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Renesas Technology Corp.
Customer Support Dept.
April 1, 2003

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HA16141P/FP, HA16142P/FP

PFC and PWM Controller



ADE-204-036D (Z)

Preliminary
Rev.4
Sep. 2001

Description

The HA16141P/FP and the HA16142P/FP are power supply controller ICs combining an AC-DC converter switching controllers for power factor correction and off-line power supply switching controllers. PFC (Power factor correction) section employs average current mode PWM and off-line power supply control section employs peak current mode PWM.

The HA16142P/FP is the change version of HA16141P/FP's PWM maximum on duty cycle.

The PFC operation can be turned on and off by external control signal. Use of this on/off function makes it possible to disable PFC operation at a low line voltage, or to perform remote control operation from the transformer secondary side. The PFC power supply boosted output voltage is not only fed to an error amplifier input signal but also fed to as the boost voltage monitor circuit. \overline{PG} signal is put out if the boost voltage is out-of-spec.

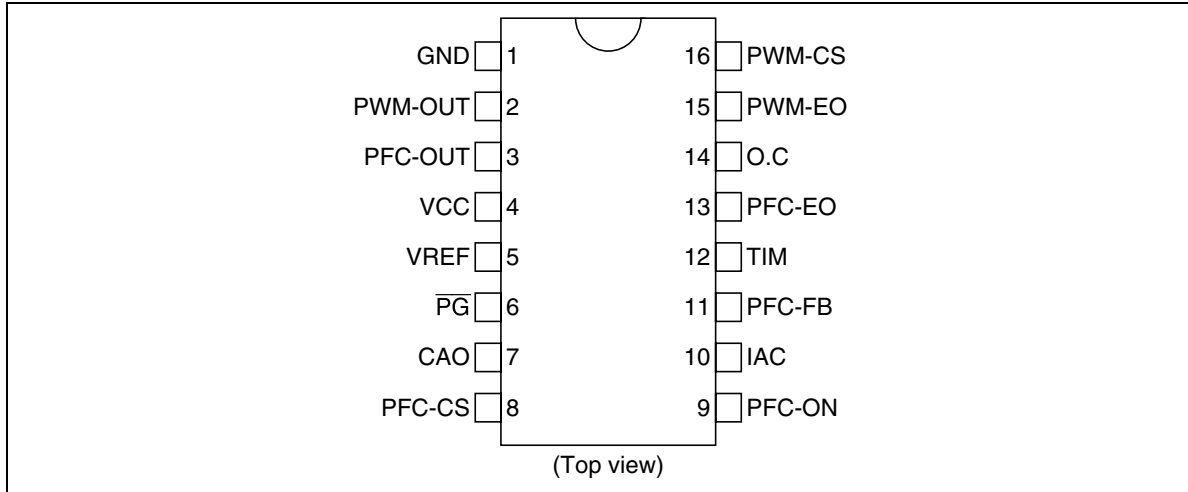
The PWM controller, which begins operation at the same time as release of the IC's UVLO (under-voltage lockout) is suitable for auxiliary power supply use in a multi-output power supply system.

Features

- Synchronized PFC and PWM timing
- Self oscillation with fixed frequency
 - PFC : 100 kHz ($\pm 15\%$)
 - PWM : 200 kHz ($\pm 15\%$)
- PFC function on/off control
- PFC boosted output voltage monitor
- High-output current gate drivers
 - PFC driver peak current : ± 1.5 A typ.
 - PWM driver peak current : ± 1.0 A typ.
- PWM maximum on duty cycle
 - 72% min (HA16141P/FP)
 - 49.5% max (HA16142P/FP)

HA16141P/FP, HA16142P/FP

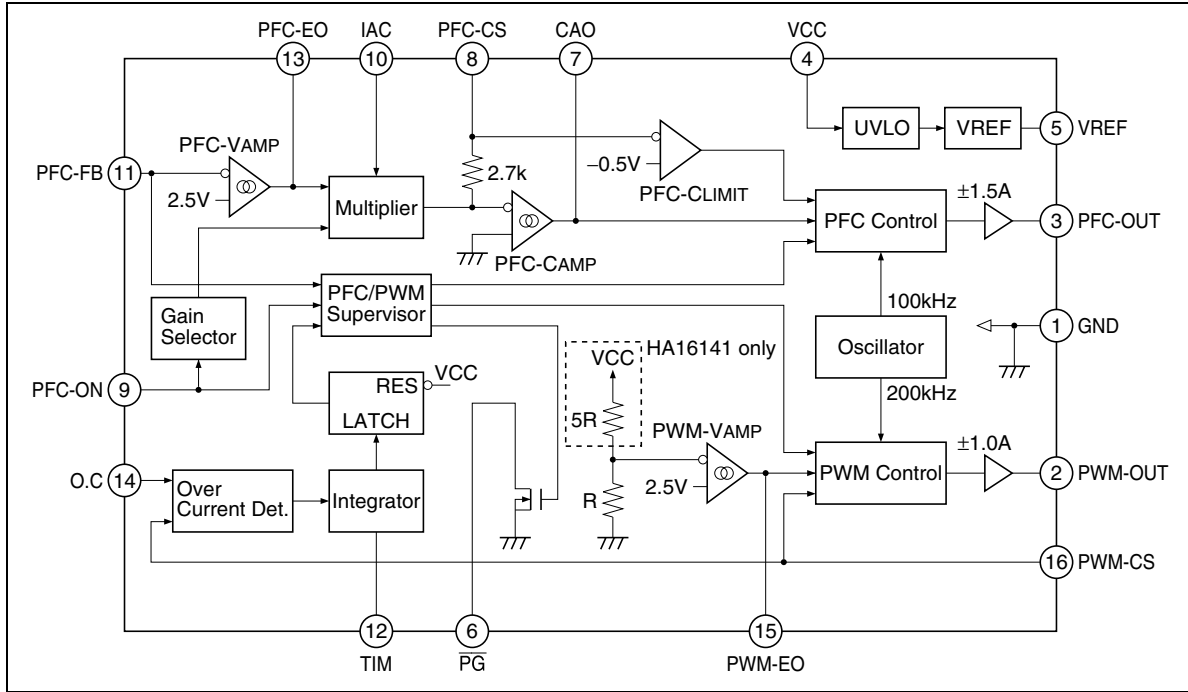
Pin Arrangement



Pin Description

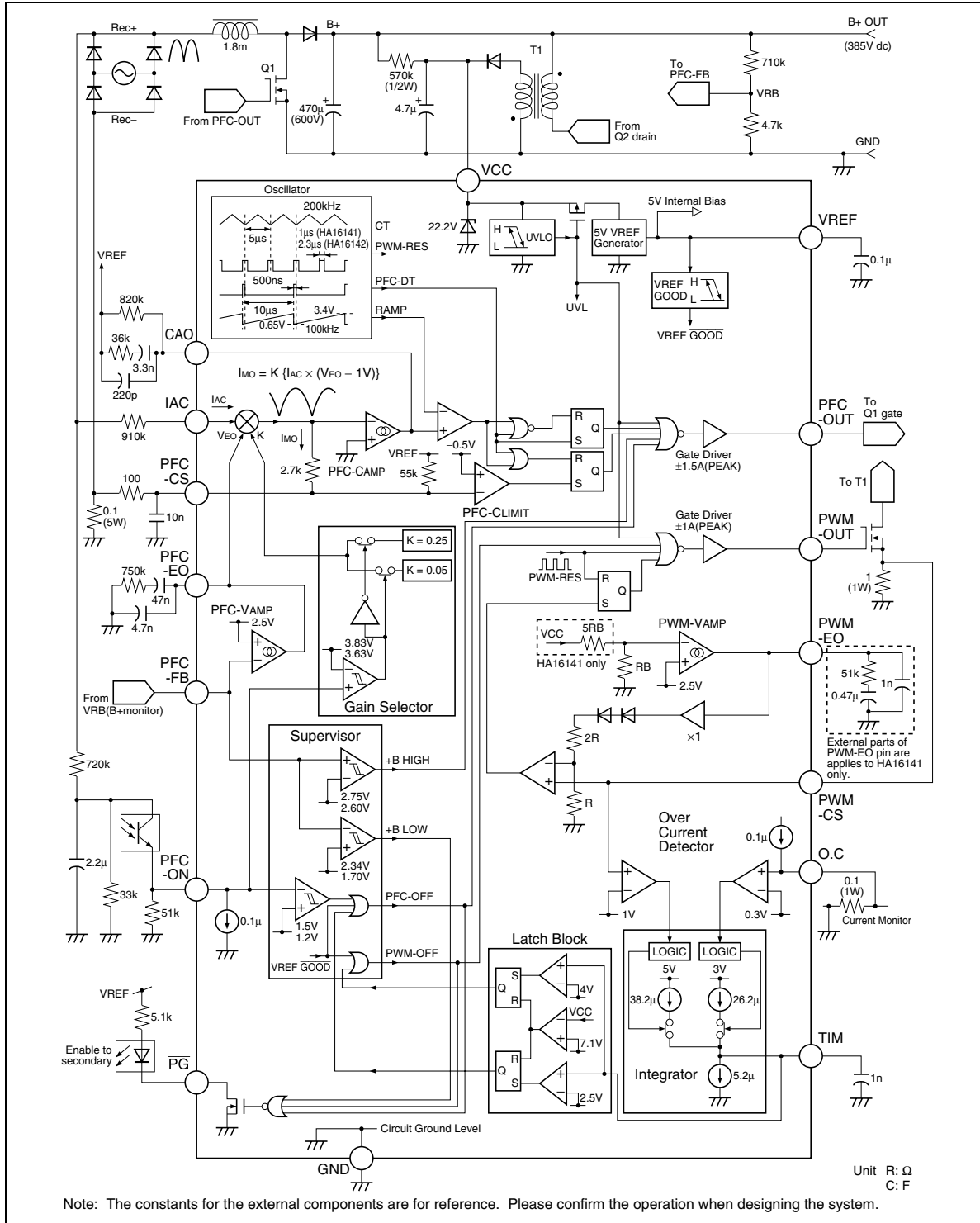
Pin No.	Symbol	Function
1	GND	Ground
2	PWM-OUT	Power MOS FET driver output (PWM control)
3	PFC-OUT	Power MOS FET driver output (PFC control)
4	VCC	Supply voltage
5	VREF	Reference voltage
6	$\overline{\text{PG}}$	Power Good signal output (open-drain output)
7	CAO	Average current control error amp. output
8	PFC-CS	PFC control current sense signal input
9	PFC-ON	PFC function on/off signal input
10	IAC	Multiplier reference current input
11	PFC-FB	PFC control error amp. input
12	TIM	Overcurrent timer time setting
13	PFC-EO	PFC control error amp. output
14	O.C	Overcurrent detector signal input
15	PWM-EO	PWM control error amp. output (photocoupler input also possible) (HA16141 only) PWM control feedback voltage signal input (HA16142 only)
16	PWM-CS	PWM control current sense signal input

Block Diagram



HA16141P/FP, HA16142P/FP

System Diagram

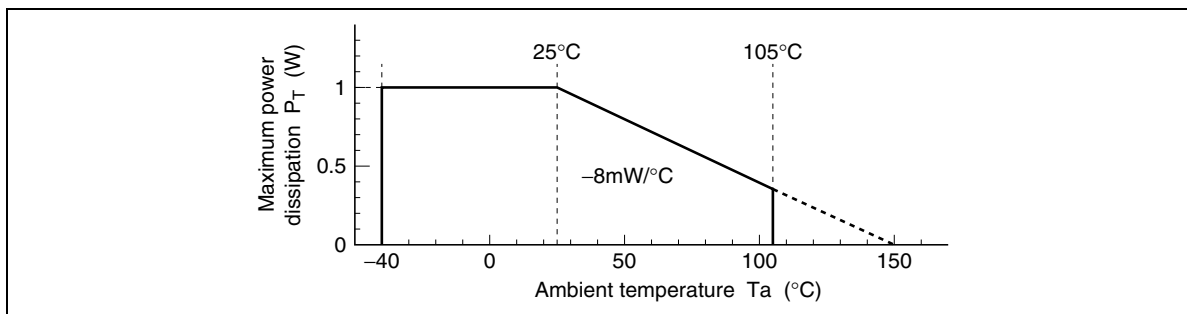


Absolute Maximum Ratings

(Ta = 25°C)

Item	Symbol	Rating	Unit	Note
Supply voltage	V _{cc}	20	V	
Peak PFC-OUT current	I _{pk-pfc}	±1.5	A	3
Peak PWM-OUT current	I _{pk-pwm}	±1.0	A	3
DC PFC-OUT current	I _{dc-pfc}	±0.15	A	
DC PWM-OUT current	I _{dc-pwm}	±0.10	A	
Terminal voltage	Vi-group1	-0.3 to V _{cc}	V	4
	Vi-group2	-0.3 to V _{ref}	V	5
CAO voltage	V _{cao}	-0.3 to V _{eah-ca}	V	
PFC-EO voltage	V _{pfc-eo}	-0.3 to V _{eah-pfc}	V	
PWM-EO voltage	V _{pwm-eo}	-0.3 to V _{eah-pwm}	V	
PFC-ON voltage	V _{pfc-on}	-0.3 to +7	V	
IAC voltage	V _{i-ac}	-0.3 to +5	V	
IAC current	I _{i-ac}	0.8	mA	
PFC-CS voltage	V _{i-cs}	-1.5 to +0.3	V	
TIM voltage	V _{i-tim}	-0.3 to +6	V	
VREF current	I _{o-ref}	-20	mA	
PG voltage	V _{o-pg}	-0.3 to +7	V	
PG current	I _{o-pg}	15	mA	
Power dissipation	P _T	1	W	6
Operating temperature	T _{opr}	-40 to +105	°C	
Storage temperature	T _{stg}	-55 to +150	°C	
Junction temperature	T _j	150	°C	

- Notes:
1. Rated voltages are with reference to the GND pin.
 2. For rated currents, inflow to the IC is indicated by (+), and outflow by (-).
 3. Shows the transient current when driving a capacitive load.
 4. Group1 is the rated voltage for the following pins: PFC-OUT, PWM-OUT
 5. Group2 is the rated voltage for the following pins: VREF, PFC-FB, PWM-CS
 6. This is the value when the ambient temperature (Ta) is 25°C or below. If Ta exceeds 25°C, the graph below applies. For the SOP package, this value is based on actual measurements on a 10% wiring density glass epoxy circuit board (40 mm × 40 mm × 1.6 mm).



HA16141P/FP, HA16142P/FP

Electrical Characteristics

(T_a = 25°C, V_{CC} = 14 V)

Item	Symbol	Min	Typ	Max	Unit	Test Conditions	
Supply	Start threshold	V _H	12.2	13.0	13.8	V	
	Shutdown threshold	V _L	9.4	10.0	10.6	V	
	UVLO hysteresis	dV _{UVL}	2.6	3.0	3.4	V	
	Start-up current	I _S	150	200	300	μA	V _{CC} = 12V
	Is temperature stability	dI _S /dT _a	—	-0.3	—	%/°C	*1
	Operating current	I _{CC}	4	7	9	mA	I _{AC} = 100μA, C _L = 0F
	Latch current	I _{LATCH}	230	310	375	μA	V _{CC} = 9V
	Shunt zener voltage	V _Z	21.2	22.2	23.2	V	I _{CC} = 14mA
	Vz temperature stability	dV _Z /dT _a	—	+4	—	mV/°C	I _{CC} = 14mA *1
	PFC-OUT	Minimum duty cycle	D _{min-pfc}	—	—	0	%
Maximum duty cycle		D _{max-pfc}	90	95	98	%	CAO = 0V
Rise time		t _{r-pfc}	—	30	100	ns	C _L = 1000p
Fall time		t _{f-pfc}	—	30	100	ns	C _L = 1000p
Peak current		I _{pk-pfc}	—	1.5	—	A	C _L = 0.01μF *1
Low voltage		Vol1-pfc	—	0.05	0.2	V	I _{out} = 20mA
		Vol2-pfc	—	0.35	1.4	V	I _{out} = 200mA
		Vol3-pfc	—	0.03	0.7	V	I _{out} = 10mA, V _{CC} = 5V
High voltage	Voh1-pfc	13.5	13.9	—	V	I _{out} = -20mA	
	Voh2-pfc	12.6	13.3	—	V	I _{out} = -200mA	
PWM-OUT	Minimum duty cycle	D _{min-pwm}	—	—	0	%	PWM-EO = 1.3V PWM-CS = 0V
	Maximum duty cycle	D _{max-pwm}	72	80	88	%	PWM-EO = 5V PWM-CS = 0V *2
			42.5	46	49.5	%	PWM-EO = 5V PWM-CS = 0V *3
	Rise time	t _{r-pwm}	—	30	100	ns	C _L = 1000p
	Fall time	t _{f-pwm}	—	30	100	ns	C _L = 1000p
	Peak current	I _{pk-pwm}	—	1.0	—	A	C _L = 0.01μF *1
	Low voltage	Vol1-pwm	—	0.05	0.2	V	I _{out} = 20mA
		Vol2-pwm	—	0.5	2.0	V	I _{out} = 200mA
		Vol3-pwm	—	0.03	0.7	V	I _{out} = 10mA, V _{CC} = 5V
	High voltage	Voh1-pwm	13.5	13.9	—	V	I _{out} = -20mA
Voh2-pwm		12.0	13.0	—	V	I _{out} = -200mA	
VREF	Output voltage	V _{ref}	4.9	5.0	5.1	V	I _{source} = 1mA
	Line regulation	V _{ref-line}	—	5	20	mV	I _{source} = 1mA V _{CC} = 12V to 18V
	Load regulation	V _{ref-load}	—	5	20	mV	I _{source} = 1mA to 20mA
	Temperature stability	dV _{ref}	—	80	—	ppm/°C	T _a = -40 to 105°C *1

- Note: 1. Design spec.
2. Apply to HA16141.
3. Apply to HA16142.

HA16141P/FP, HA16142P/FP

Electrical Characteristics (cont.)

(T_a = 25°C, V_{cc} = 14 V)

Item	Symbol	Min	Typ	Max	Unit	Test Conditions	
Oscillator	Initial accuracy	fpwm	170	200	230	kHz	Measured pin: PWM-OUT
		fpfc	85	100	115	kHz	Measured pin: PFC-OUT
	fpwm temperature stability	dfpwm/dTa	—	±0.1	—	%/°C	T _a = -40 to 105°C *1
	fpwm voltage stability	fpwm(line)	-1.5	+0.5	+1.5	%	V _{cc} = 12V to 18V
	Ramp peak voltage	Vramp-H	—	3.4	3.6	V	
	Ramp valley voltage	Vramp-L	—	0.65	—	V	*1
PFC-ON	PFC on voltage	Von-pfc	1.3	1.5	1.7	V	
	PFC off voltage	Voff-pfc	1.0	1.2	1.4	V	
	PFC on-off hysteresis	dVon-off	0.15	0.30	0.45	V	
	Input current	lpfc-on	—	0.1	1.0	μA	PFC-ON = 2V
Supervisor/ PG	PFC GOOD threshold voltage	Vb-good	2.29	2.34	2.39	V	Input pin: PFC-FB
	PFC FAIL threshold voltage	Vb-fail	1.66	1.70	1.74	V	Input pin: PFC-FB
	+B High PFC inhibit voltage	Vb-h	2.69	2.75	2.81	V	Input pin: PFC-FB
	+B High PFC restart voltage	Vb-res	2.54	2.60	2.66	V	Input pin: PFC-FB
	PG leak current	loff-pg	—	0.001	1.0	μA	PG = 5V
	PG shunt current	lon-pg	5	15	—	mA	PG = 3V *2
	Delay to PG	tg-pg	—	0.2	1	μs	Step signal (5 to 0V) to PFC-ON
O.C (Over Current Detector)	O.C threshold voltage	V _{oc}	0.27	0.30	0.33	V	
	PWM-CS threshold voltage	V _{cs}	0.9	1.0	1.1	V	
	O.C input current	I _{oc}	—	-0.1	-1.0	μA	O.C = 0V
Integrator	Sink current	Isnk-tim	3.9	5.2	6.5	μA	TIM = 2V
	Source current O.C trigger	Isrc-tim1	-16	-21	-26	μA	TIM = 2V, O.C = 0.5V *1
	Source Current PWM-CS trigger	Isrc-tim2	-25	-33	-41	μA	TIM = 2V, PWM-CS = 2V *1
	Integrated time O.C trigger	t-tim1	88	110	132	μs	Step signal (0 to 1V) to O.C, C _{tim} = 1000p, Measured pin: PG
	Integrated Time PWM-CS trigger	t-tim2	53	67	81	μs	Step signal (0 to 2V) to PWM-CS, C _{tim} = 1000p, Measured pin: PG

Notes: 1. Design spec.

2. Maximum rating of PG current is 15 mA. Use series resistor to limit PG current lower than 15 mA.

HA16141P/FP, HA16142P/FP

Electrical Characteristics (cont.)

(T_a = 25°C, V_{cc} = 14 V)

Item		Symbol	Min	Typ	Max	Unit	Test Conditions
Latch	Threshold voltage for PFC stop	Vlch-pfc	2.4	2.5	2.6	V	Input pin: TIM
	Threshold Voltage for PWM stop	Vlch-sys	3.8	4.0	4.2	V	Input pin: TIM
	Latch Reset Voltage	Vcc-res	6.1	7.1	8.1	V	
PWM-VAMP	Feedback V _{cc} voltage	Vfb-pwm	14.2	14.8	15.4	V	PWM-EO = 2.5V *2
	Open loop gain	Av-pwm	—	45	—	dB	*1, *2
	High voltage	Veoh-pwm	5.1	5.7	6.3	V	V _{cc} = 14V, PWM-EO: Open
	Low voltage	Veol-pwm	—	0.1	0.3	V	V _{cc} = 16V, PWM-EO: Open *2
	Source current	Isrc-pwm	—	-77	—	μA	*1 V _{cc} = 11V
	Sink current	Isnk-pwm	—	77	—	μA	*1 V _{cc} = 18V *2
	Transconductance respect to V _{cc}	Gm-pwm	19	27	35	μA/V	V _{cc} = 15V, PWM-EO = 2.5V *2
PWM current sense	Delay to output	td-cs	—	210	300	ns	PWM-EO = 5V, PWM-CS = 0 to 2V
PFC current limit	Threshold voltage	V _{LM}	-0.47	-0.50	-0.53	V	
	Delay to output	td-LM	—	280	500	ns	PFC-CS = 0 to -1V
PFC-VAMP	Feedback voltage	Vfb-pfc	2.45	2.50	2.55	V	PFC-EO = 2.5V
	Input bias current	I _{fb} -pfc	-0.30	-0.07	+0.30	μA	Measured pin: PFC-FB
	Open loop gain	Av-pfc	—	65	—	dB	*1
	High voltage	Veoh-pfc	5.1	5.7	6.3	V	PFC-FB = 2.3V, PFC-EO: Open
	Low voltage	Veol-pfc	—	0.1	0.3	V	PFC-FB = 2.7V, PFC-EO: Open
	Source current	Isrc-pfc	-62	-77	-93	μA	PFC-FB = 1.0V, PFC-EO = 2.5V
	Sink current	Isnk-pfc	62	77	93	μA	PFC-FB = 4.0V, PFC-EO = 2.5V
	Transconductance	Gm-pfcv	120	160	200	μA/V	PFC-FB = 2.5V, PFC-EO = 2.5V

Note: 1. Design spec.
2. Apply to HA16141.

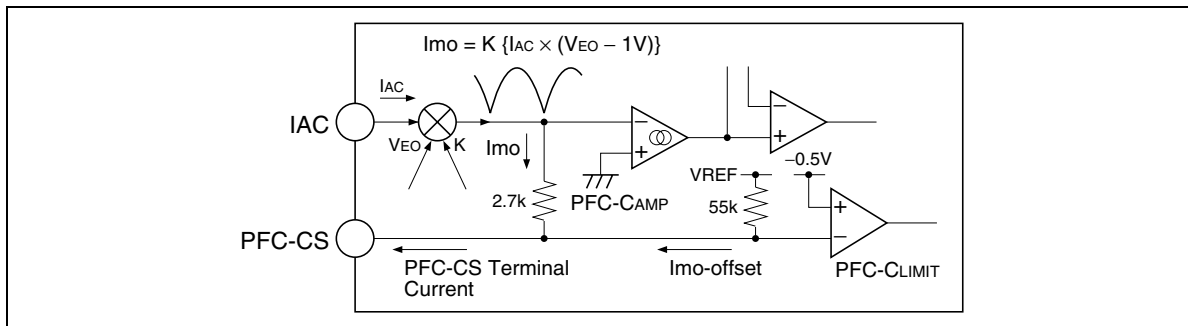
HA16141P/FP, HA16142P/FP

Electrical Characteristics (cont.)

($T_a = 25^\circ\text{C}$, $V_{cc} = 14\text{ V}$)

Item	Symbol	Min	Typ	Max	Unit	Test Conditions	
PFC-CAMP	Input offset voltage	V_{io-ca}	—	± 7	mV	* ¹	
	Open loop gain	A_{v-ca}	—	65	dB	* ¹	
	High voltage	V_{eoh-ca}	5.1	5.7	6.3	V	
	Low voltage	V_{eol-ca}	—	0.1	0.3	V	
	Source current	I_{src-ca}	—	-77	—	μA	CAO = 2.5V * ¹
	Sink current	I_{snk-ca}	—	77	—	μA	CAO = 2.5V * ¹
	Transconductance	G_{m-pfcc}	120	160	200	$\mu\text{A/V}$	* ¹
IAC/ Multiplier	IAC PIN voltage	V_{iac}	0.7	1.0	1.3	V	IAC = 100 μA
	Terminal offset current	$I_{mo-offset}$	-56	-75	-94	μA	IAC = 0A, PFC-CS = 0V, Measured pin: PFC-CS
	Output current (PFC-ON = 3.4V)	I_{mo1}	—	-25	—	μA	PFC-EO = 2V, IAC = 100 μA * ^{1, *2}
		I_{mo2}	—	-75	—	μA	PFC-EO = 4V, IAC = 100 μA * ^{1, *2}
	Output current (PFC-ON = 3.9V)	I_{mo3}	—	-5	—	μA	PFC-EO = 2V, IAC = 100 μA * ^{1, *2}
		I_{mo4}	—	-15	—	μA	PFC-EO = 4V, IAC = 100 μA * ^{1, *2}
	PFC-CS resistance	R_{mo}	—	2.7	—	k Ω	* ¹
Gain selector	Threshold voltage for K = 0.05	V_{K-H}	3.71	3.83	3.95	V	
	Threshold voltage for K = 0.25	V_{K-L}	3.51	3.63	3.75	V	
	V_K hysteresis voltage	dV_K	0.15	0.20	0.25	V	* ¹

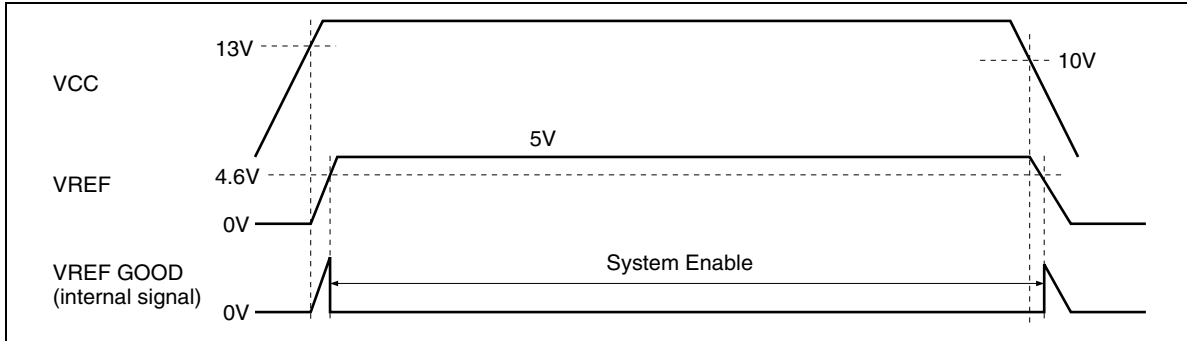
- Notes: 1. Design spec.
2. I_{mo1} to I_{mo4} are defined as,
 $I_{mo} = (\text{PFC-CS Terminal Current}) - (I_{mo-offset})$



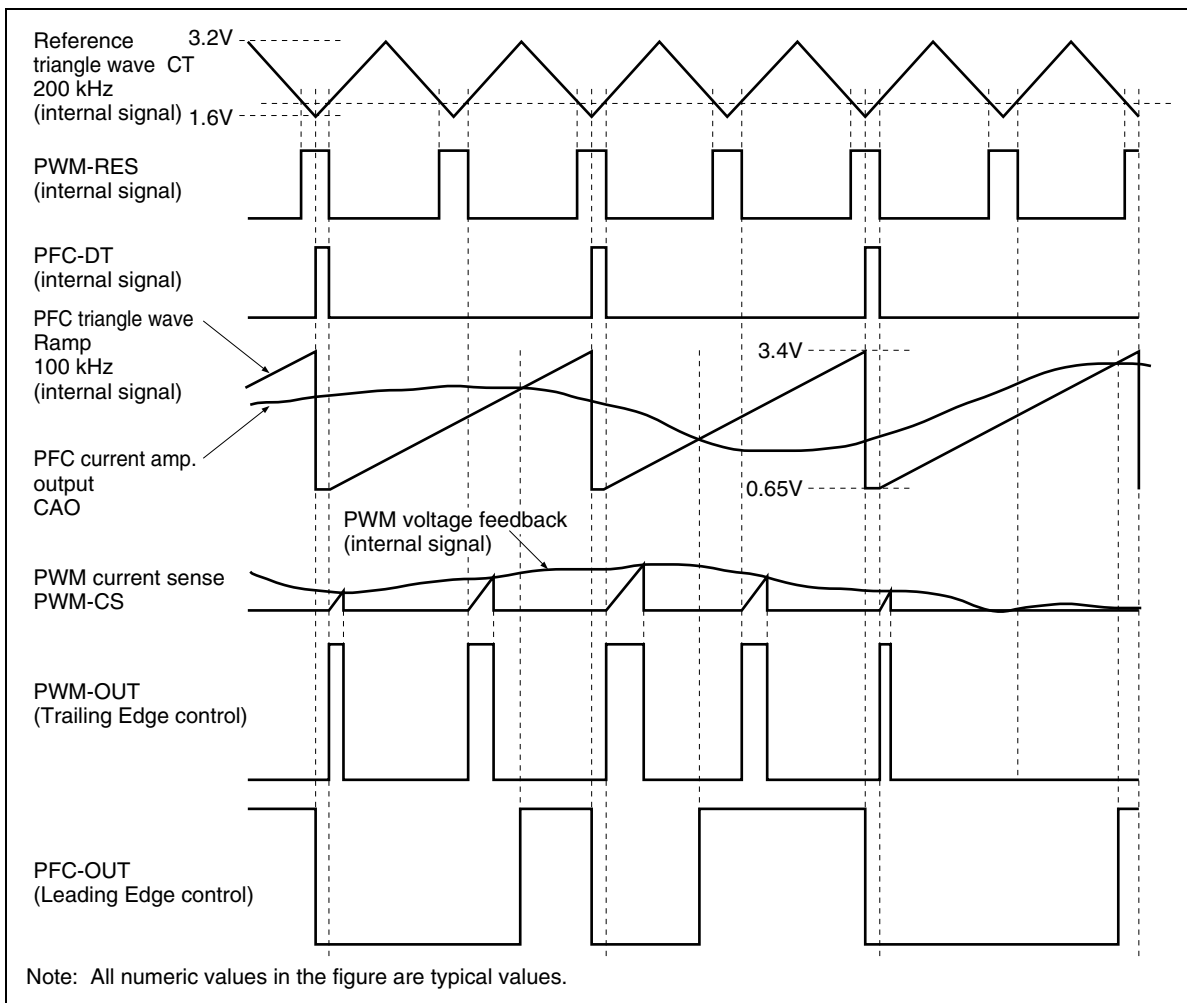
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Internal Timing

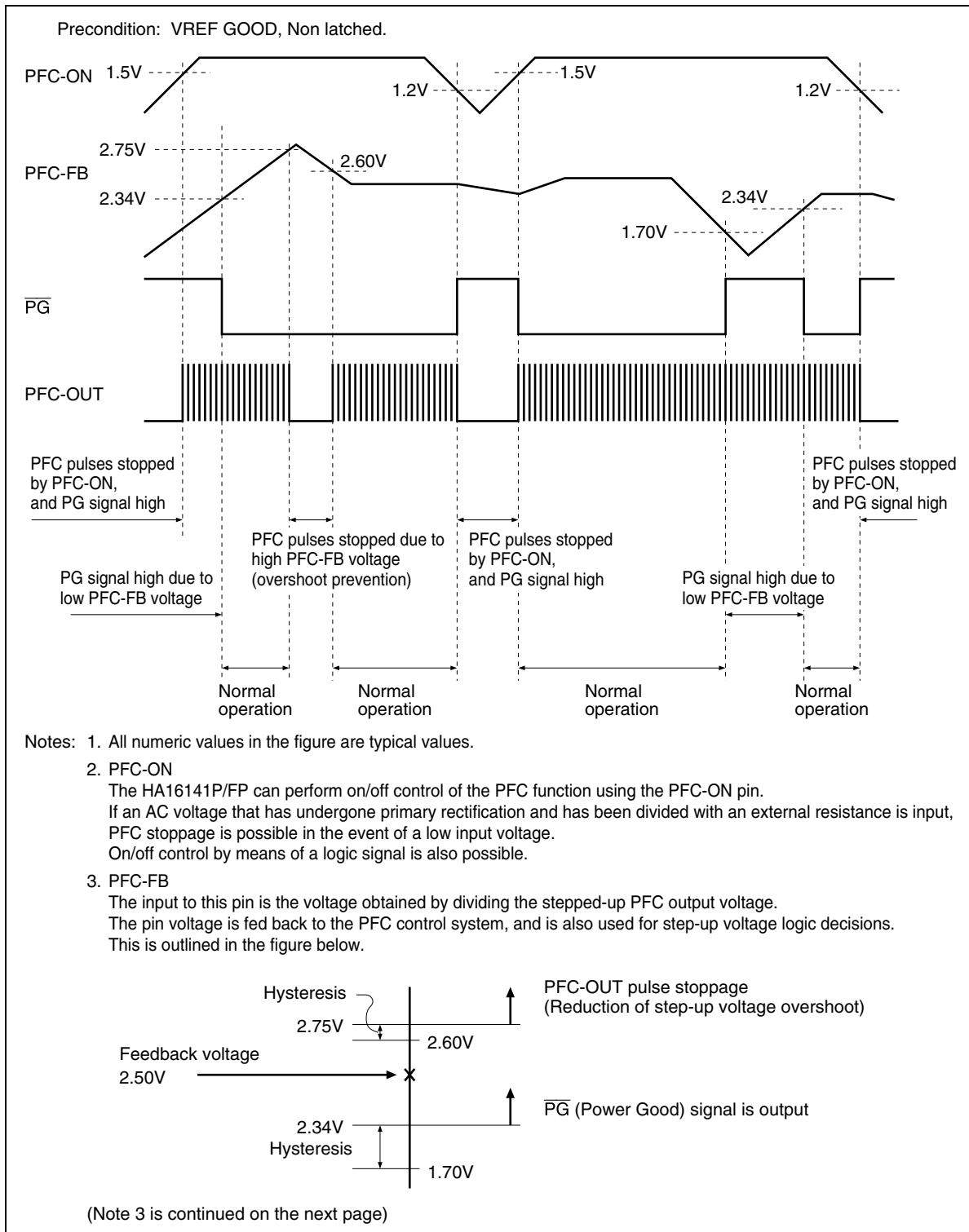
1. UVLO



2. Oscillator, Gate driver output



3. PFC controller status



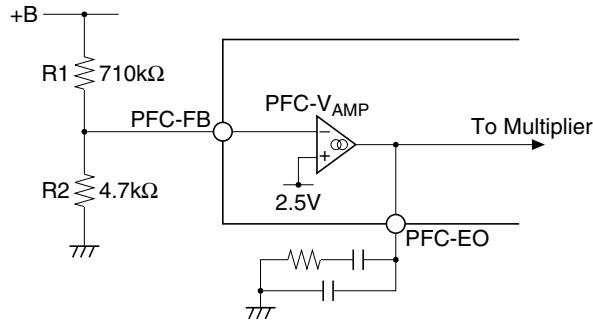
HA16141P/FP, HA16142P/FP

3. PFC controller status (cont.)

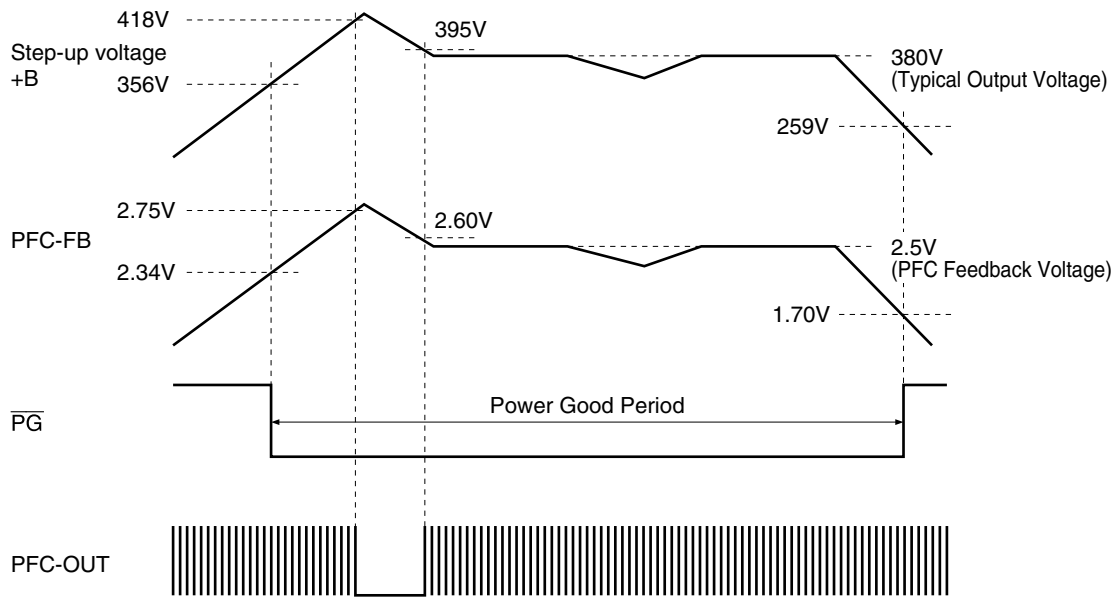
Notes: 3. PFC-FB (cont.)

The actual input voltage to the PFC-FB pin is the step-up voltage divided with a resistance (see figure below).

If R1 is set as 710 kΩ and R2 as 4.7 kΩ, the decision voltage at the step-up pin (+B) is as shown in the figure below.



Precondition: VREF GOOD, PFC-ON, Non latched.

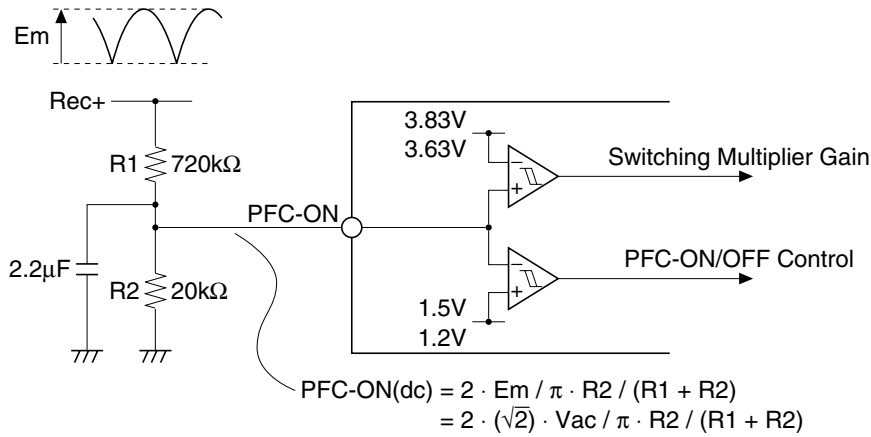


Notes: 4. All numeric values in the figure are typical values.

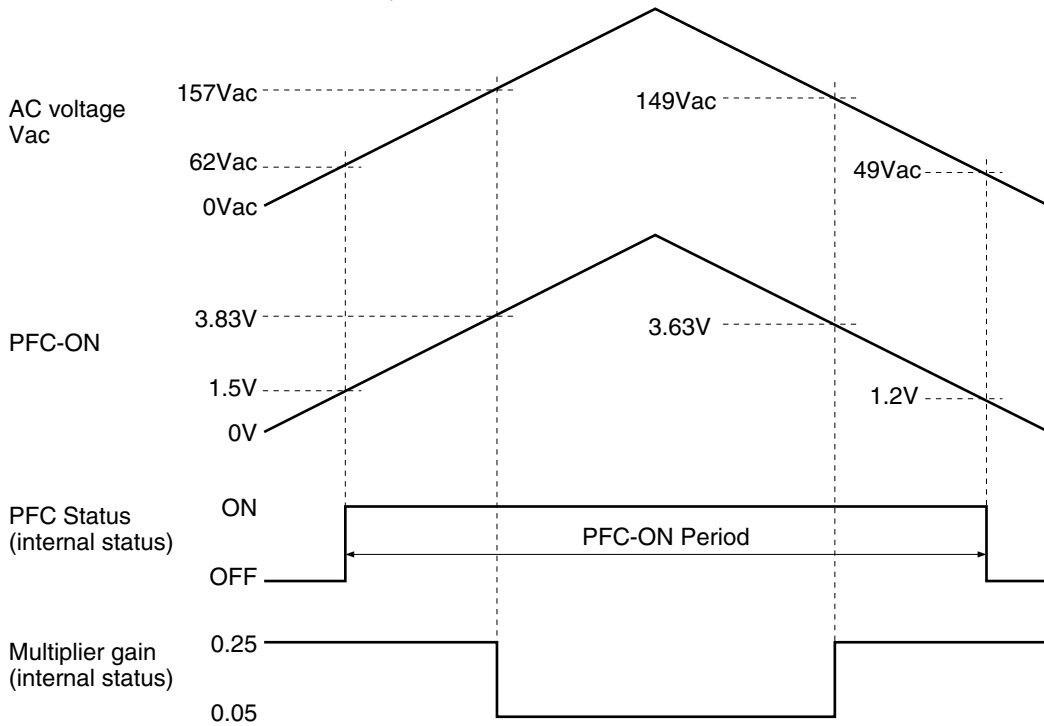
4. PFC-ON pin

The following functions are effected by inputting an AC voltage that has undergone primary rectification and has been divided with an external resistance to the PFC-ON pin (see figure below).

- a) Turning PFC operation off when AC voltage is low
- b) Switching multiplier gain with AC 100 V system and 200 V system input



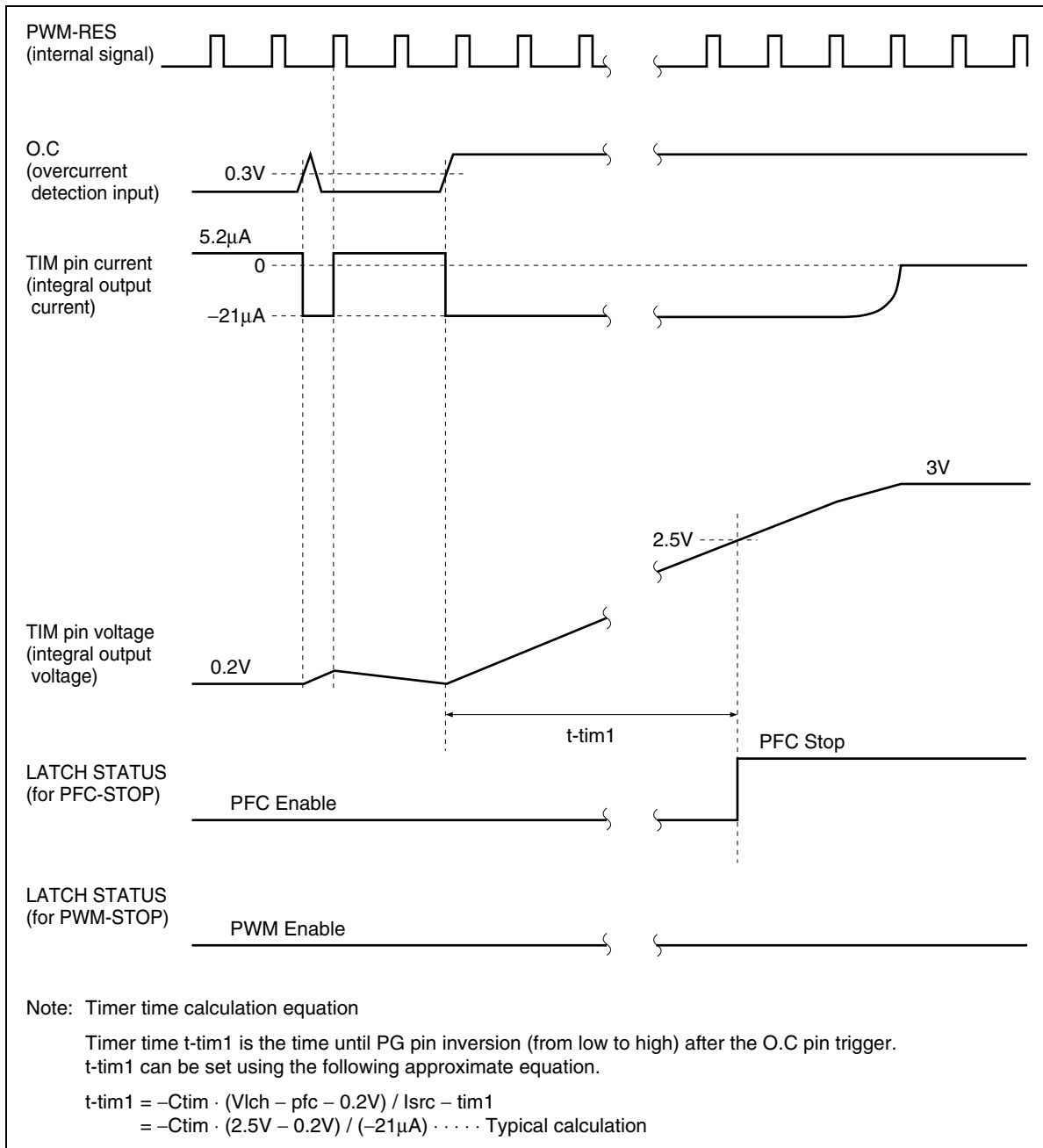
Precondition: VREF GOOD, Non latched.



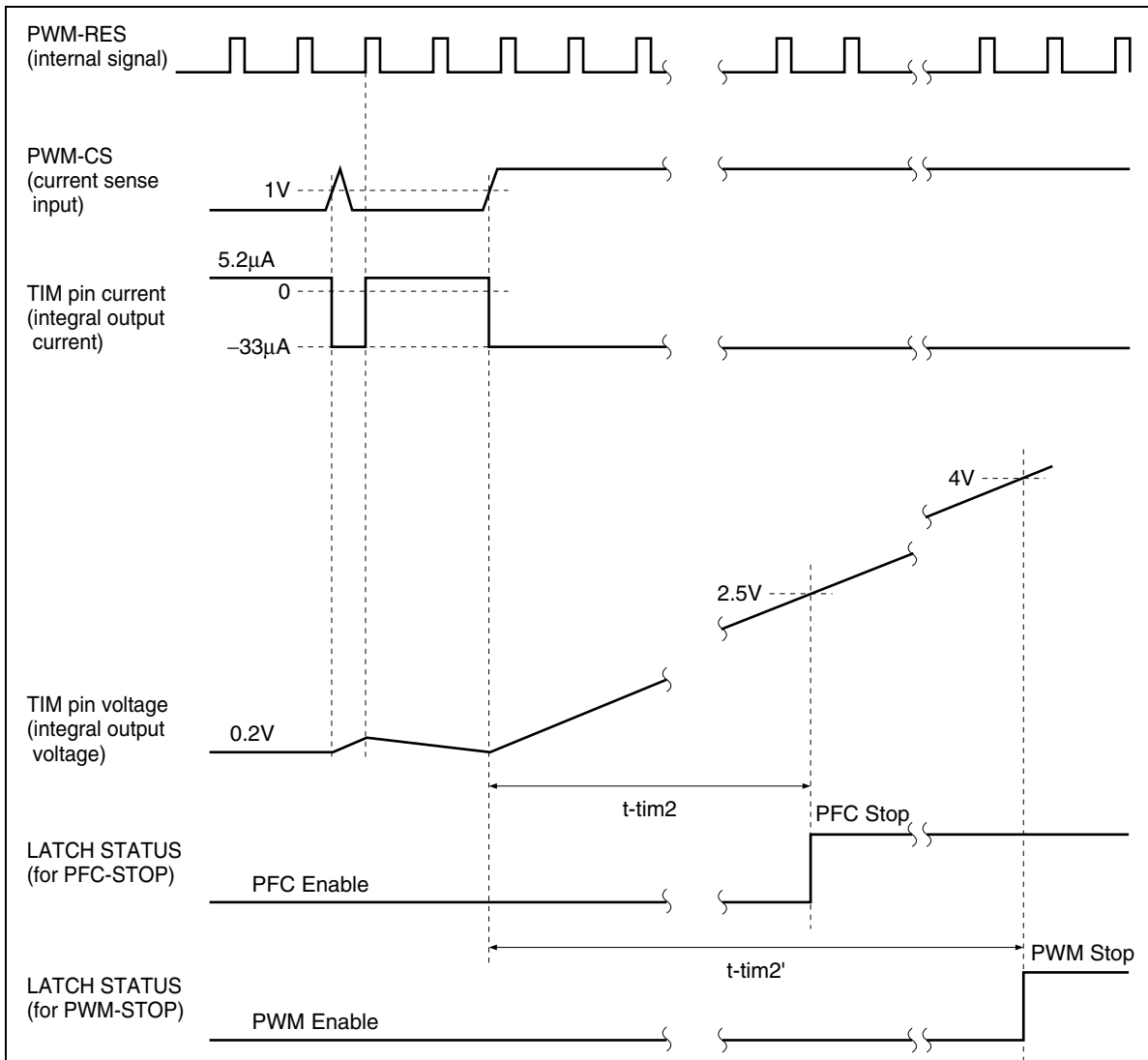
Note: All numeric values in the figure are typical values.

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5. Integrator (OC detection operation)



6. Integrator (PWM-CS detection operation)



Note: Timer time calculation equation

Timer time $t-tim2$ is the time until PG pin inversion (from low to high) after the PWM-CS pin trigger. $t-tim2$ can be set using the following approximate equation.

$$t-tim2 = -C_{tim} \cdot (V_{ch} - pfc - 0.2V) / I_{src} - tim2$$

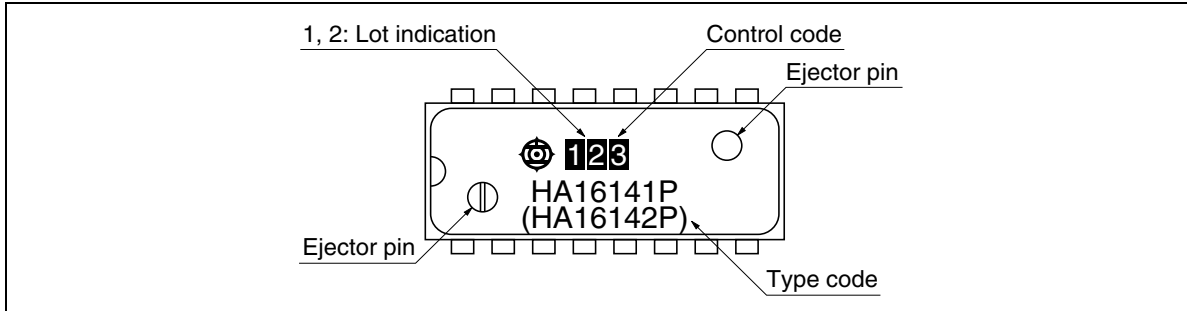
$$= -C_{tim} \cdot (2.5V - 0.2V) / (-33\mu A) \dots \dots \text{Typical calculation}$$

The time at which both the PFC and PWM functions are stopped by this timer can be calculated using the following approximate equation.

$$t-tim2' = 1.65 \cdot t - tim2 \dots \dots \text{Typical calculation}$$

HA16141P/FP, HA16142P/FP

Mark Pattern



Notes: 1. Example of lot indication.

For example, a product manufactured in May 2000 has the markings "0E" in positions **1** **2** in the above figure.

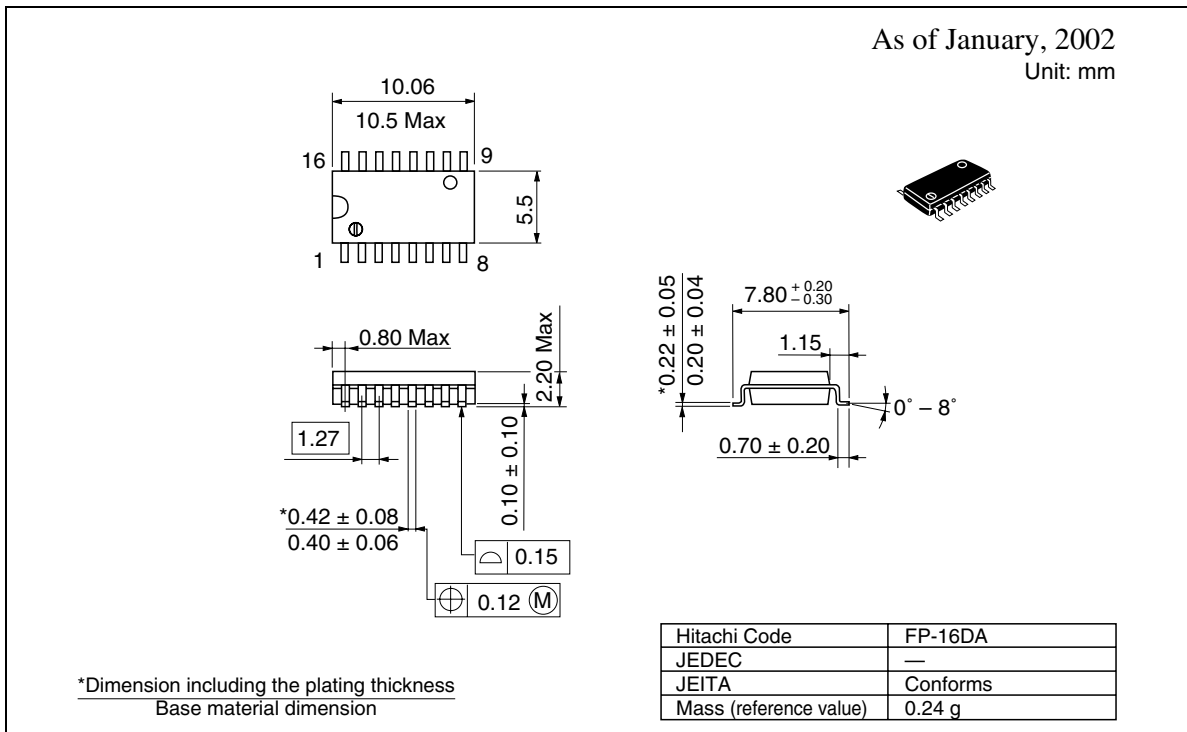
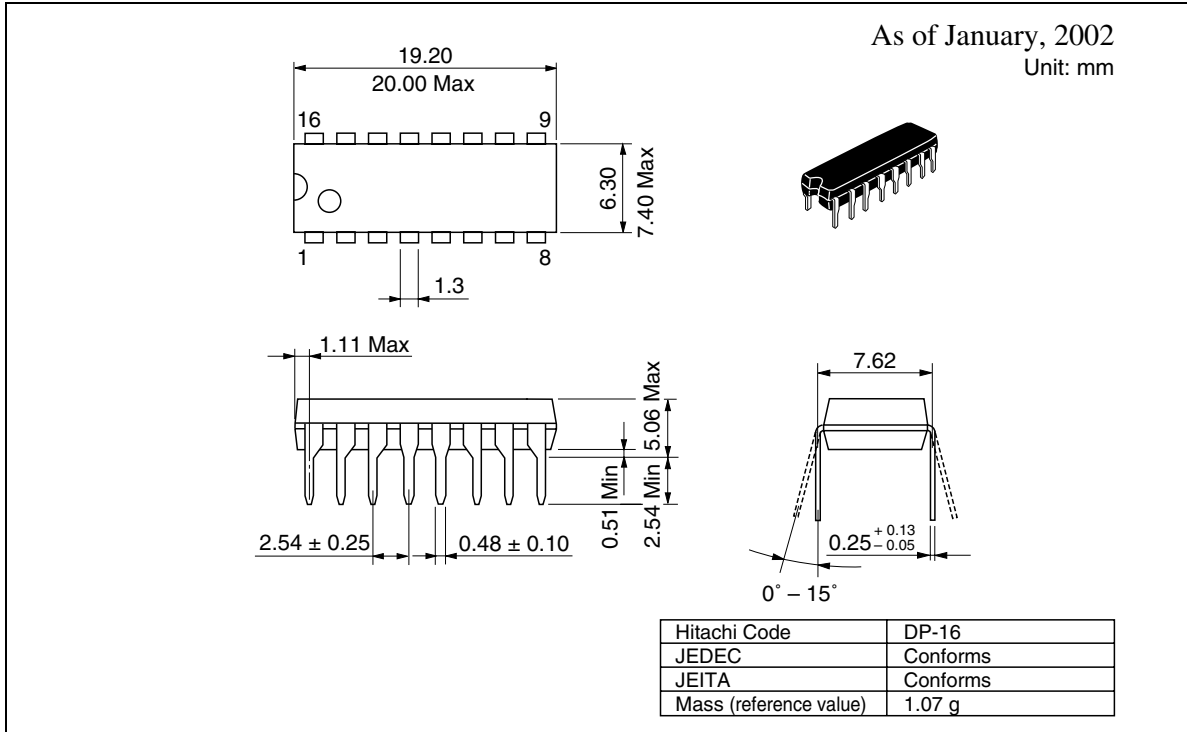
Production		Indication	
Month	Year	1	2
May	2000	0	E

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Code	A	B	C	D	E	F	G	H	J	K	L	M

2. Laser marking is used.

HA16141P/FP, HA16142P/FP

Package Dimensions



HA16141P/FP, HA16142P/FP

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