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Bipolar

-Diodes and Transistors in Electronic Ballast

2005-09-28

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Electronic ballast in various lighting applications

Electronic Ballast for Fluorescent lamps

Ballast

Lamps

TLD and PLL lamps

TL,TL5 and CFL

TLE lamps

Electronic Ballast for High Integrity Discharger lamps

Ballast

Lamps

CDM lamps

SDW-TG LAMPS

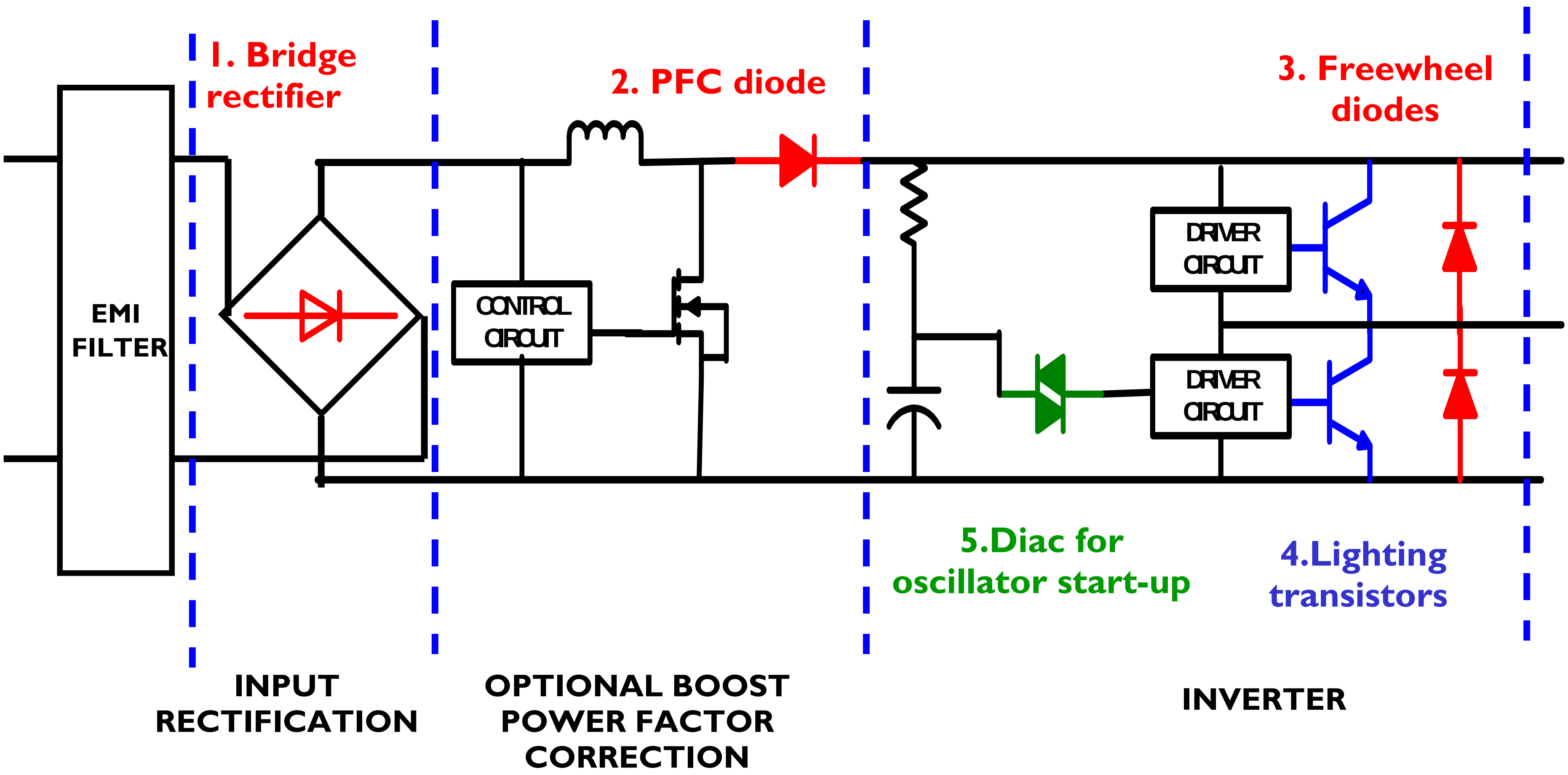
Electronic Ballast for Halogen Lamps

Ballast

Lamps

<u>low voltage halogen lamps</u>

Diodes in electronic lighting ballast topology



1. Bridge rectifiers(general purpose rectifiers) :

BYD17,PRLL4001,PS07

VRRM (V)	IO(AV) / IF(AV) (A)	VF (V)	IF (A)	SOD87
50	1.6	1.1	1	PRLL4001
100	1.6	1.1	1	PRLL4002
200	1.5	1.05	1	BYD17D
200	1.8	1.05	1	PS07D
400	1.5	1.05	1	BYD17G
400	1.8	1.05	1	PS07G
600	1.5	1.05	1	BYD17J
600	1.8	1.05	1	PS07J
800	1.5	1.05	1	BYD17K
1000	1.5	1.05	1	BYD17M

2. PFC diodes (ultrafast/hyperfast recovery diodes):

BYV29-500/600, BYC5/8/10-600,BYD167

VRRM (V)	PFC Output power [W]	fs [kHz]	trr [ns]	IO(AV) [A]	VF (V)	TO220AC (SOD59)	D2PAK (SOT404)	TO220AB	SOD87	SOD113
ultrafast recovery diode										
500	400	50	60	9	1.03	BYV29-500				BYV29X-500
600	>400	50	55	9	1		BYV29B-600			BYV29X-600
600	50	50	50	2	1.25				BYD167	
hyperfast recovery diode										
600	200	200	19	5	1.75	BYC5-600	BYC5B-600			
600	400	100	19	5	1.75	BYC5-600	BYC5B-600			
600	400	200	19	8	1.75	BYC8-600	BYC8B-600			
600	>400	50~200	19	10	1.75	BYC10-600	BYC10B-600			
600	>400	50~200	19	2 x 5	1.75			BYC10-600CT		

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3. Freewheel/limiter diodes (ultrafast recovery diodes)

BYD77,BYD57,BYD127,BYD147,BYD167

VRRM (V)	IO(AV) / IF(AV) (A)	VF (V)	IF (A)	trr [ns]	SOD87
Ultrafast recovery diodes					
50	2	0.98	1	25	BYD77A
100	2	0.98	1	25	BYD77B
150	2	0.98	1	25	BYD77C
200	2	0.93	1	25	BYD127
200	2	0.98	1	25	BYD77D
400	1	3.6	1	30	BYD57G
400	2	1.15	1	50	BYD147
400	1.85	1.05	1	50	BYD77G
600	1	3.6	1	30	BYD57J
600	2	1.25	1	50	BYD167
800	1	3.6	1	75	BYD57K
1000	1	3.6	1	75	BYD57M
1400	1.2	3.6	1	150	BYD57V

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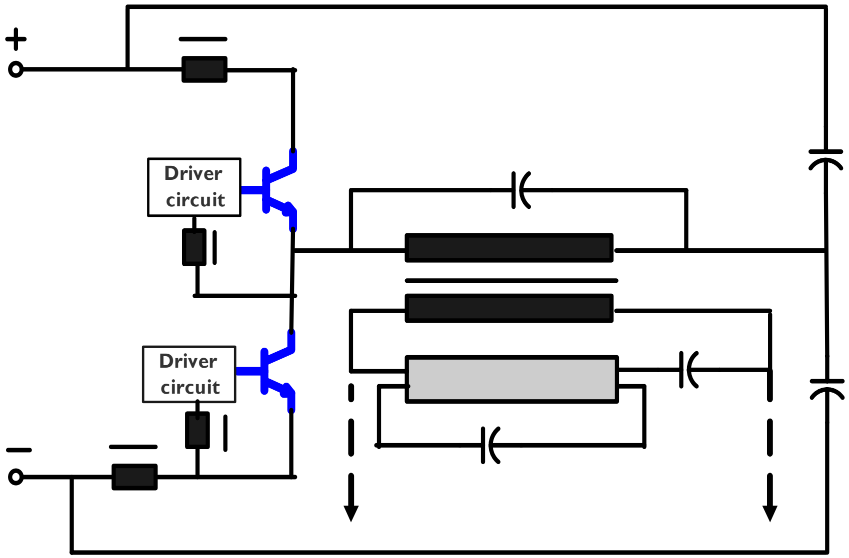
5. Diac for oscillator start-up:

BR100/03

I(FRM) (A)	V(BO) (V)	I(BO) max (uA)	SOD27
2	28~36	50	BR100/03

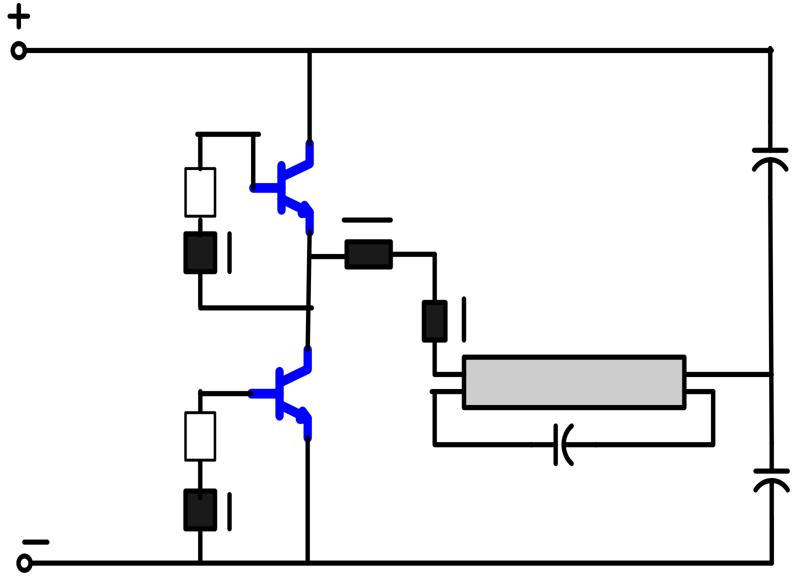
Lighting transistors in electronic ballast topologies

Current fed half bridge inverter



- BUX84, BUX87,BUX85,
- BUT211,BUT18A,BUT12A,BUW12A,BUT11A
- BU1508AX,BU508A

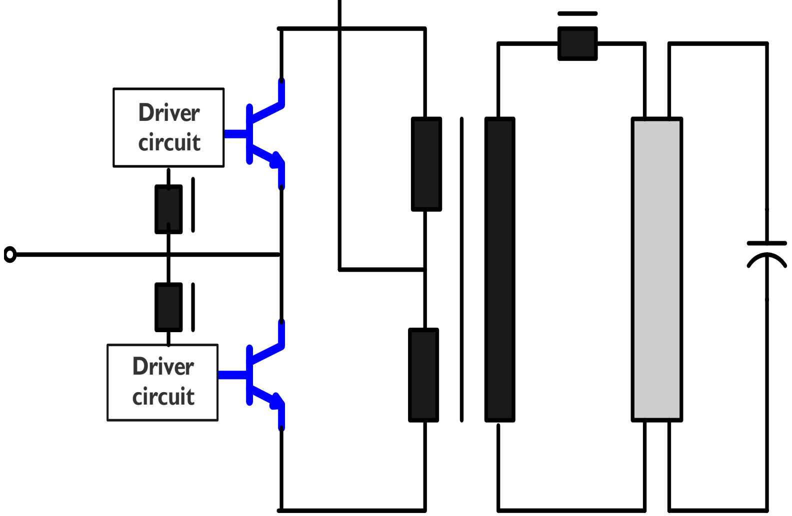
Voltage fed half bridge inverter



- BUX100, BUX84
- BUT211,BUT18A,BUT12A,BUW12A

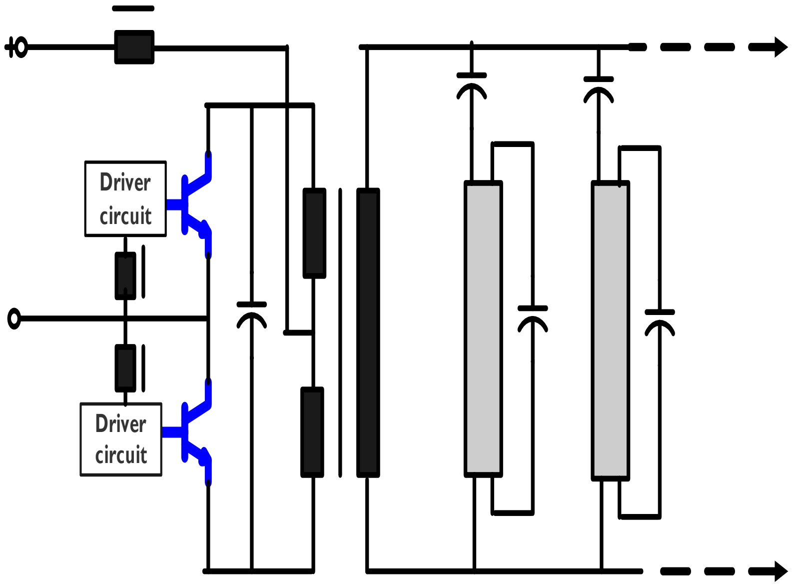
Lighting transistors in electronic ballast topologies

Voltage fed push pull inverter



- BUX84,BUX85,BUX87,
- BUT211,BUT18A,BUT12A,BUW12A,BUT11A
- BU1508AX,BU508A

Current fed push pull inverter



- BUX87,BUX85
- BUT11A,BUT18A,BUT12A,BUW12A
- BU1508AX,BU508A
- BU1706A,BU1706AX,BU1708AX

Lighting transistors selection guide

Topology		Voltage fed push pull		Current fed push pull		Current fed half bridge		Voltage fed half bridge	
A.C. Supply	120V	BUX84	35W	BUX87	13W	BUX84	25W	BUX100	15W
		BUT211	90W	BUX85	55W	BUT211	70W	BUT211	40W
		BUT18A	110W	BUT11A	140W	BUT18A	80W	BUT18A	55W
		BUT12A	140W	BUT18A	170W	BUT12A	110W	BUT12A	70W
		BUW12A	140W	BUT12A	230W	BUW12A	110W	BUW12A	70W
				BUW12A	230W				
	230V	BUX87	15W	BU1508AX	360W	BUX87	13W	BUX84	30W
		BUX85	70W	BU508A	360W	BUX85	55W	BUT211	80W
		BUT11A	170W			BUT11A	140W	BUT18A	100W
		BUT18A	210W			BUT18A	160W	BUT12A	140W
		BUT12A	280W			BUT12A	220W	BUW12A	140W
		BUW12A	280W			BUW12A	220W		
	277V&most PFC designs	BU1508AX	280W	BU1706A	215W	BU1508AX	220W	BUX84	40W
		BU508A	280W	BU1706AX	215W	BU508A	220W	BUT211	100W
				BU1708AX	340W			BUT18A	125W
								BUT12A	170W
								BUW12A	170W

4.Lighting transistors (fast bipolar transistors)

BUJ xxx; BUX 8xP; BUT 1xA; PHE 1300x

Vcesm (V)	Ic[DC] (A)	Ic[SAT] (A)	tf[max] (us)	SOT82	TO220AB (SOT78)	SOT186A (isolated TO220AB)	TO92 (SOT54)	D2-PAK (SOT404)
700	1	0.5	0.05				BUJ100	
700	1	0.5	0.05				BUJ100B	
700	4	3	0.033		BUJ103A			
700	4	2	0.16		PHE13005			
700	8	4	0.045		BUJ105A			BUJ105AB
700	8	5	0.04		PHE13007			
700	10	6	0.05		BUJ106A			
700	12	6	0.15		PHE13009			
800	0.5		0.28	BUX86P				
1000	0.5		0.28	BUX87P				
1000	2	1	0.4		BUX85			
1000	5	2.5	0.8		BUT11A	BUT11AX		
1000	5	2.5	0.8		BUT11AI			

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4.Lighting transistors (fast bipolar transistors)

BU1508AX/DX; BU508AF/DF/AW/DW

Vcesm (V)	Ic[DC] (A)	Ic[SAT] (A)	tf[max] (us)	SOT186A (isolated TO220AB)	TO220AB (SOT78)	SOT199	TO247 (SOT429)
1000	5	3	0.145		BUJ303A		
1000	6	4	0.8		BUT18A		
1000	8	5	0.8			BUT12AX	
1000	8	5	0.8		BUT12AI		
1050	5	3	0.45		BUJ303B		
1200	6	2	0.17		BUJ403A		
1500	4.5	0.6		BU1508AX			
1500	4.5	0.6		BU1508DX			
1500	4.5	1				BU508AF	BU508AW
1500	4.5	1				BU508DF	BU508DW

- **Appendix:**

PFC (Power Factor Corrector)

PFC diodes in various applications

Computer

desktop

file server

Notebook adaptor

Consumer

adaptor

display

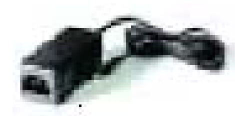
Plasma TV

LCD TV

CRT TV

Telecom (switching and terrestrial equipment)

AC/DC converter



UPS

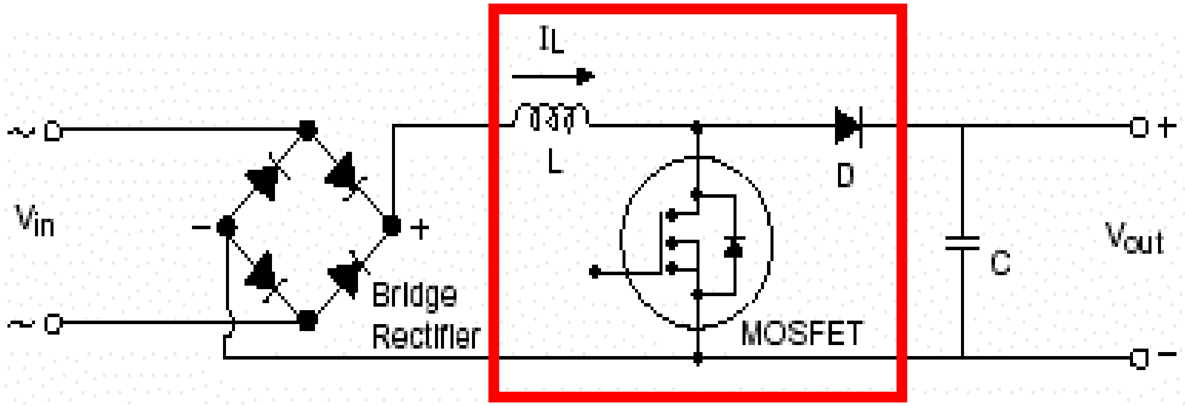
Lighting

Ballast

What is PFC

■Power Factor Correction (PFC) can be defined as the reduction of the harmonic content, and/or the aligning of the phase angle of incoming current

■ PFC is necessary to reduce disturbance on AC distribution net and to maximize the real power drawn by the power supply from the AC line.



Boost PFC circuit

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PFC basic concept

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■Preal (real power available) = Vrms * Irms*(maximum power)* PF

PF (power factor)= $Cos\varphi \;/ \sqrt{1+THD^2}$

where THD is the total harmonic distoration

and φ is the phase shift between the voltage and the current.

■Two causes of power factor degradation

-Phase shift: caused by reactive inductive load (motor) or highly capacitive load(electroluminescent lighting)

-Distortion : caused by rectification into a capacitive filter , leading current spikes not to follow the input voltage waveform.

AC line without PFC

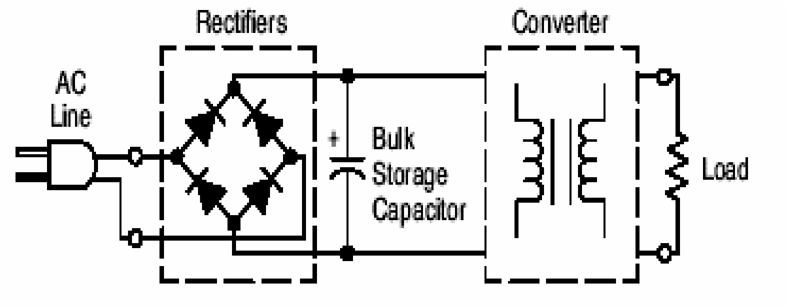
Most off-line appliances use a bridge rectifier associated to a huge bulk capacitor to derive raw dc voltage from the utility ac line.

PF<1 and Preal<<Pmax

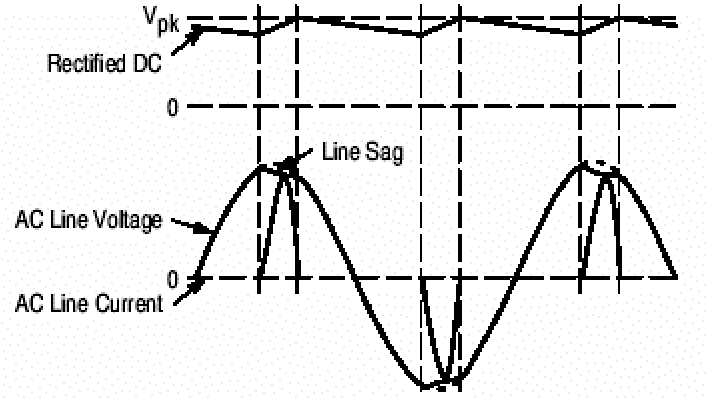
▪Disadvantages:
--results in a high harmonic content and in poor power factor ratios.

--results in a high charge current spike, excessive voltage drops in the wiring and imbalance problems in the three-phase power delivery utilized.

-a poor power factor (in the range of 0.5 - 0.7) means that only 50% to 60% of the maximum power is available.



Typical circuit without PFC



Line waveform without PFC

AC line with PFC

A boost converter placed after the bridge rectifier transforms a crest into a resistive load with a power factor equal 1 and a very low harmonic distortion.

PF ≅ 1 and Preal ≅ Pmax

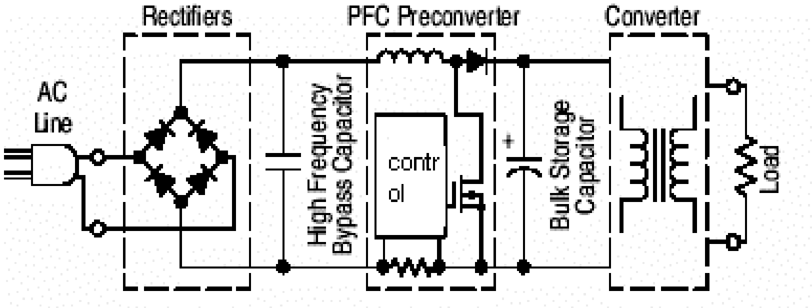
■Advantages:

– reduction of mains harmonic content

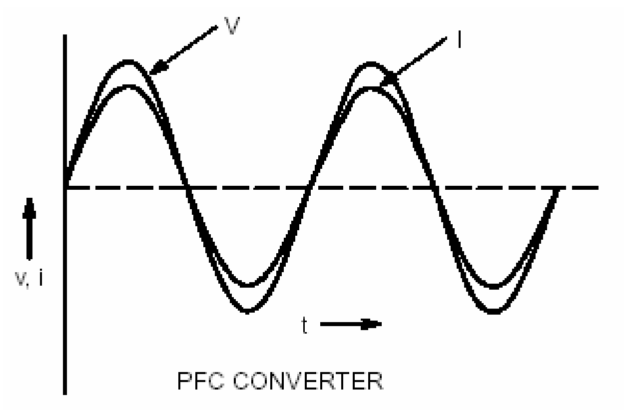
– reduction of peak current at mains frequency

– reduced Volt/Amp requested to the mains

– improvement of the output regulation of the downstream dc-dc converter



AC line with PFC



Line waveform with PFC

Other benefits of PFC

1.Comply with regulation

Regulation such as IEC1000-3-2/EN61000-3-2 in Europe; JICC61000-3-2 and CCC in China and "80plus policy" in America impose restrictions on power factor and total harmonic distortion(THD) of high-power application like off-line power supplies

2. Optimize and cost saving of circuit

– reduction of the electrolytic bulk capacitor used at PFC stage output

– reduced mains transformer size and weight

Other benefits of PFC

3. Meet the trend of energy saving and green energy and also save electricity bill

For example

■ If the total user with PF below 80% is about 1.3billion and each person consumes one killowatt-hour electricity per day, when PF improve from 80% to 95%, electricity loss can be reduced 0.25billion per day

■ If PF is improve from 70% to 90%, the electricity bill will be reduced by 20% per month

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Why Philips PFC diodes ?

<u>PFC diodes benefits</u>

- World's fastest reverse recovery enable a high PFC frequency (up to 200 kHz)
- Ultrafast switching to minimise turn-off switch losses
- Low forward recovery voltage to minimise turn-on switch losses
- Minimised Vf to keep conduction losses as low as possible
- Excellent soft recovery characteristics minimise power-consuming oscillations
- High maximum junction temperature makes product suitable for operating at high temperature

Why Philips lighting transistors ?

BUJ range of Bipolar Transistors

- Wide choice of current ratings and packages meets all self-oscillating ballast requirements
- Planar passivation technology offers stable voltage blocking at elevated temperature for longterm reliability and long life
- Transistor design optimised for the lowest power dissipation in lighting ballasts
- Very fast,smooth turn-off performance yields the lowest switching dissipation
- Very low Vcesat yields low On-state losses
- Very fast turn-off is maintained, even when base is driven hard to minimise On-state losses
- BUJ 100 in TO92 is suitable for all Compact Fluorescent Lamps and ballast up to 26W @ 230V AC
- Tightly-controlled gain makes selection and gain banding unnecessary
- Flat gain characteristic over a wide range of IC guarantees correct operation under all conditions

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Why Philips SOD87 diodes?

<u>SOD87</u>

- Better current/power capability than SMA-can be used in wide range of application with higher current/power than a standard 1A SMA (1.5 A SMA vs 1A)
- Smaller than SMA equivalents-aids miniaturisation of board space requirement, key to most SMD applications

<u>Features and benefits over plastic devices</u>

- Device hermetically sealed-no moisture ingress. Better than plastic equivalents
- good avalanche energy absorption-this benefit overcomes problems caused by noisy lines in various circuitry such as input rectification
- Glass package-reduced risk of diode thermal runaway, due to a higher maximum operating temperature of the device compared to plastic equivalents

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