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FM3 MB9B100A/300A/400A/500A Microcontroller Power Factor Correction

This document describes the principle and usage of PFC

1 Introduction

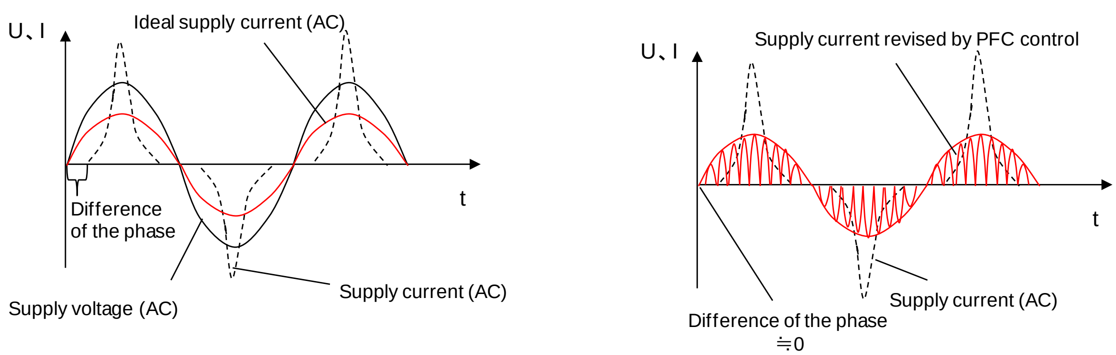
This document describes the principle and usage of PFC

2 Significance of power factor

Power Factor is a parameter that gives the amount of working power used by any system in terms of the total apparent power. Power Factor becomes an important measurable quantity because it often results in significant power savings.

Typical waveforms of current with and without PFC are shown in Figure 1 below.

Figure 1.WAVEFORM WITH/WITHOUT PFC



These waveforms illustrate that PFC can improve the input current drawn from the mains supply and reduce the DC bus voltage ripple.

The objective of PFC is to make the loading for a power supply look like a simple resistor. This allows the power distribution system to operate more efficiently, reducing energy consumption.

When Power Factor deviates from a constant, the input contains phase displacement, harmonic distortion or both, and either one degrades the Power Factor.

The remaining power that is lost as Reactive Power in the system is due to reasons:

- Phase shift of current with respect to voltage, resulting in displacement.
- Harmonic content present in current, resulting in distortion.

2.1 Harmonic introduce

Current harmonics are sinusoidal waves that are integral multiples of fundamental wave.

Source of current harmonics:

- Power Electronic Equipment
- Auxiliary Equipment
- Saturable Inductive Equipment

Problems created by current harmonics:

- Erroneous operation of control system
- Damage to sensitive electronic equipment
- Nuisance tripping of circuit breakers and blowing fuses
- Excessive overheating of capacitors, transformers, motors, lighting ballasts and other electrical equipment
- Interference with near electronic equipment

To reduce these problems, the current drawn from main supply needs to be shaped similar to that of voltage wave profile.

By making power converter appear as a linear resistance to the main supply voltage, the input current shape can be made to follow the input voltage wave.

3 Principle of PFC

In order to making power converter appear as a linear resistance despite having reactive passive elements like inductors, capacitors and active switching elements like MOSFETs and IGBTs, the answer lies in the fact that PFC is a low-frequency requirement. Therefore, the converter need not be resistive at all frequencies, provided a filtering mechanism exists to remove the high-frequency ripples.

The basic elements present in a converter are an inductor and a capacitor, which are zero order elements. This means that these elements cannot store energy in a single switching cycle due to their fundamental properties.

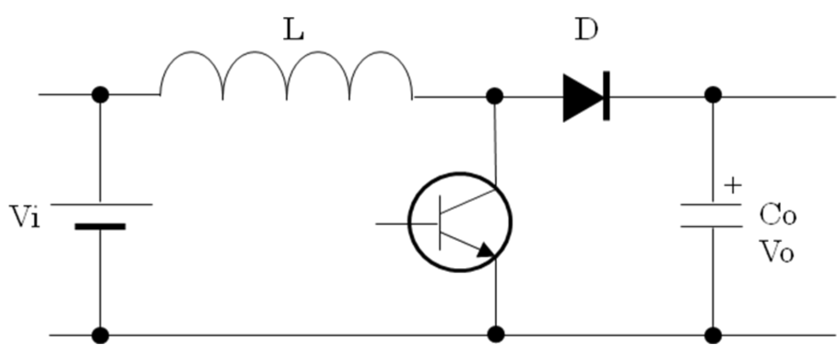
Active PFC must control both the input current and the output voltage. The current is shaped by the rectified live voltage so that the input to the converter appears to be resistive. The output voltage is controlled by changing the average amplitude of the current programming signal.

3.1 Power factor correction topologies

3.1.1 Boost PFC Circuit

The boost converter produces a voltage higher than the input rectified voltage, thereby giving a switch (MOSFET) voltage rating of Vout. Figure 2 shows the circuit for the boost PFC stage.

Figure 2. BOOST PFC

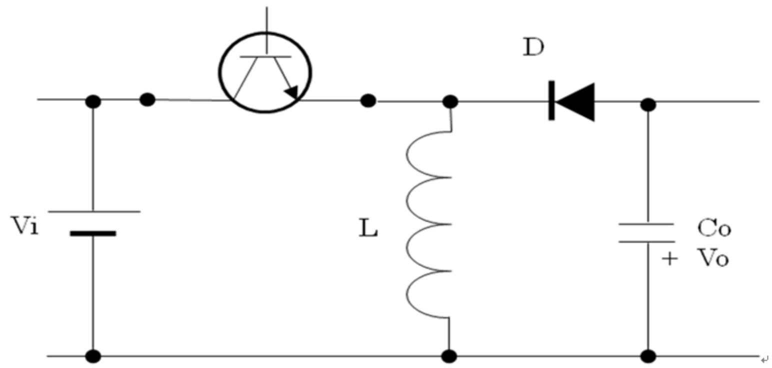


The switch on Figure 2 close and open at a fixed rate. But the duty is based on the value of input voltage and voltage on capacitor. When input voltage is higher than capacitor voltage, the duty is small. When input voltage is lower than capacitor voltage, the duty should be large enough for the inductor having a way to discharge.

3.2 Buck PFC Circuit

In a buck PFC circuit, the output DC voltage is less than the input rectified voltage. Large filters are needed to suppress switching ripples and this circuit produces considerable Power Factor improvement. The switch (MOSFET) is rated to Vin this case. Figure 3 shows the buck PFC input current shape.

Figure 3. BUCK/BOOST PFC CIRCUIT



4 PFC Implementation

4.1 Smart power module of PFC

FPAB30BH60 is an advanced smart power module of PFC that Fairchild has developed and designed mainly targeting mid-power application especially for an conditioners. It combines optimized circuit protection and drive IC matched to high frequency switching IGBTs. System reliability is further enhanced by the integrated under-voltage lock-out and over-current protection function

Figure 4.PIN CONFIGURATION

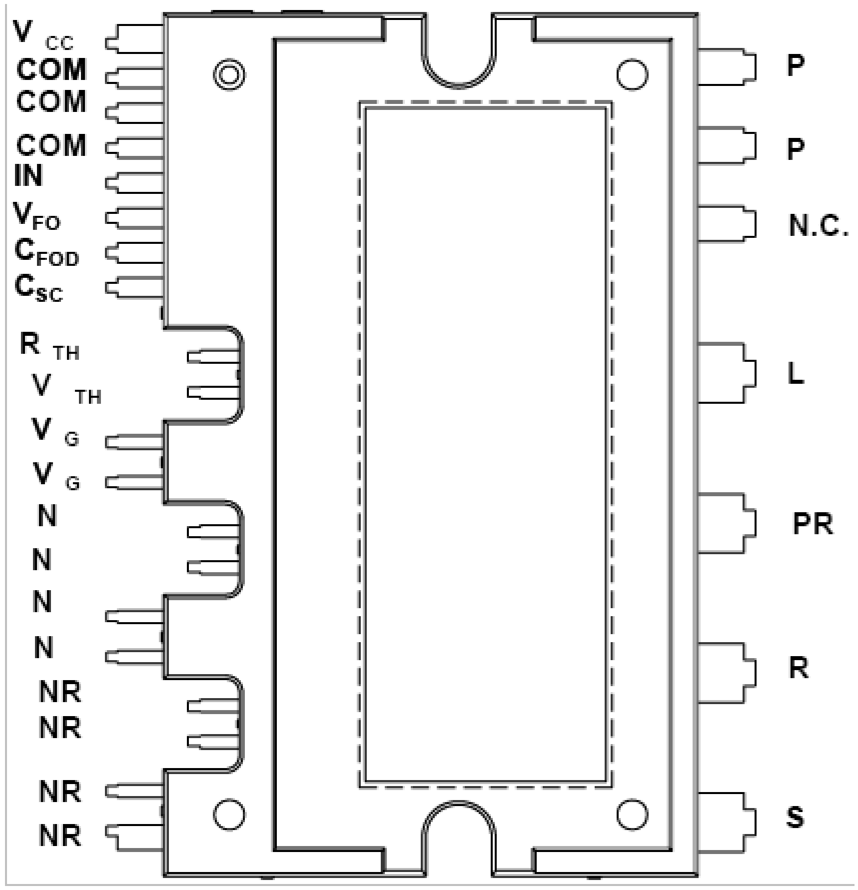
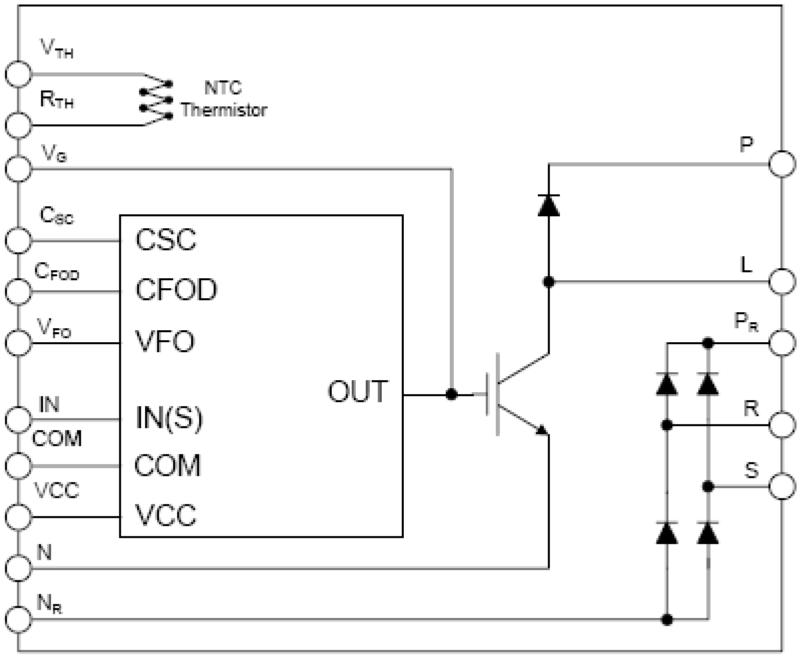


Figure 5.PIN DESCRIPTION

Pin Number	Pin Name	Pin Description
1	V_{CC}	Common Bias Voltage for IC and IGBTs Driving
2,3,4	COM	Common Supply Ground
5	$IN_{(R)}$	Signal Input for Low-side R-phase IGBT
6	V_{FO}	Fault Output
7	C_{FOD}	Capacitor for Fault Output Duration Time Selection
8	C_{SC}	Capacitor (Low-pass Filter) for Over Current Detection
9	$R_{(TH)}$	NTC Thermistor terminal
10	$V_{(TH)}$	NTC Thermistor terminal
11,12	Vg	IGBT gate dummy
13~16	N	IGBT emitter
17~20	N_R	Negative DC-Link of Rectifier
21,22	P	Positive Rail of DC–Link
23	N.C	No Connection
24	L	Reactor connection pin
25	P_R	Positive DC–Link of Rectifier
26	R	AC input for R-phase
27	S	AC input for S-phase

Figure 6. INTERNAL EQUIVALENT CIRCUIT AND INPUT/OUTPUT PINS



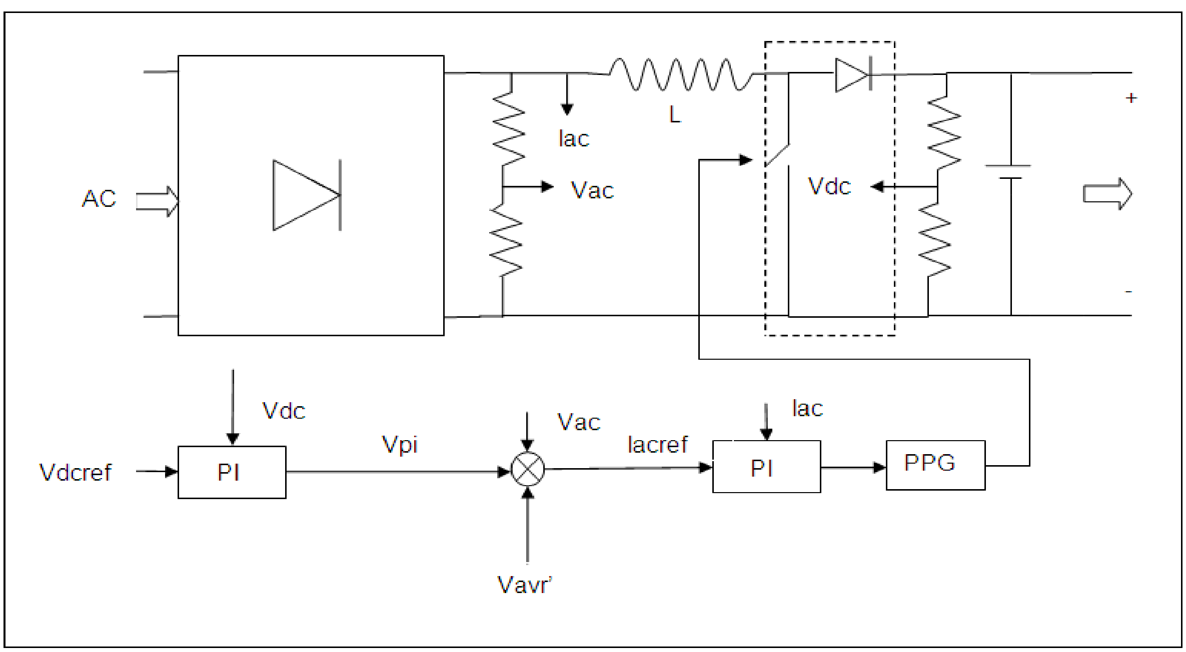
FPAB30BH60 datasheet: http://www.fairchildsemi.com/pf/FP/FPAB30BH60.html

4.2 PFC implementation

In this part, it mainly talk about the implementation in hardware and software.

4.2.1 Block Diagram for PFC Implementation

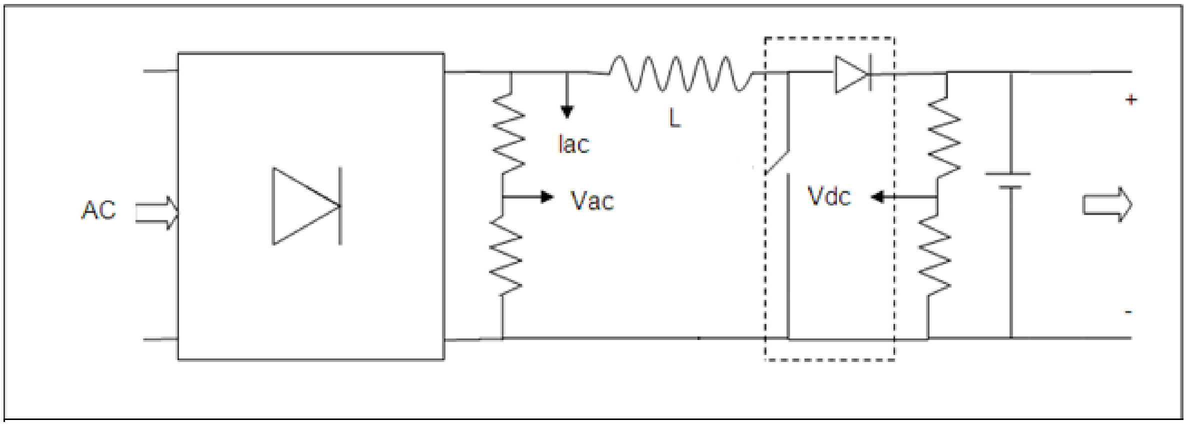
Figure 7. BLOCK DIAGRAM FOR PFC IMLEMENTATION



4.2.2 PFC hardware interface

PFC hardware interface is shown in Figure 8 below.

Figure 8. PFC HARDWARE INTERFACE

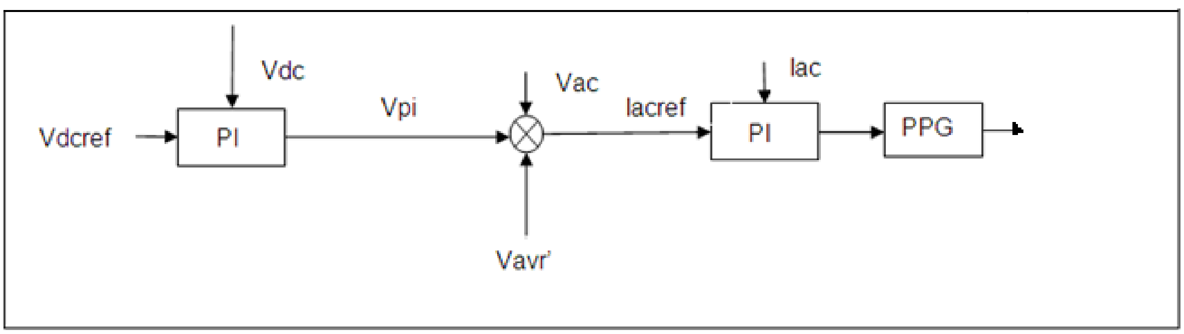


The dotted line frame in Figure 8 is integrated into FPAB30BH60.

4.2.3 PFC software arithmetic

Software block is shown below in Figure 9.

Figure 9. PFC SOFTWARE BLOCK



Vavr' : Vavr(the average value of Vac)multiply 1/(Vavr*Vavr).

Output of PPG is to control the duty of IGBT integrated in FPAB30BH60.

4.2.4 PFC software arithmetic implementation

This part mainly mentions functions.

Function name:	
	Int_PFC
description:	
	Initialize PFC
input:	
	none
output:	
	none
Function name:	
	PFC_start
description:	
	start PFC
input:	
	none
output:	
	none
Function name:	
	PFC_stop
description:	
	stop PFC
input:	
	none
output:	
	none

5 Document History

Document Title: AN204344 - FM3 MB9B100A/300A/400A/500A Microcontroller Power Factor Correction

Document Number: 002-04344

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	–	YUIS	06/17/2011	Initial Release.
*A	5031203	YUIS	11/30/2015	Migrated Spansion Application Note AN706-00033-1v0-E to Cypress format.

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