

**INTEGRATED
POWER**
SEMICONDUCTORS, LTD.

Regulating Pulse Width Modulators

T-58-11-31

Description

The IP35060A series of switching regulator control circuits contain all the functions required to implement single-ended switching regulators. Included are voltage reference, two error amplifiers, oscillator, PWM comparator, uncommitted output driver, dead-time control and under voltage lockout circuitry.

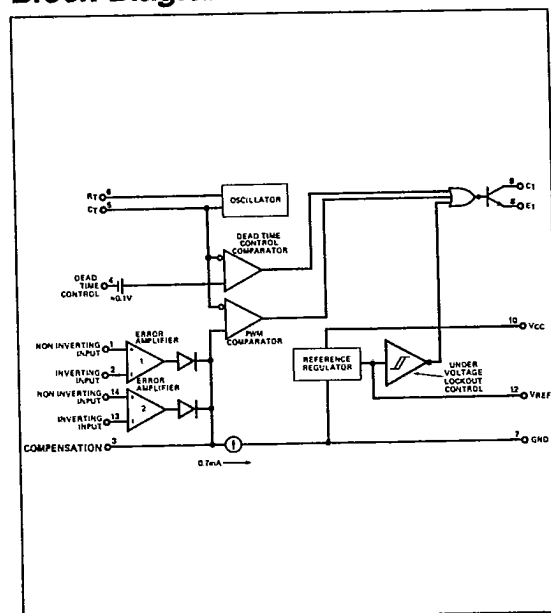
Although pin-compatible with the industry standard MC35060 and MC34060, Integrated Power has incorporated several improvements in the IP35060A and IP34060A allowing tighter and more complete specification of electrical performance.

Features

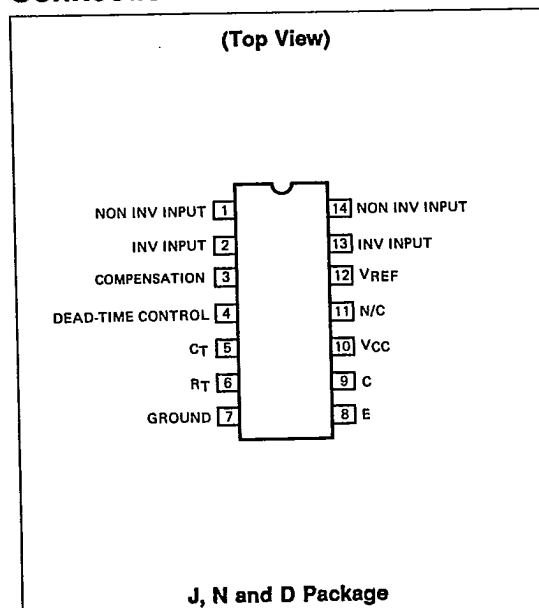
- **Guaranteed $\pm 1\%$ reference voltage tolerance (A series)**
- **Guaranteed 10% frequency tolerance**
- **Undervoltage lockout with hysteresis**
- **Fully specified temperature performance**
- **Interchangeable with MC35060 and MC34060 for improved performance**

Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060

Block Diagram



Connections



4825898 INTEGRATED POWER

82D 00211 D

7-58-11-31

Absolute Maximum Ratings

Supply Voltage (+V _{CC})	+45V	Power Dissipation at	
Amplifier Input Voltage	V _{CC} +0.3V	T _A = +25°C (Note 1)	1000mW
Collector Output Voltage	+45V	T _C = +25°C (Note 2)	2000mW
Output Current	250mA	Storage Temperature Range	-65°C to +150°C
		Lead Temperature (Soldering, 10 sec.)	+300°C

Absolute maximum ratings are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the device should be operated at these limits. The electrical characteristics provide conditions for actual device operation.

Recommended Operating Conditions (Note 3)

Supply Voltage (+V _{CC})	7 to 40V	Reference Output Current	0 to 10 mA
Error Amplifier Input Voltage	-0.3 to V _{CC} -2V	Oscillator Frequency	1kHz to 300kHz
Collector Output Voltage	0 to 40V	Oscillator Timing Capacitor	0.47nF to 10μF
Collector Output Current	0 to 200 mA	Oscillator Timing Resistor	1.8kΩ to 500kΩ
Current into Feedback Terminal	0 to 0.3 mA	Operating Ambient Temperature Range:	

IP35060A, IP35060	-55°C to +125°C
IP33060A, IP33060	-40°C to +85°C
IP34060A, IP34060	0°C to +70°C

Note 1. Derate at 10mW/°C for ambient temperatures above +50°C.

Note 2. Derate at 16mW/°C for case temperatures above +25°C.

Note 3. Range over which the device is functional and parameter limits are guaranteed.

Electrical Characteristics

V_{CC} = 15V, f = 10kHz unless otherwise specified.

Parameter	Test Conditions	IP35060A IP33060A IP34060A			Units	
		Min	Typ	Max		
Reference Section						
Output Voltage (V _{REF})	I _O = 1mA		4.95	5	5.05	V
Input Regulation	V _{CC} = 7 to 40 V	•		2	25	mV
Output Regulation	I _O = 1 to 10 mA	•		1	15	mV
Output Voltage	I _O = 1mA	•	4.90		5.10	V
Short Circuit Output Current	V _{REF} = 0	•	10	35	70	mA
Oscillator Section						
Frequency	C _T = 0.01 μF, R _T = 12 kΩ		9	10	11	kHz
	C _T = 0.001 μF, R _T = 47 kΩ			25		kHz
Frequency Change with Voltage	V _{CC} = 7 to 40 V	•		0.1	2	%
Frequency Change with Temperature	ΔT _A = Min to Max (Note 4)	•			2	%
Amplifier Sections						
Input Offset Voltage	V _O (PIN 3) = 2.5 V	•		2	10	mV
Input Offset Current	V _O (PIN 3) = 2.5 V	•		25	250	nA
Input Bias Current	V _O (PIN 3) = 2.5 V	•		-0.2	-1	μA
Common-Mode Input Voltage Range	V _{CC} = 7 V to 40 V		-0.3 to V _{CC} -2			V
Open Loop Voltage Gain	ΔV _O = 3 V, V _O = 0.5 to 3.5 V	•	70	95		dB
Unity Gain Bandwidth				350		kHz
Common-Mode Rejection Ratio	V _{CC} = 40 V	•	65	80		dB
Supply Voltage Rejection	V _O = 2.5 V	•	60	100		dB
Output Sink Current (Pin 3)	V _(PIN 3) = 0.7 V	•	0.3	0.7		mA
Output Source Current (Pin 3)	V _(PIN 3) = 3.5 V	•	-2	-4		mA

2-78

IPS

Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060

4825898 INTEGRATED POWER

82D 00212 D

T-58-11-31

Electrical Characteristics (Cont.)

				IP35060A IP33060A IP34060A				
Parameter		Test Conditions		Min	Typ	Max	Units	
Deadtime Control Section								
Input Bias Current (Pin 4)		$V(\text{PIN } 4) = 0 \text{ to } 5.25\text{V}$	•		-2	-10	μA	
Maximum Duty Cycle		$V(\text{PIN } 4) = 0\text{ V}$	•	90			%	
Input Threshold Voltage		Zero Duty Cycle	•		3	3.3	V	
(Pin 4)		Maximum Duty Cycle	•	0			V	
PWM Comparator Section								
Input Threshold Voltage (Pin 3)		Zero Duty Cycle	•		3.5	4.5	V	
Input Sink Current (Pin 3)		$V(\text{PIN } 3) = 0.7\text{ V}$	•	0.3	0.7		mA	
Output Section								
Collector Off-state Current		$V_{\text{CE}} = 40\text{ V}, V_{\text{CC}} = 40\text{ V}$	•		2	100	μA	
Emitter Off-state Current		$V_{\text{CC}} = V_{\text{C}} = 40\text{ V}, V_{\text{E}} = 0$	•			-100	μA	
Collector-emitter	Common-Emitter	$V_{\text{E}} = 0, I_{\text{C}} = 200\text{ mA}$	•		1.1	1.3	V	
Saturation Voltage	Emitter-Follower	$V_{\text{C}} = 15\text{ V}, I_{\text{E}} = -200\text{ mA}$	•		1.5	2.5	V	
Output Voltage Rise Time		$R_{\text{L}} = 68\ \Omega$, Common-Emitter			100	200	ns	
		$C_{\text{L}} = 15\text{ pF}$ Emitter-Follower			100	200	ns	
Output Voltage Fall Time		$R_{\text{L}} = 68\ \Omega$, Common-Emitter			25	100	ns	
		$C_{\text{L}} = 15\text{ pF}$ Emitter-Follower			40	100	ns	
Total Device								
Standby Supply Current		Pin 6 at V_{REF} . All Other Inputs and Outputs Open	$V_{\text{CC}} = 15\text{V}$	•		6	10	mA
			$V_{\text{CC}} = 40\text{ V}$	•		9	15	mA
Under-Voltage Lockout		V_{IN} Rising	•	4.1	5.3	6.5	V	
Hysteresis			•	200	600	1000	mV	

Parameter	Test Conditions	IP35060 IP33060 IP34060			Unit	
		Min	Typ	Max		
Reference Section						
Output Voltage (V_{REF})	$I_O = 1\text{mA}$		4.80	5	5.20	V
Input Regulation	$V_{CC} = 7 \text{ to } 40 \text{ V}$	•		2	25	mV
Output Regulation	$I_O = 1 \text{ to } 10 \text{ mA}$	•		1	15	mV
Output Voltage	$I_O = 1\text{mA}$	•	4.75		5.25	V
Short Circuit Output Current	$V_{REF} = 0$	•	10	35	70	mA
Oscillator Section						
Frequency	$C_T = 0.01 \mu\text{F}, R_T = 12 \text{ k}\Omega$		9	10	11	kHz
	$C_T = 0.001 \mu\text{F}, R_T = 47 \text{ k}\Omega$			25		kHz
Frequency Change with Voltage	$V_{CC} = 7 \text{ to } 40 \text{ V}$	•		0.1	2	%
Frequency Change with Temperature	$\Delta T_A = \text{Min to Max (Note 4)}$	•			2	%
Amplifier Sections						
Input Offset Voltage	$V_O (\text{PIN } 3) = 2.5 \text{ V}$	•		2	10	mV
Input Offset Current	$V_O (\text{PIN } 3) = 2.5 \text{ V}$	•		25	250	nA

Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060



4825898 INTEGRATED POWER

82D 00213 D

T-58-11-31

Electrical Characteristics (Cont.)

Parameter	Test Conditions		IP35060 IP33060 IP34060			Unit
			Min	Typ	Max	
Input Bias Current	V_O (PIN 3) = 2.5 V	•		-0.2	-1	μ A
Common-Mode Input Voltage Range	V_{CC} = 7 V to 40 V		-0.3 to $V_{CC}-2$			V
Open Loop Voltage Gain	ΔV_O = 3 V, V_O = 0.5 to 3.5 V	•	70	95		dB
Unity Gain Bandwidth				350		kHz
Common-Mode Rejection Ratio	V_{CC} = 40 V	•	65	80		dB
Supply Voltage Rejection	V_O = 2.5 V	•	60	100		dB
Output Sink Current (Pin 3)	$V_{I(PIN 3)}$ = 0.7 V	•	0.3	0.7		mA
Output Source Current (Pin 3)	V (PIN 3) = 3.5 V	•	-2	-4		mA
Deadtime Control Section						
Input Bias Current (Pin 4)	V (PIN 4) = 0 to 5.25 V	•		-2	-10	μ A
Maximum Duty Cycle	V (PIN 4) = 0 V	•	90			%
Input Threshold Voltage (Pin 4)	Zero Duty Cycle	•		3	3.3	V
	Maximum Duty Cycle	•	0			V
PWM Comparator Section						
Input Threshold Voltage (Pin 3)	Zero Duty Cycle	•		3.5	4.5	V
Input Sink Current (Pin 3)	V (PIN 3) = 0.7 V	•	0.3	0.7		mA
Output Section						
Collector Off-state Current	V_{CE} = 40 V, V_{CC} = 40 V	•		2	100	μ A
Emitter Off-state Current	$V_{CC} = V_C$ = 40 V, V_E = 0	•			-100	μ A
Collector-emitter	Common-Emitter V_E = 0, I_C = 200 mA	•		1.1	1.3	V
Saturation Voltage	Emitter-Follower V_C = 15 V, I_E = -200 mA	•		1.5	2.5	V
Output Voltage Rise Time	R_L = 68 Ω , Common-Emitter			100	200	ns
	C_L = 15 pF, Emitter-Follower			100	200	ns
Output Voltage Fall Time	R_L = 68 Ω , Common-Emitter			25	100	ns
	C_L = 15 pF, Emitter-Follower			40	100	ns
Total Device						
Standby Supply Current	Pin 6 at V_{REF} . All Other Inputs and Outputs Open	V_{CC} = 15 V	•	6	10	mA
		V_{CC} = 40 V	•	9	15	mA
Under-Voltage Lockout	V_{IN} Rising	•	4.1	5.3	6.5	V
Hysteresis		•	200	600	1000	mV

The • denotes the specifications which apply over the full operating temperature range, all others apply at $T_J = 25^\circ\text{C}$ unless otherwise specified.

Note 4: These parameters, although guaranteed over the recommended conditions, are not 100% tested in production.

Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060

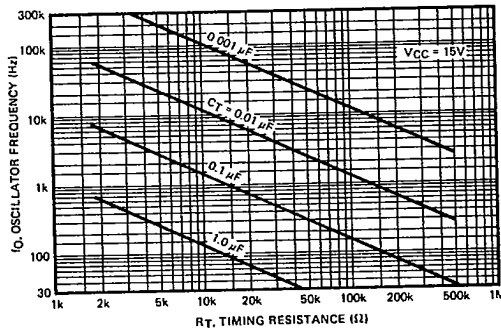
4825898 INTEGRATED POWER

82D 00214 D

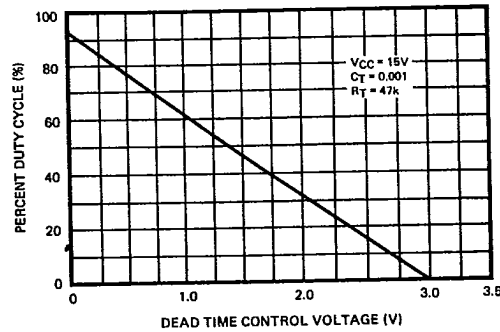
T-58-11-31

Typical Performance Characteristics

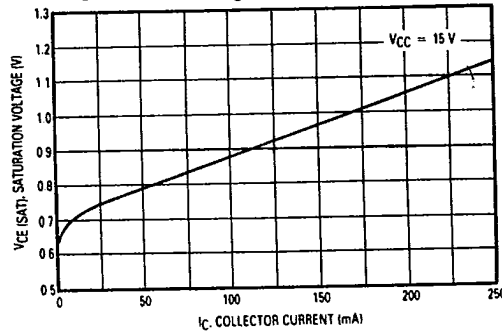
Oscillator Frequency vs. Timing Resistance



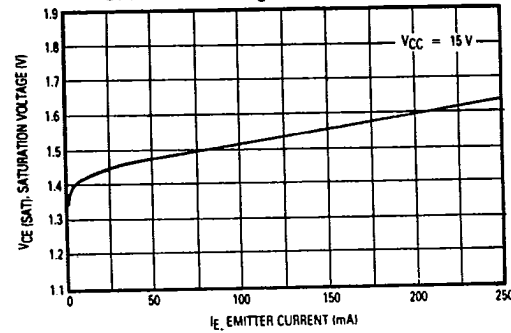
Percent Duty Cycle vs. Dead Time Control Voltage



Common-Emitter Configuration Output-Saturation Voltage vs. Collector Current



Emitter-Follower Configuration, Output-Saturation Voltage vs. Emitter Current



Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060

IPS

2-81

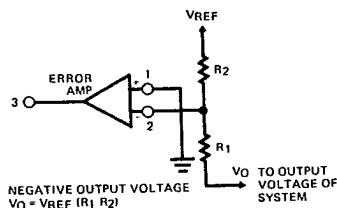
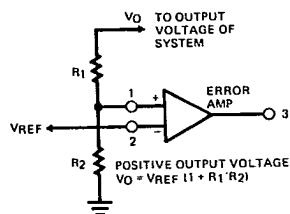
4825898 INTEGRATED POWER

82D 00215 D

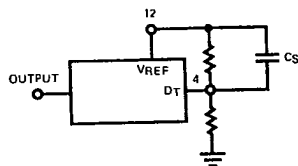
T-58-11-31

Applications Information

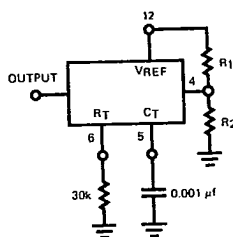
Error Amplifier Sensing Techniques



Soft Start Circuit

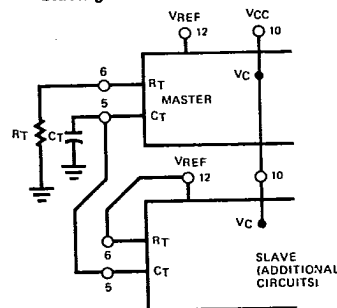


Dead-Time Control



$$\text{MAX \% ON TIME} \approx 82 \left(\frac{150}{1 + \frac{R_1}{R_2}} \right)$$

Slaving Two or More Circuits



Section 2 - Pulse Width Modulators
IP35060A, IP33060A, IP34060A,
IP35060, IP33060, IP34060

Order Information

Part Number

IP35060AJ
IP35060J
IP33060AD
IP33060D
IP33060AJ
IP33060J
IP33060AN
IP33060N
IP34060AD
IP34060D
IP34060AJ
IP34060J
IP34060AN
IP34060N

Temperature Range

-55°C to +125°C
-55°C to +125°C
-40°C to +85°C
-40°C to +85°C
-40°C to +85°C
-40°C to +85°C
-40°C to +85°C
-40°C to +85°C
0°C to +70°C
0°C to +70°C
0°C to +70°C
0°C to +70°C
0°C to +70°C
0°C to +70°C
0°C to +70°C

Package

14 Pin Ceramic DIP
14 Pin Ceramic DIP
14 Pin Plastic SOIC
14 Pin Plastic SOIC
14 Pin Ceramic DIP
14 Pin Ceramic DIP
14 Pin Plastic DIP
14 Pin Plastic DIP
14 Pin Plastic SOIC
14 Pin Plastic SOIC
14 Pin Ceramic DIP
14 Pin Ceramic DIP
14 Pin Plastic DIP
14 Pin Plastic DIP

Integrated Power Semiconductors, Ltd. cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in an Integrated Power product. No circuit patent licenses are implied. Integrated Power reserves the right to change the circuitry and specifications without notice at any time.

Integrated Power Semiconductors, Ltd.

2727 Walsh Avenue, Suite 201, Santa Clara, CA 95051 • Telephone: 408-727-2772 • Telex: 350073 (IPS SNTA) • FAX: 408-988-6185
8 Quaker Drive, West Warwick, RI 02893 • Telephone: 401-821-4260 • Telex: 332948 (IPS RI) • FAX: 401-823-7260
2081 Business Center Drive, Suite 140, Irvine, CA 92715 • Telephone: 714-752-0188 • FAX: 714-752-5019
789 Turnpike Street, North Andover, MA 01845 • Telephone: 617-683-9042 • FAX: 617-975-0193