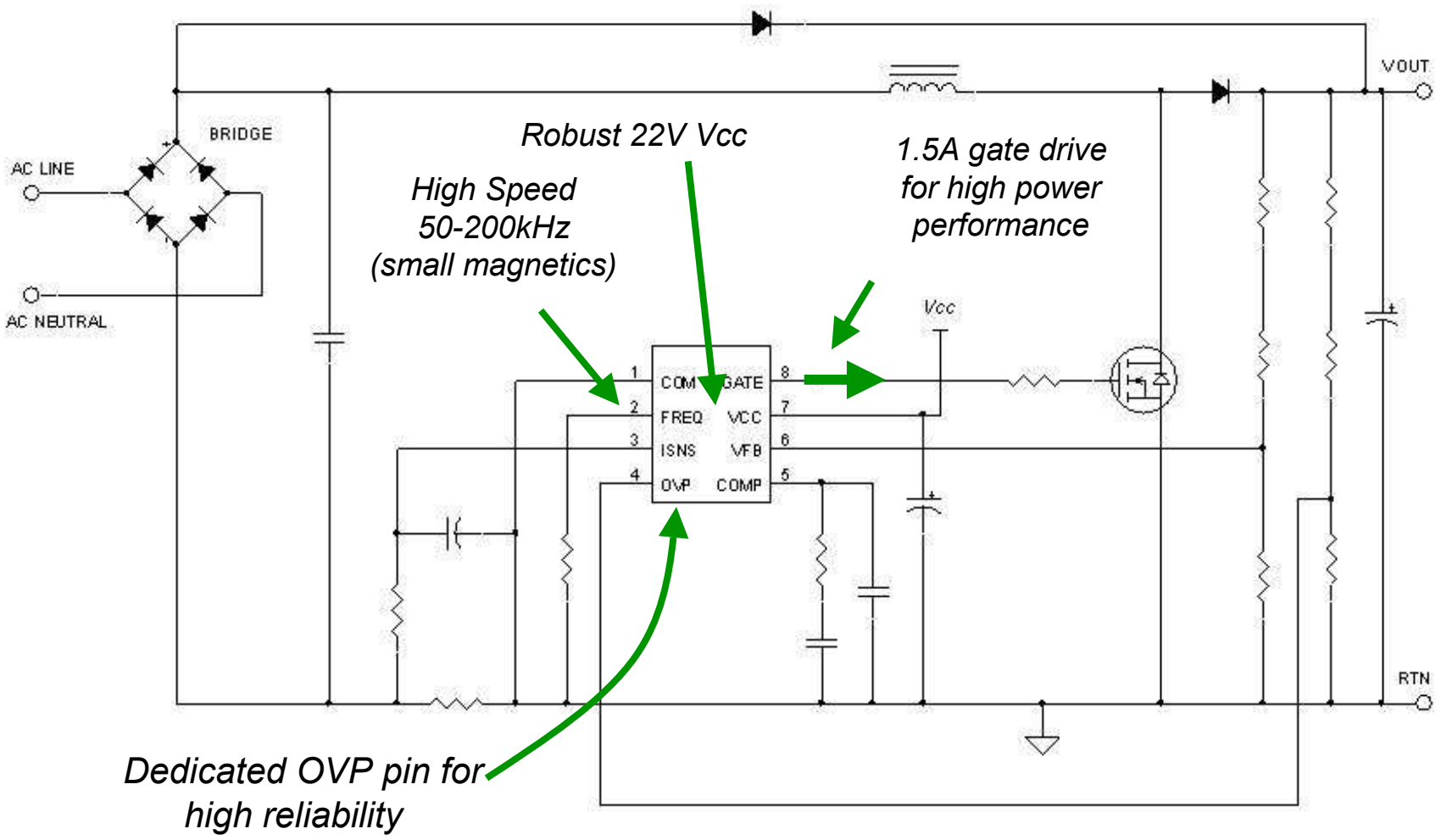


OCC Controller



- **The instant peak current (switching frequency) is proportional to instant input voltage, thus PFC achieved**
- **Duty cycle is achieved as desired**
- **No input voltage sensing is required**
- **Only peak current sensing is required**

IR1150S Typical Circuit



- **Simple, low component count, powerful, small-space design**

International
IOR Rectifier

Data Sheet No. PD60230

IR1150S
IR1150IS
ONE CYCLE CONTROL PFC IC

Features

- PFC with IR proprietary "One Cycle Control"
- Continuous Conduction Mode Boost Type PFC
- No Line Voltage Sense Required
- Programmable Switching Frequency (50kHz 200kHz)
- Programmable Output Overvoltage Protection
- Brownout and Output Undervoltage Protection
- Cycle by Cycle Peak Current Limit
- Soft Start
- User initiated micropower "Sleep Mode"
- Open Loop Protection
- Maximum duty cycle limit of 98%
- User programmable fixed frequency operation
- Min. off time of 150-350ns over freq range
- V_{CC} Under Voltage Lockout
- Internally Clamped 13V Gate Drive
- Fast 1.5A peak Gate Drive
- Micropower startup (<200 µA)
- Latch immunity and ESD protection

Description

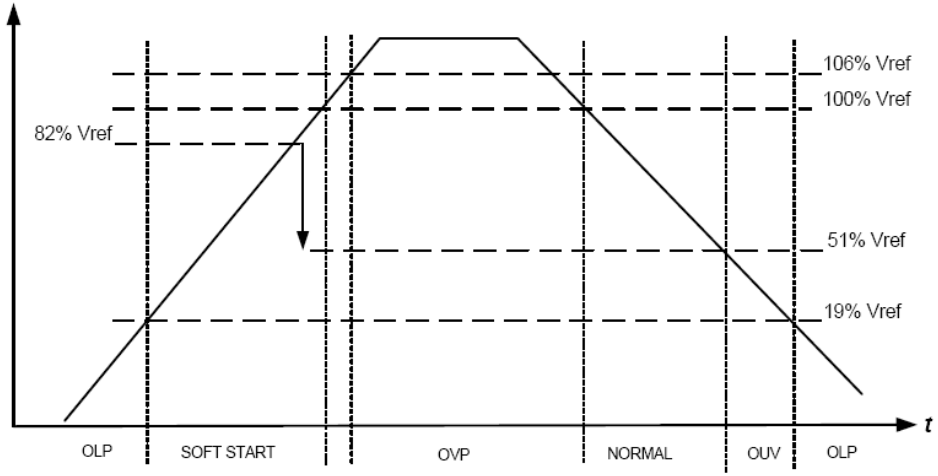
The IR1150 is a power factor correction (PFC) control IC designed to operate in continuous conduction mode (CCM) over a wide range input line voltages. The IR1150 is based on IR's proprietary "One Cycle Control" (OCC) technique providing a cost effective solution for PFC.
The proprietary control method allows major reductions in component count, PCB area and design time while delivering the same high system performance as traditional solutions.
The IC is fully protected and eliminates the often noise sensitive line voltage sensing requirements of existing solutions.
The IR1150 features include programmable switching frequency, programmable dedicated over voltage protection, soft start, cycle-by-cycle peak current limit, brownout, open loop, UVLO and micropower startup current.
In addition, for low standby power requirements, (Energy Star, Green Power, Blue Angel, etc.), the IC can be driven into sleep mode with total current consumption below 200µA, by pulling the OVP pin below 0.62V.

Package

8-Lead SOIC

Protection Section

Parameters	Symbols	Min.	Typ.	Max.	Units	Remarks
Open loop protection (OLP) Vfb threshold	V_{OLP}	17	19	21	$\%V_{REF}$	
Output under voltage protection (OUV)	V_{OUV}	49	51	53	$\%V_{REF}$	Brown out protection
Output over voltage protection (OVP)	V_{OVP}	104	105.5	107	$\%V_{REF}$	
OVP hysteresis	—	350	450	550	mV	
Peak current limit protection (IPKLMT) ISNS voltage threshold	V_{ISNS}	-1.11	-1.04	-0.96	V	



Output Protection

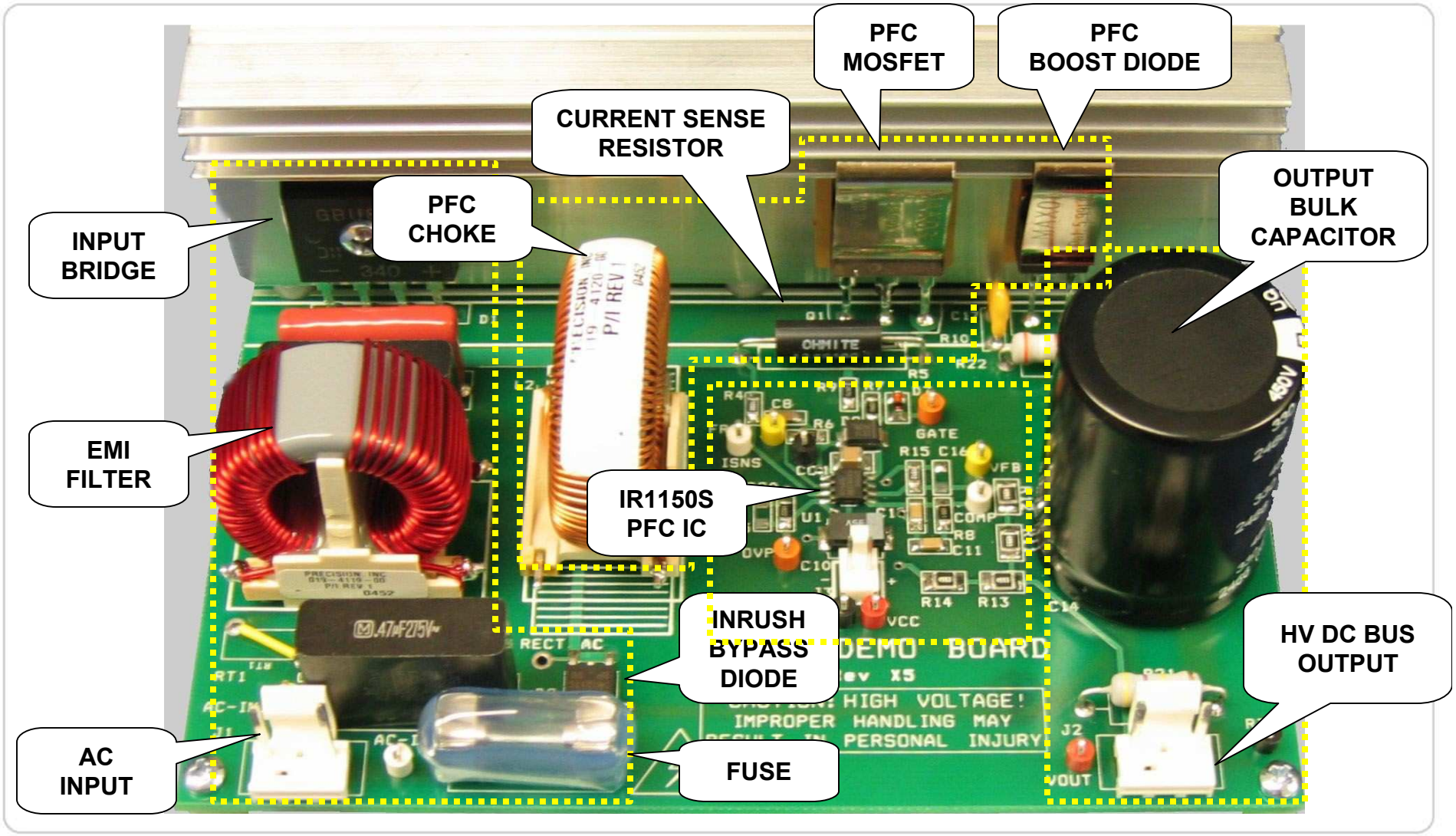
IR1150 µPFC™ IC Family

Part Number	Package	V_{cc} (V)	I_o +/- (A)	Freq. (kHz)	T_{amb} (°C)	Environment	RoHS
IR1150S	**SO-8**	**13-22**	**1.5**	**50-200**	**0 to +70**	**Consumer**	**—**
IR1150IS	**SO-8**	**13-22**	**1.5**	**50-200**	**-25 to +85**	**Industrial**	**—**
IR1150SPbF	**SO-8**	**13-22**	**1.5**	**50-200**	**0 to +70**	**Consumer**	**Lead Free**
IR1150ISPbF	**SO-8**	**13-22**	**1.5**	**50-200**	**-25 to +85**	**Industrial**	**Lead Free**

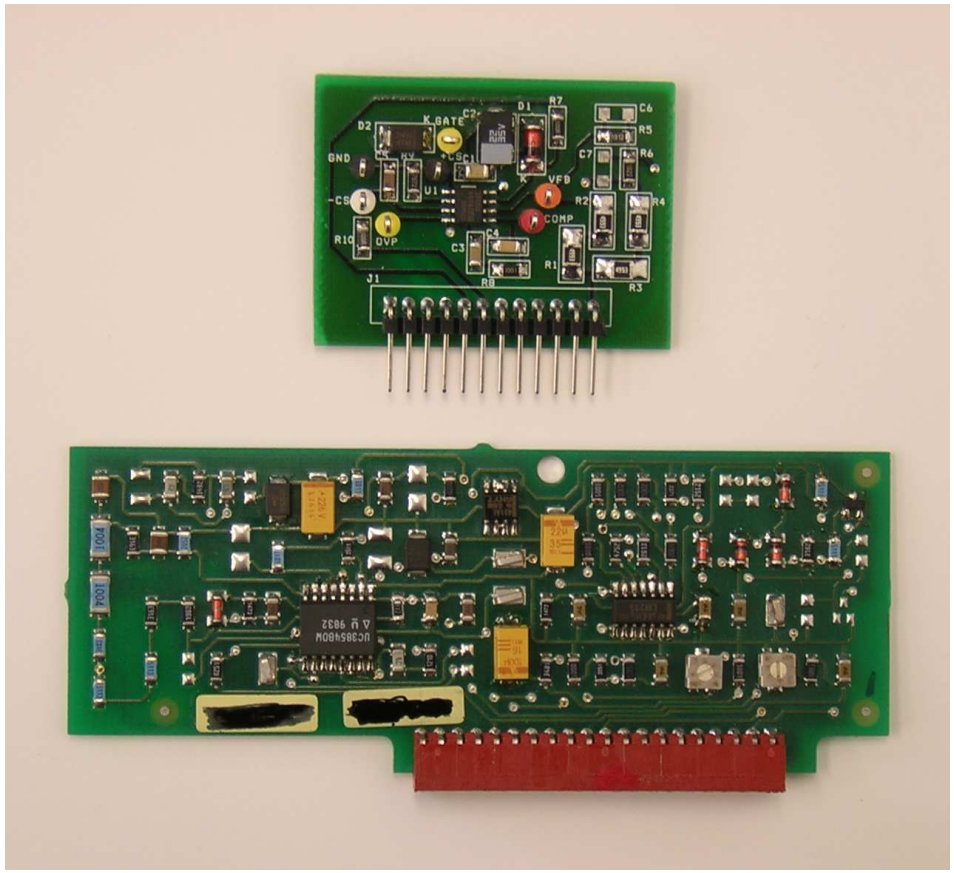
IR devices are being qualified as lead-free to comply with RoHS 2006 guidelines. Over 1,200 IR devices are already fully qualified and available as lead free (PbF). Lead-free devices are available at the same price as standard products.

For more information on IR's lead-free roadmap, please go to www.irf.com/ehs/leadfreepackage.html

µPFC IR1150S 300W demo board



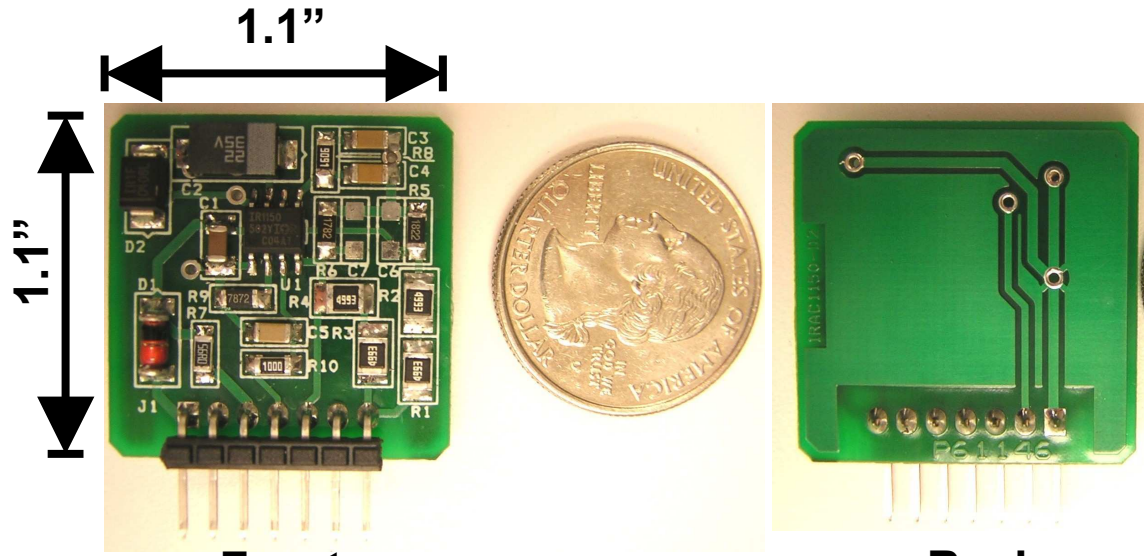
1kW Server PFC



- 1kW board with New μPFC
- 1kW board with Traditional Multiplier

One-Cycle Control: Control Card

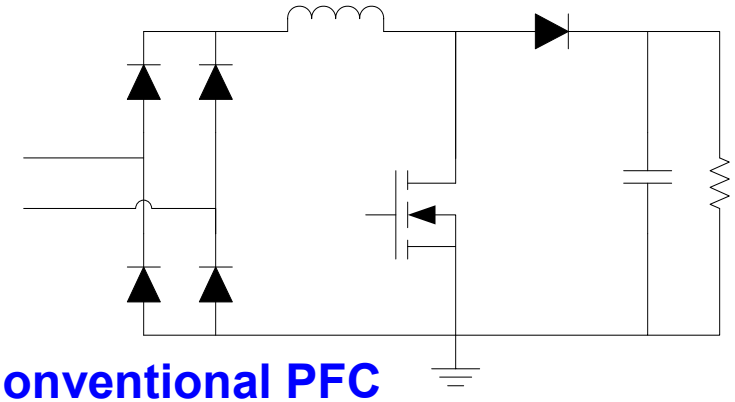
- 1.5A gate can directly drive 2 x 190mohm 600V SuperJunction FETs



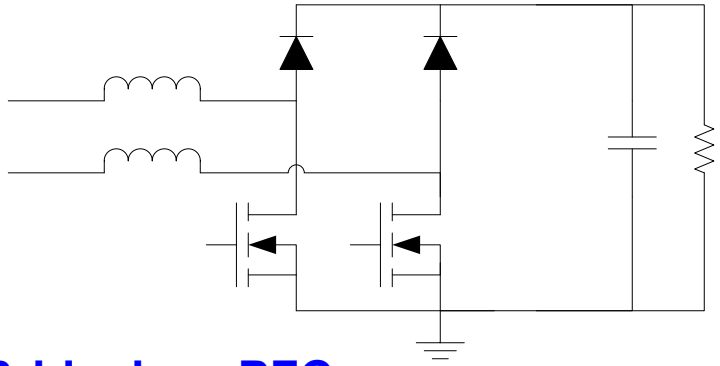
IR1150S Features and Benifits

Features	Benefits
PFC with IR proprietary "One Cycle Control"	**Fast, easy design with few components, small space.** **Reduction in cost, PCB area, component count.**
Continuous Conduction Mode (CCM) operation	**High power, low current ripple, high performance.**
0.999 Power Factor **3% Total Harmonic Distortion (typical results)**	**Compliance with PFC regulations for Japan, Europe and China**
No AC Line Voltage Sense Required	**Minimum component count for fast design** **Minimum board space for high power density** **Easier EMI design / compliance**
SO8 package	**Half the size of conventional CCM PFC chips**
Dedicated, Programmable Output Overvoltage Protection (Open Loop Protection)	**High reliability, reduced component count**
Fast 1.5A peak Gate Drive **Min. off time of 150-350ns over freq range** **Maximum duty cycle limit of 98%**	**Fast switching** **High efficiency**
User initiated micro power "Sleep Mode" **Micro power startup (<200 µA)**	**Low power operation / standby compliance:** **•1W, Blue Angel, Energy Star**
Peak Current Mode Control	**Only one Current Sense Transformer required (need 2 for traditional CCM)** **Can be used for Bridge-less Boost (BLB) high efficiency designs**
VCC Under Voltage Lockout, Internally Clamped 13V Gate Drive **Latch immunity and ESD protection, Soft Start** **Brownout and Output Undervoltage Protection** **Cycle by Cycle Peak Current Limit**	**System protection** **Robust design** **Excellent transient response without voltage feed forward**
Programmable, Fixed Switching Frequency (50-200kHz)	**One device fits wide range of applications**

Advanced Topology: Bridge-Less Boost PFC

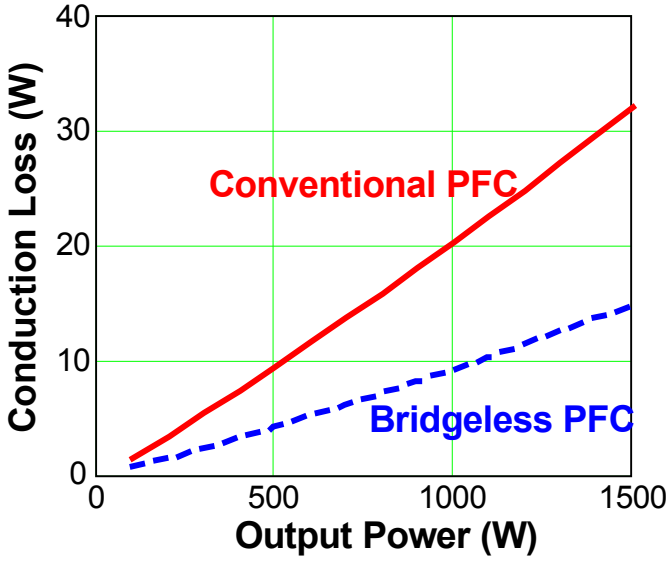


Conventional PFC



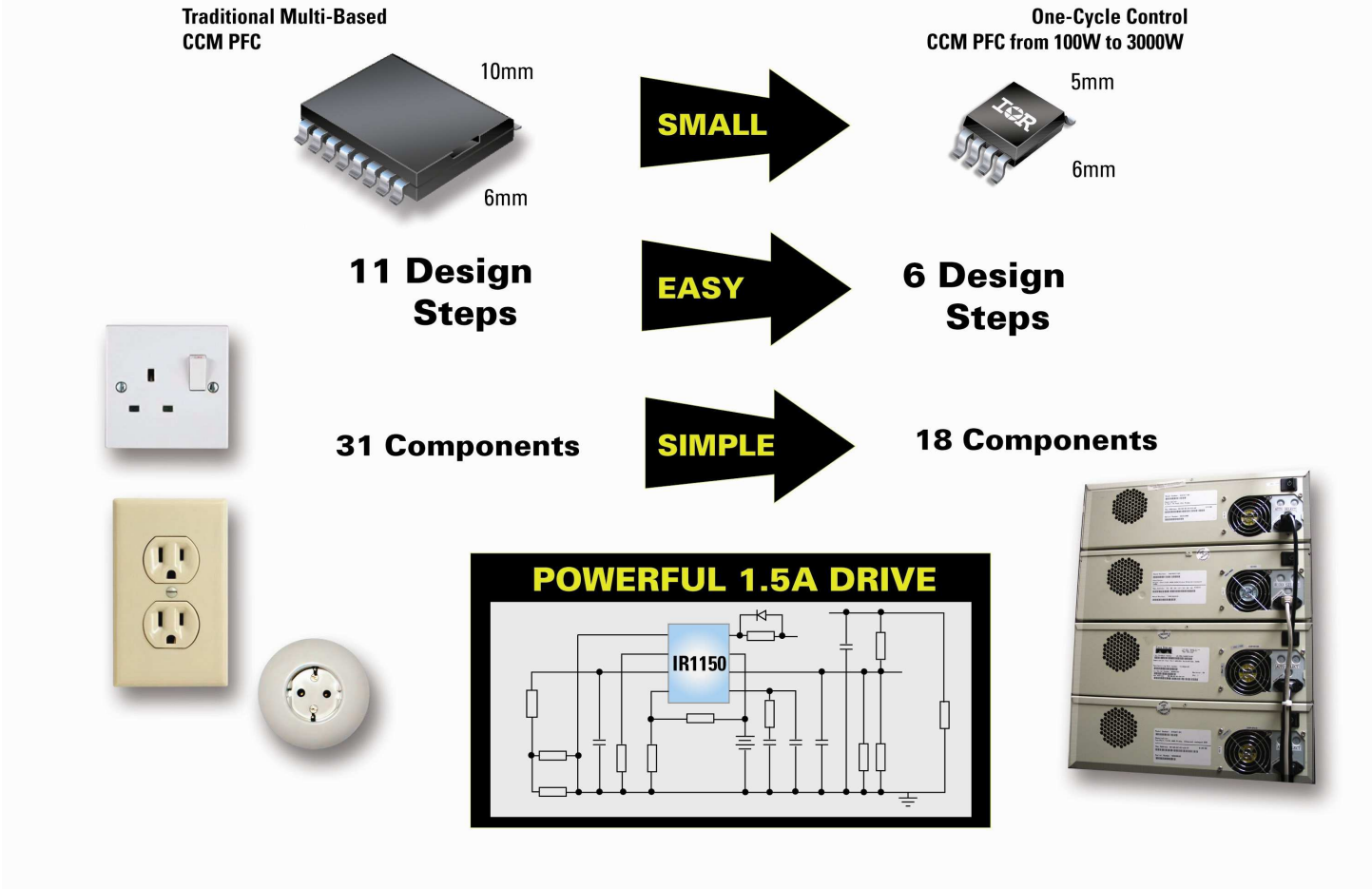
Bridgeless PFC

- Original patent (US 4,412,277) by Rockwell Corp. 1983
  - Difficult to implement
- IR1150 OCC enables simple, high density BLB
  - No AC-line voltage sensing required
  - Easy current sensing due to peak current mode
- >1% efficiency improvement (=10W at 1kW)



- **Technical Paper (APEC 2005) on: http://www.irf.com/technical-info/whitepaper/blbapec2005.pdf**

IR1150S: µPFC™ IC with One-Cycle Control



High Density, Cost Effective CCM PFC from 75W to 4kW+