HA16141P/FP, HA16142P/FP

PFC and PWM Controller

REJ03F0145-0500
(Previous: ADE-204-036D)
Rev.5.00
Jun 15, 2005

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.

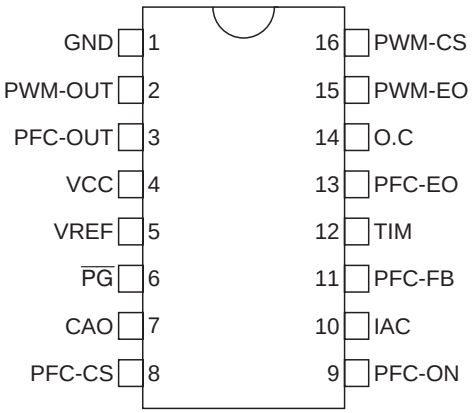
The PFC operation can be turned on and off by external control signal. Use of this on/off function makes it possible to disable PFC operation at a low line voltage, or to perform remote control operation from the transformer secondary side. The PFC power supply boosted output voltage is not only fed 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 (±15 %)
  PWM : 200 kHz (±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)

Pin Arrangement

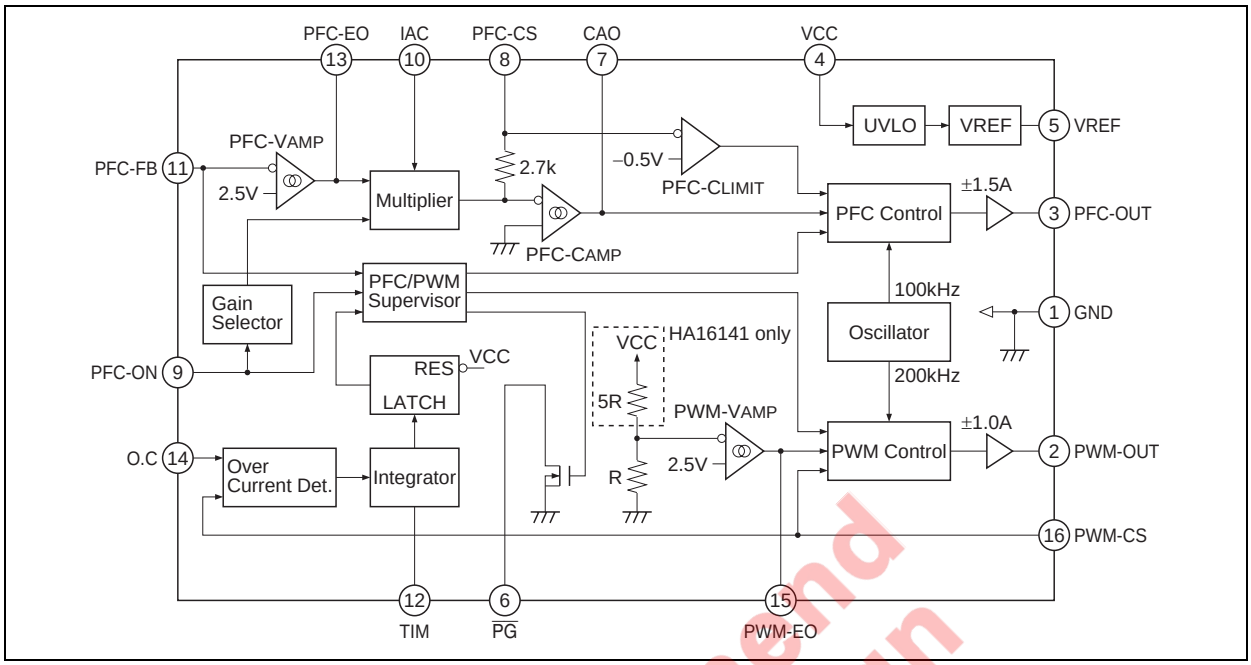


(Top view)

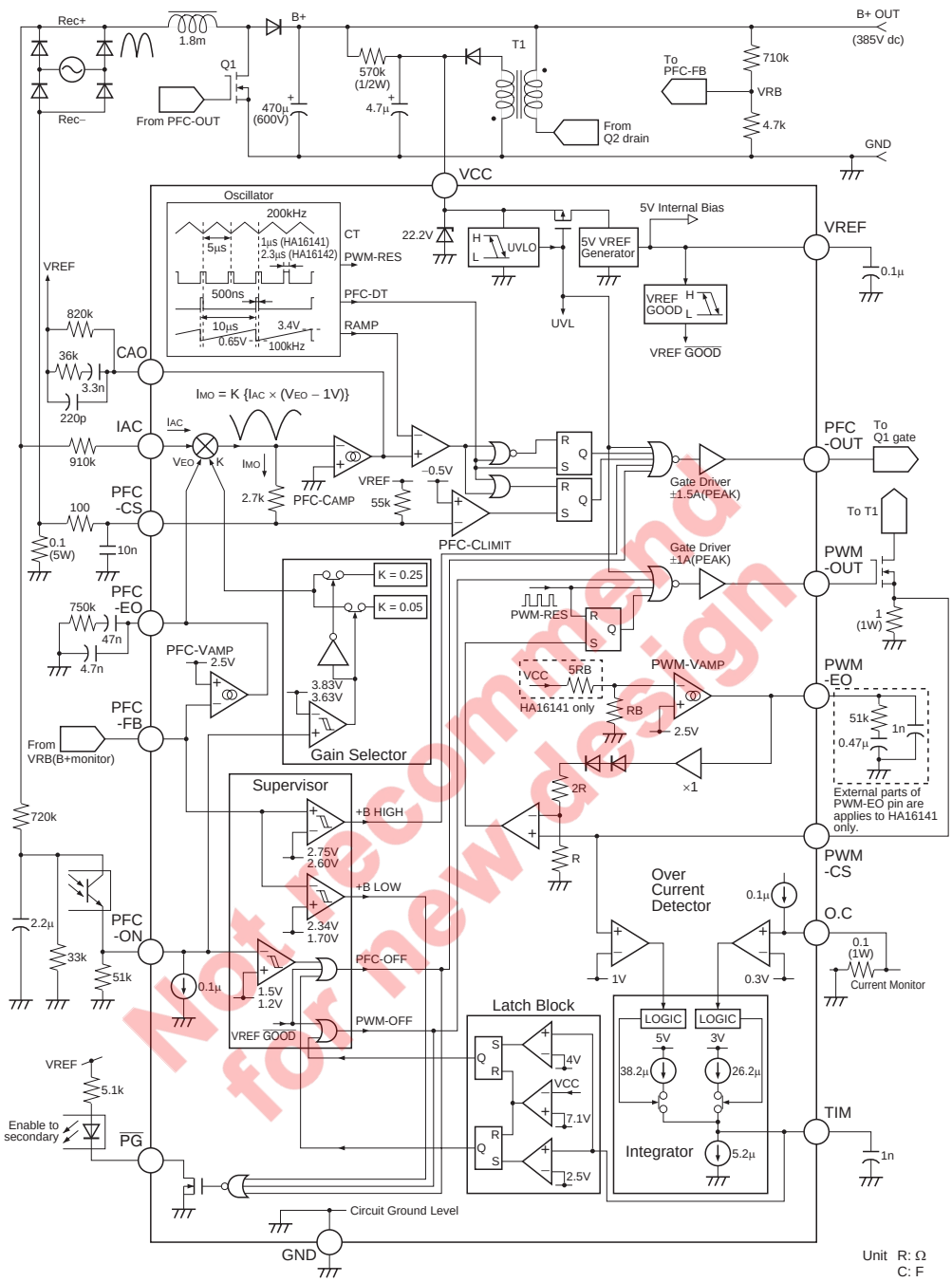
Pin Description

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	$\overline{PG}$	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



System Diagram



Unit R: Ω
C: F

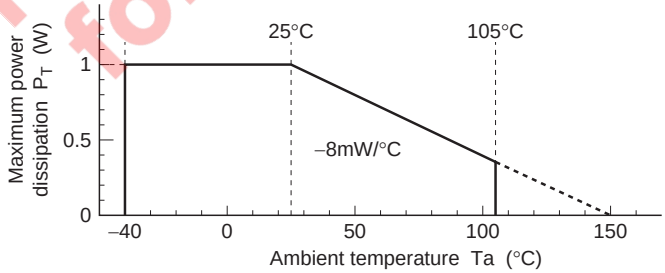
Note: The constants for the external components are for reference. Please confirm the operation when designing the system.

Absolute Maximum Ratings

(Ta = 25°C)

Item	Symbol	Rating	Unit	Note
Supply voltage	V_{CC}	20	V	
Peak PFC-OUT current	Ipk-pfc	±1.5	A	3
Peak PWM-OUT current	Ipk-pwm	±1.0	A	3
DC PFC-OUT current	Idc-pfc	±0.15	A	
DC PWM-OUT current	Idc-pwm	±0.10	A	
Terminal voltage	Vi-group1	–0.3 to V_{CC}	V	4
	Vi-group2	–0.3 to Vref	V	5
CAO voltage	Vcao	–0.3 to Veoh-ca	V	
PFC-EO voltage	Vpfc-eo	–0.3 to Veoh-pfc	V	
PWM-EO voltage	Vpwm-eo	–0.3 to Veoh-pwm	V	
PFC-ON voltage	Vpfc-on	–0.3 to +7	V	
IAC voltage	Vi-ac	–0.3 to +5	V	
IAC current	Ii-ac	0.8	mA	
PFC-CS voltage	Vi-cs	–1.5 to +0.3	V	
TIM voltage	Vi-tim	–0.3 to +6	V	
VREF current	Io-ref	–20	mA	
$\overline{PG}$ voltage	Vo-pg	–0.3 to +7	V	
$\overline{PG}$ current	Io-pg	15	mA	
Power dissipation	P_T	1	W	6
Operating temperature	Topr	–40 to +105	°C	
Storage temperature	Tstg	–55 to +150	°C	
Junction temperature	Tj	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).



Electrical Characteristics

(Ta = 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/dTa	–	–0.3	–	%/°C	*1
	Operating current	I_{CC}	4	7	9	mA	IAC = 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/dTa	–	+4	–	mV/°C	I_{CC} = 14mA *1
PFC-OUT	Minimum duty cycle	Dmin-pfc	–	–	0	%	CAO = 3.6V
	Maximum duty cycle	Dmax-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	Ipk-pfc	–	1.5	–	A	C_L = 0.01µF *1
	Low voltage	Vol1-pfc	–	0.05	0.2	V	Iout = 20mA
		Vol2-pfc	–	0.35	1.4	V	Iout = 200mA
		Vol3-pfc	–	0.03	0.7	V	Iout = 10mA, V_{CC} = 5V
	High voltage	Voh1-pfc	13.5	13.9	–	V	Iout = –20mA
		Voh2-pfc	12.6	13.3	–	V	Iout = –200mA
PWM-OUT	Minimum duty cycle	Dmin-pwm	–	–	0	%	PWM-EO = 1.3V PWM-CS = 0V
	Maximum duty cycle	Dmax-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	Ipk-pwm	–	1.0	–	A	C_L = 0.01µF *1
	Low voltage	Vol1-pwm	–	0.05	0.2	V	Iout = 20mA
		Vol2-pwm	–	0.5	2.0	V	Iout = 200mA
		Vol3-pwm	–	0.03	0.7	V	Iout = 10mA, V_{CC} = 5V
	High voltage	Voh1-pwm	13.5	13.9	–	V	Iout = –20mA
		Voh2-pwm	12.0	13.0	–	V	Iout = –200mA
VREF	Output voltage	Vref	4.9	5.0	5.1	V	Isource = 1mA
	Line regulation	Vref-line	–	5	20	mV	Isource = 1mA V_{CC} = 12V to 18V
	Load regulation	Vref-load	–	5	20	mV	Isource = 1mA to 20mA
	Temperature stability	dVref	–	80	–	ppm/°C	Ta = –40 to 105°C *1

Notes: 1. Design spec.
2. Apply to HA16141.
3. Apply to HA16142.

Electrical Characteristics (cont.)

(Ta = 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	Ta = –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 volatge	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	Ipfc-on	–	0.1	1.0	µA	PFC-ON = 2V
Supervisor/ $\overline{PG}$	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
	$\overline{PG}$ leak current	Ioff-pg	–	0.001	1.0	µA	$\overline{PG}$ = 5V
	$\overline{PG}$ shunt current	Ion-pg	5	15	–	mA	$\overline{PG}$ = 3V *2
	Delay to $\overline{PG}$	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, Ctim = 1000p, Measured pin: $\overline{PG}$
	Integrated Time PWM-CS trigger	t-tim2	53	67	81	µs	Step signal (0 to 2V) to PWM-CS, Ctim = 1000p, Measured pin: $\overline{PG}$

Notes: 1. Design spec.
2. Maximum rating of PG current is 15 mA. Use series resistor to limit PG current lower than 15 mA.

Electrical Characteristics (cont.)

(Ta = 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-V_{AMP}	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-V_{AMP}	Feedback voltage	Vfb-pfc	2.45	2.50	2.55	V	PFC-EO = 2.5V
	Input bias current	Ifb-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

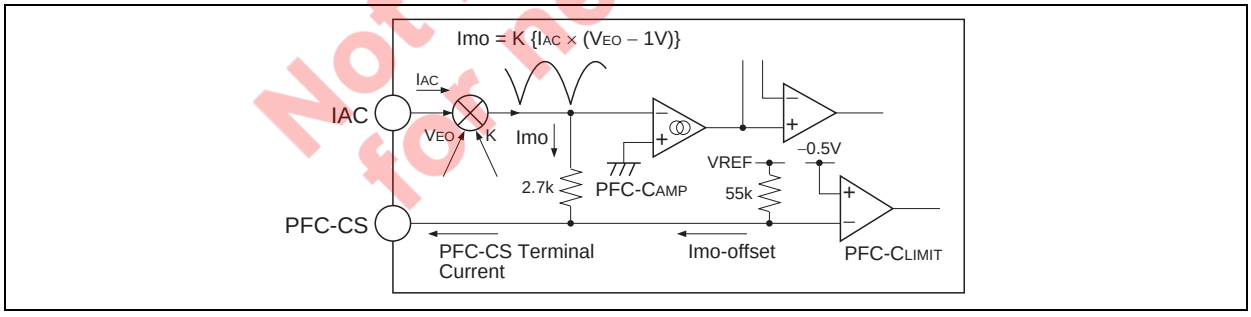
Notes: 1. Design spec.
2. Apply to HA16141.

Electrical Characteristics (cont.)

(Ta = 25°C, V_{CC} = 14 V)

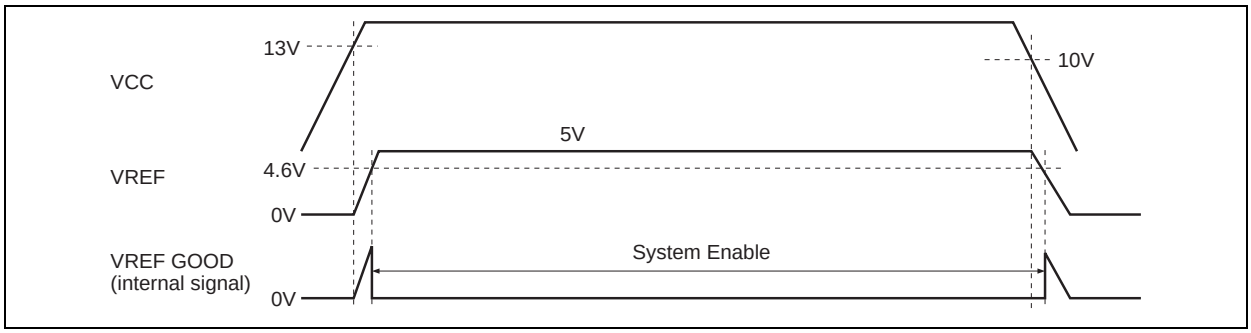
Item		Symbol	Min	Typ	Max	Unit	Test Conditions
PFC-CAMP	Input offset voltage	Vio-ca	–	±7	–	mV	*1
	Open loop gain	Av-ca	–	65	–	dB	*1
	High voltage	Veoh-ca	5.1	5.7	6.3	V	
	Low voltage	Veol-ca	–	0.1	0.3	V	
	Source current	Isrc-ca	–	–77	–	µA	CAO = 2.5V *1
	Sink current	Isnk-ca	–	77	–	µA	CAO = 2.5V *1
	Transconductance	Gm-pfcc	120	160	200	µA/V	*1
IAC/ Multiplier	IAC PIN voltage	Viac	0.7	1.0	1.3	V	IAC = 100µA
	Terminal offset current	Imo-offset	–56	–75	–94	µA	IAC = 0A, PFC-CS = 0V, Measured pin: PFC-CS
	Output current (PFC-ON = 3.4V)	Imo1	–	–25	–	µA	PFC-EO = 2V, IAC = 100µA *1, *2
		Imo2	–	–75	–	µA	PFC-EO = 4V, IAC = 100µA *1, *2
	Output current (PFC-ON = 3.9V)	Imo3	–	–5	–	µA	PFC-EO = 2V, IAC = 100µA *1, *2
		Imo4	–	–15	–	µA	PFC-EO = 4V, IAC = 100µA *1, *2
	PFC-CS resistance	Rmo	–	2.7	–	kΩ	*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. Imo1 to Imo4 are defined as,
Imo = (PFC-CS Terminal Current) – (Imo-offset)

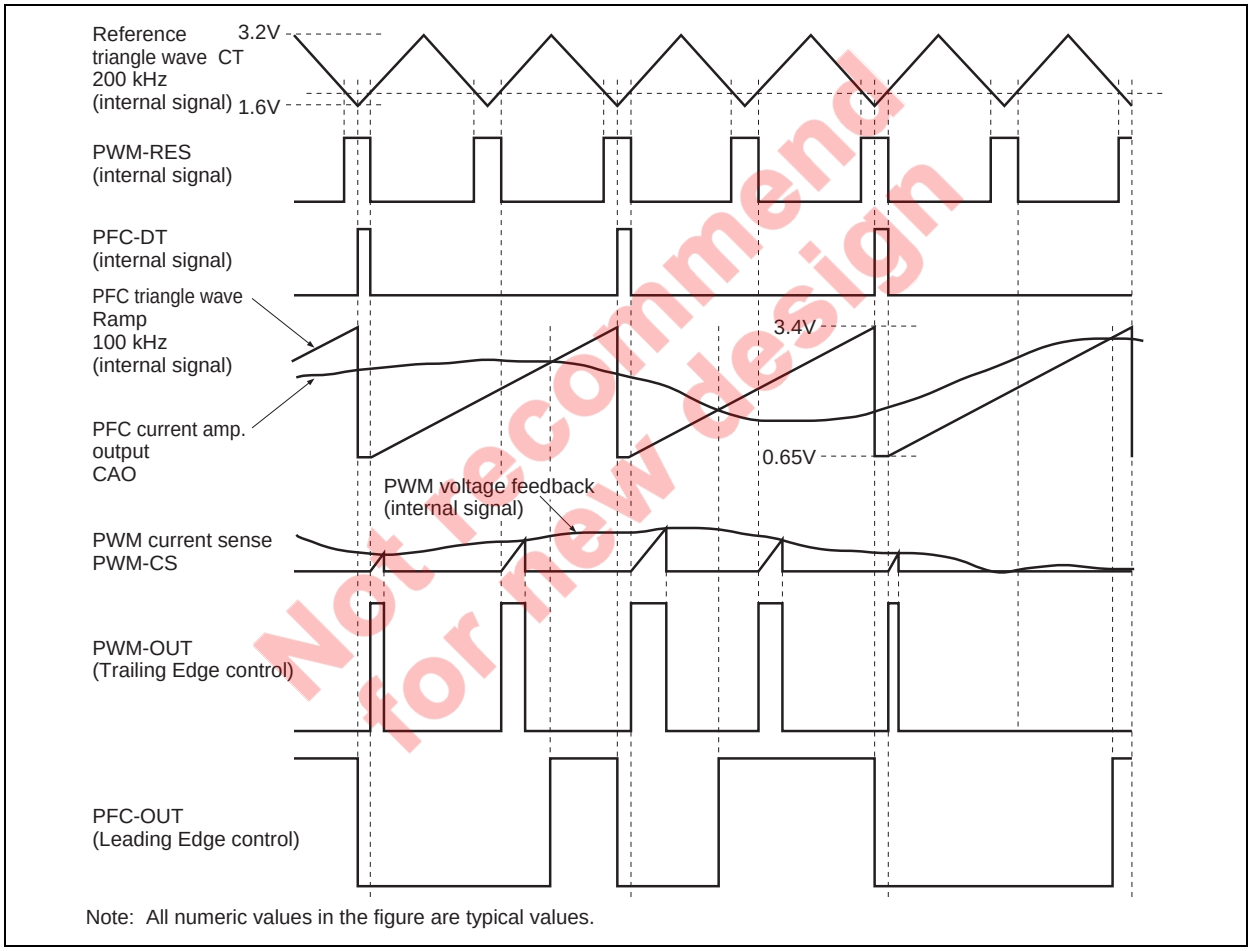


Internal Timing

1. UVLO



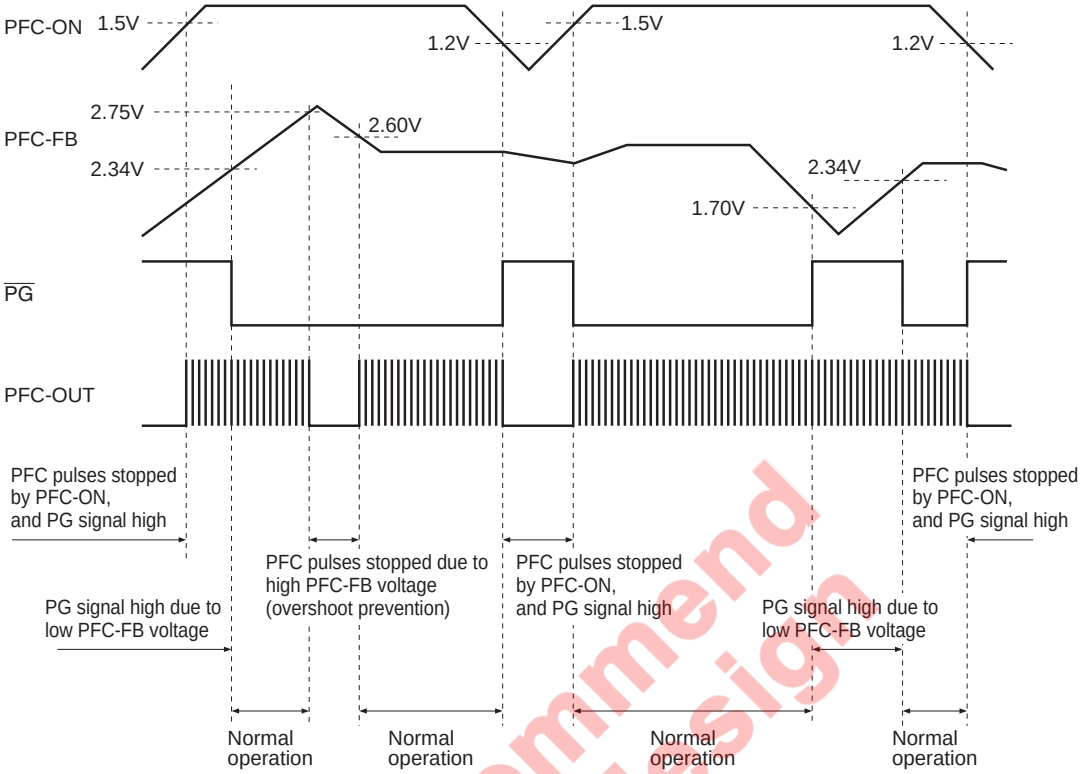
2. Oscillator, Gate driver output



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

3. PFC controller status

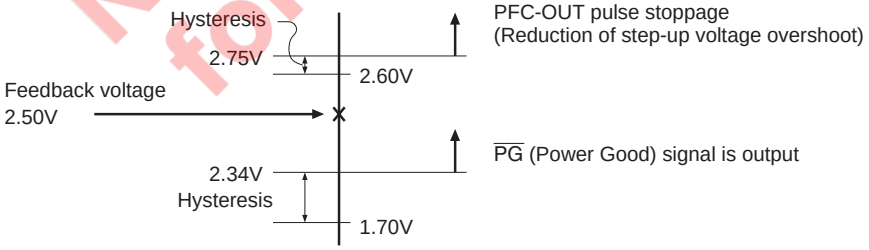
Precondition: VREF GOOD, Non latched.



Notes: 1. All numeric values in the figure are typical values.

2. PFC-ON
The HA16141P/FP can perform on/off control of the PFC function using the PFC-ON pin.
If an AC voltage that has undergone primary rectification and has been divided with an external resistance is input, PFC stoppage is possible in the event of a low input voltage.
On/off control by means of a logic signal is also possible.

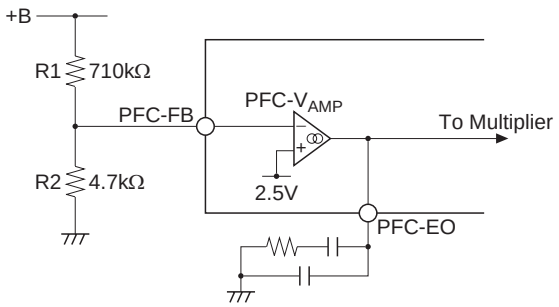
3. PFC-FB
The input to this pin is the voltage obtained by dividing the stepped-up PFC output voltage.
The pin voltage is fed back to the PFC control system, and is also used for step-up voltage logic decisions.
This is outlined in the figure below.



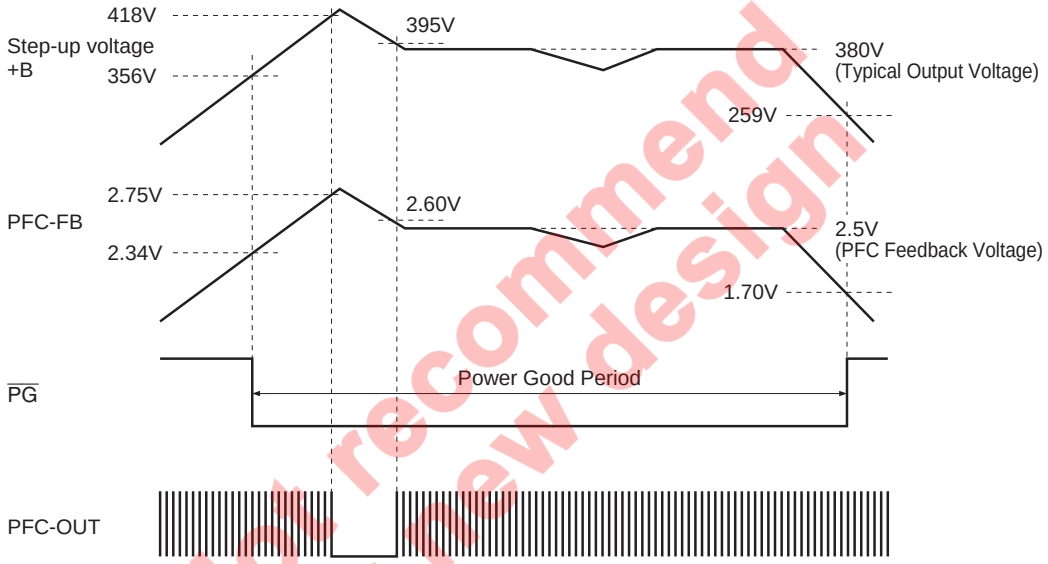
(Note 3 is continued on the next page)

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.



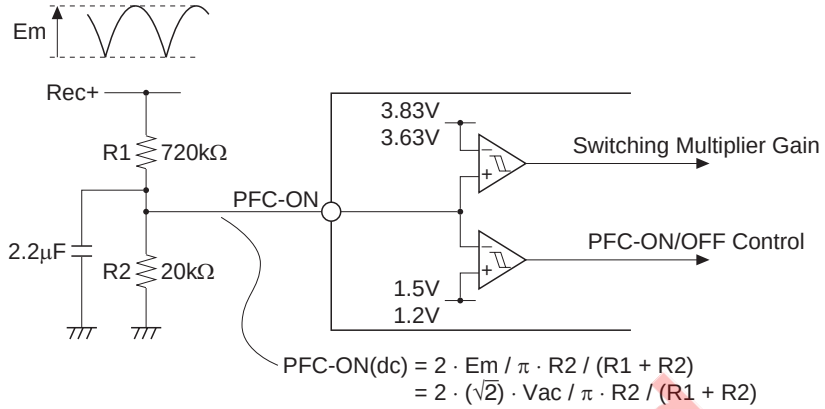
Precondition: VREF GOOD, PFC-ON, Non latched.



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

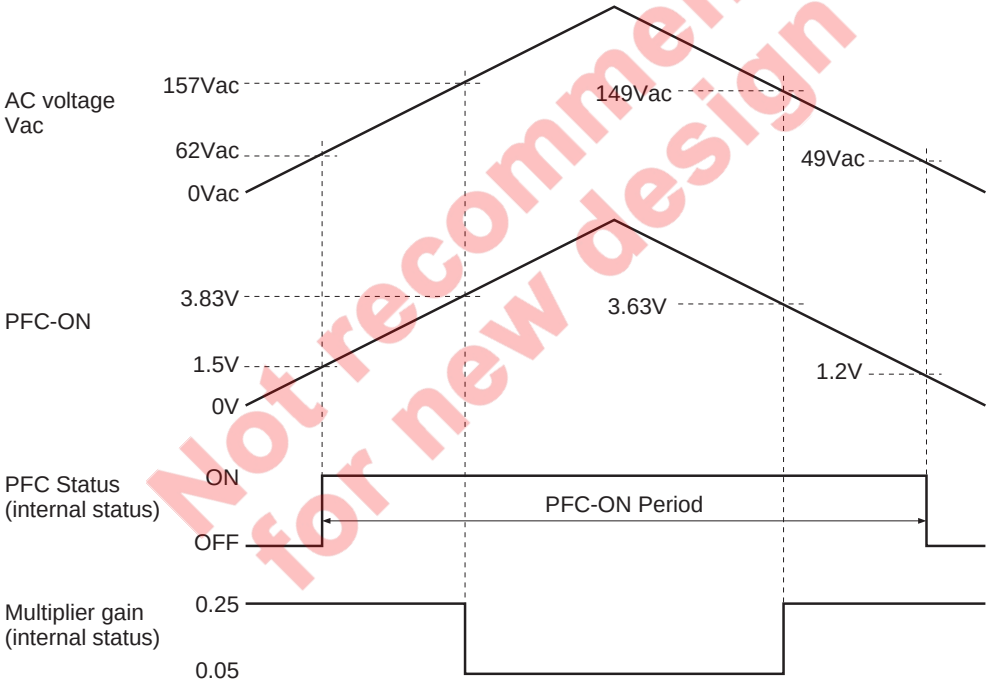
4. PFC-ON pin

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



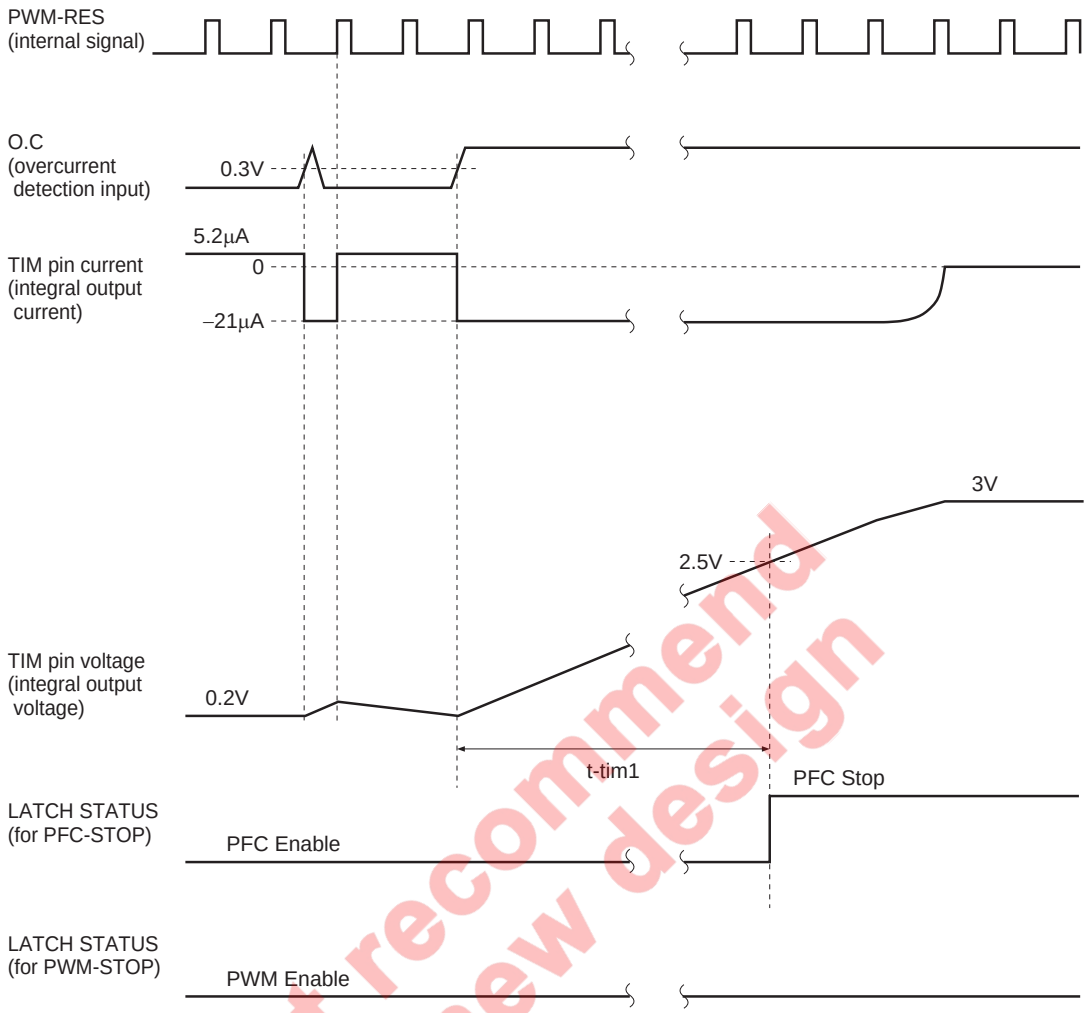
PFC-ON(dc) = 2 · Em / π · R2 / (R1 + R2)
= 2 · (√2) · Vac / π · R2 / (R1 + R2)

Precondition: VREF GOOD, Non latched.



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

5. Integrator (OC detection operation)

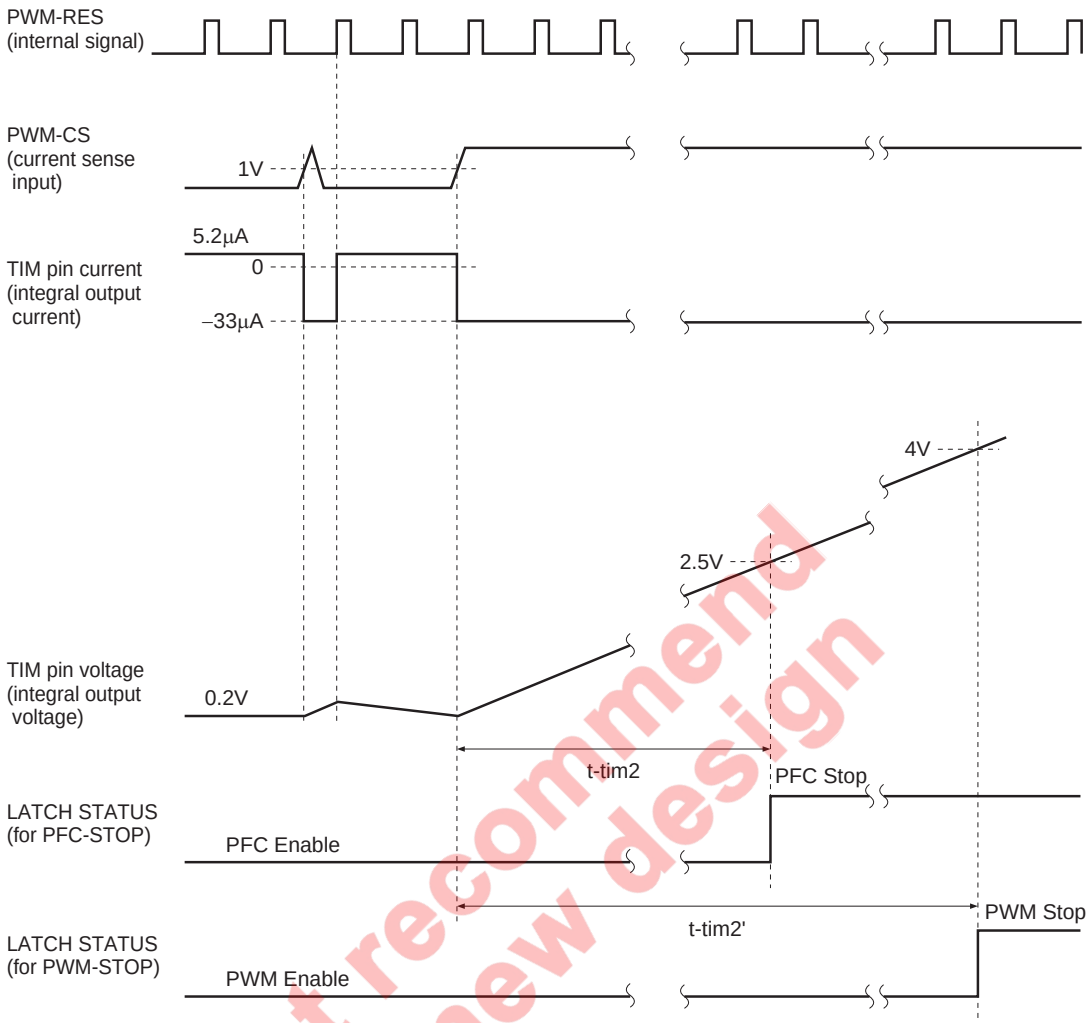


Note: Timer time calculation equation

Timer time t-tim1 is the time until PG pin inversion (from low to high) after the O.C pin trigger. t-tim1 can be set using the following approximate equation.

t-tim1 = –Ctim · (Vlch – pfc – 0.2V) / Isrc – tim1
= –Ctim · (2.5V – 0.2V) / (–21μA) · · · · · Typical calculation

6. Integrator (PWM-CS detection operation)



Note: Timer time calculation equation

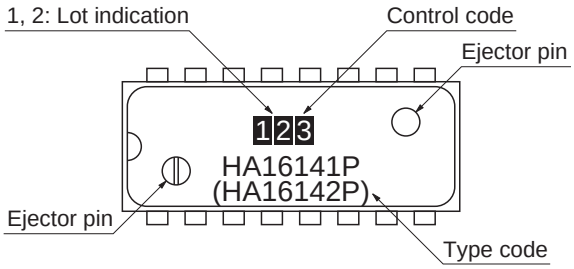
Timer time t-tim2 is the time until PG pin inversion (from low to high) after the PWM-CS pin trigger. t-tim2 can be set using the following approximate equation.

t-tim2 = –Ctim · (Vlch – pfc – 0.2V) / Isrc – tim2
= –Ctim · (2.5V – 0.2V) / (–33µA) · · · · · 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 · t – tim2 · · · · · Typical calculation

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.

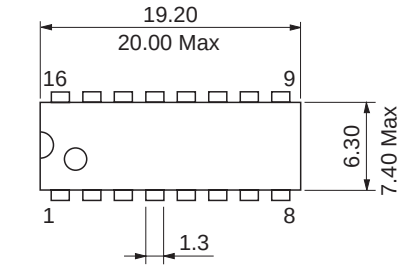
Production		Indication	
Month	Year	1	2
May	2000	0	E

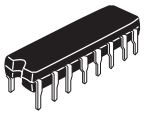
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Code	A	B	C	D	E	F	G	H	J	K	L	M

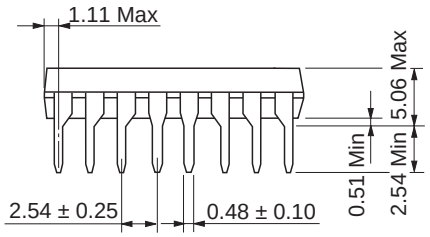
2. Laser marking is used.

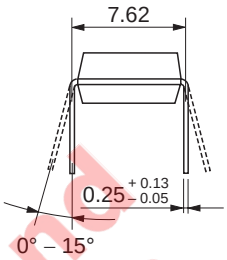
Package Dimensions

As of January, 2003
Unit: mm



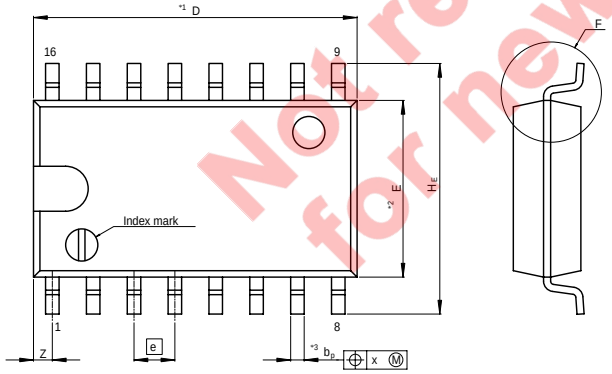




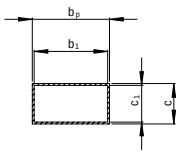


Package Code	DP-16
JEDEC	Conforms
JEITA	Conforms
Mass (reference value)	1.07 g

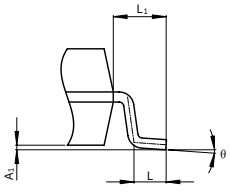
JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-SOP16-5.5x10.06-1.27	PRSP0016DH-A	FP-16DA	0.24g



NOTE)
1. DIMENSIONS"*1 (Nom)"AND"*2" DO NOT INCLUDE MOLD FLASH.
2. DIMENSION"*3"DOES NOT INCLUDE TRIM OFFSET.



Terminal cross section



Detail F

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	——	10.06	10.5
E	——	5.5	——
A_2	——	——	——
A_1	0.00	0.10	0.20
A	——	——	2.20
b_p	0.34	0.42	0.50
b_1	——	0.40	——
c	0.17	0.22	0.27
c_1	——	0.20	——
θ	0°	——	8°
H_E	7.50	7.80	8.00
e	——	1.27	——
x	——	——	0.12
y	——	——	0.15
Z	——	——	0.80
L	0.50	0.70	0.90
L_1	——	1.15	——

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Colophon 2.0