Dual PWM Controller with SCP/DTC Function

Halogen Free

General Description

The FP5462 is a single chip composed of a 2.5V precision voltage reference regulator, totem-pole output stages, two pulse width modulation control circuits each with one error amplifier and one duty comparator (DTC). Its built-in functions includes under-voltage lockout circuit (UVLO) and short circuit protection circuit (SCP). With above features, it offers space and low cost solutions in many applications such as the DC / DC converter.

FP5462, a high performance IC, is designed to complete a control circuit with few external components. The circuit diagram of the typical application example is shown in below.

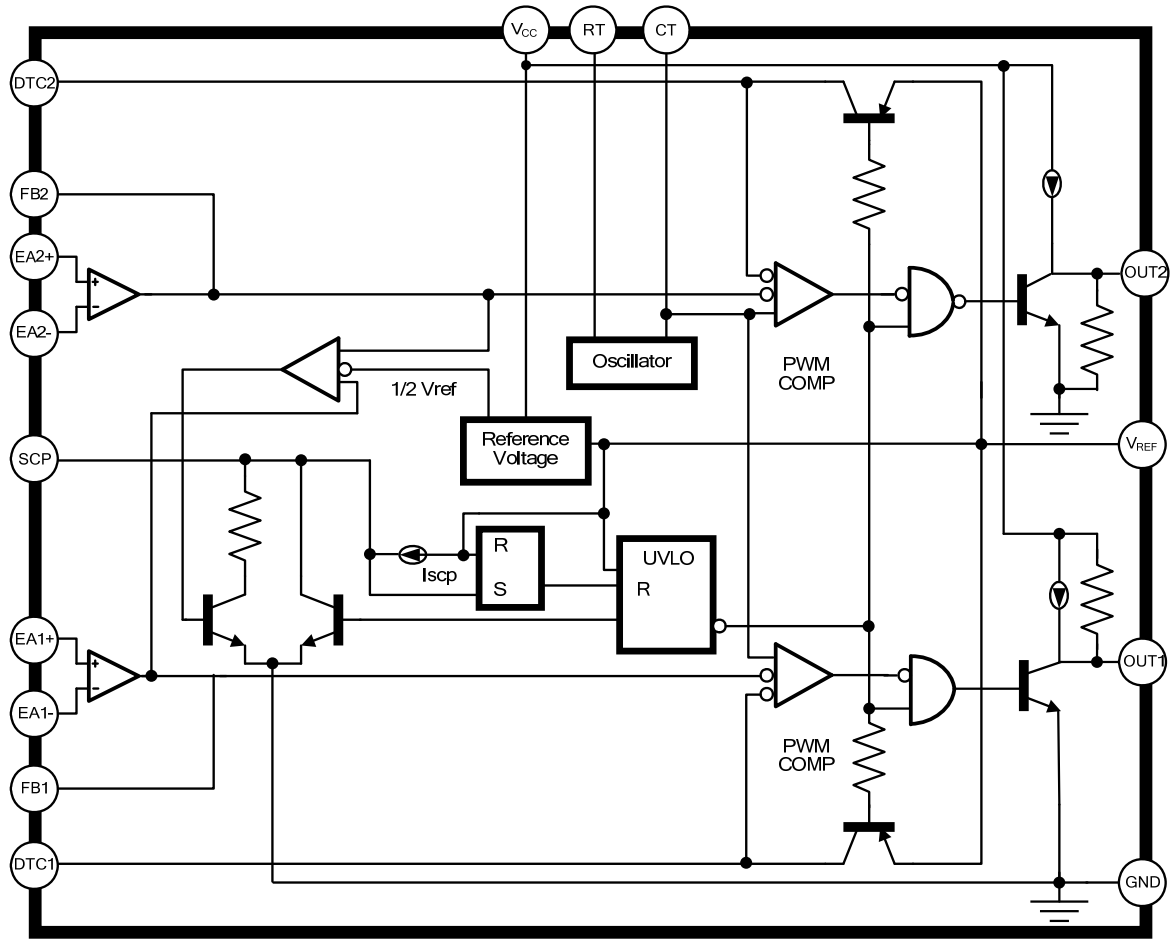
Features

- Wide Operating Voltage Range: 3.6~40V
- Fixed Reference Voltage: 2.5V
- Reference Voltage Precision: 1%
- Oscillator Frequency: Max. 500KHz
- Low Quiescent Supply Current Under 3.5mA
- Totem-pole Output Stage
- Variable Duty Control (DTC)
- UVLO Protection Function
- SCP Protection Function (Threshold Voltage: 1.3V)
- Package: SOP-16L / SSOP-16L

Applications

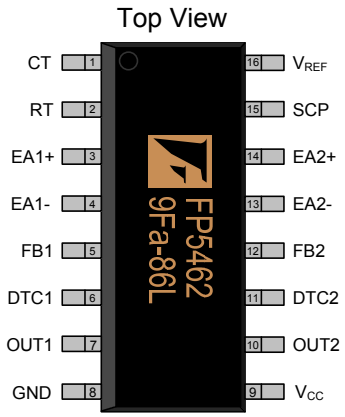
- DC / DC Converters for Video Cameras and TFT LCD Monitor Etc.
- 1-ch Boost/1-ch Buck Topology Converter

Function Block Diagram



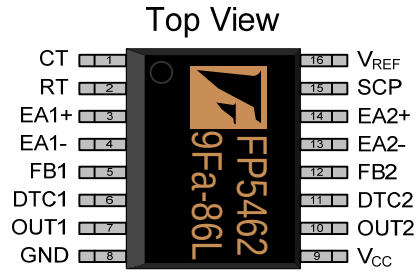
Pin Descriptions

SOP-16L



Name	No.	I / O	Description
CT	1	I	Connect a Capacitor to This Pin to Adjust Oscillator Frequency
RT	2	I	Connect a Resistor to This Pin to Adjust Oscillator Frequency
EA1+	3	I	Error Amplifier 1 Non-inverting Input
EA1-	4	I	Error Amplifier 1 Inverting Input
FB1	5	O	Error Amplifier 1 Output
DTC1	6	I	Output 1 Max. Duty Limit Pin
OUT1	7	O	Totem-pole Output 1
GND	8	P	IC Ground
V_{CC}	9	P	IC Power Supply
OUT2	10	O	Totem-pole Output 2
DTC2	11	I	Output 2 Max. Duty Limit Pin
FB2	12	O	Error Amplifier 2 Output
EA2-	13	I	Error Amplifier 2 Inverting Input
EA2+	14	I	Error Amplifier 2 Non-inverting Input
SCP	15	I	Short Circuit Protection Input
V_{REF}	16	O	2.5V Reference Voltage Output

SSOP-16L



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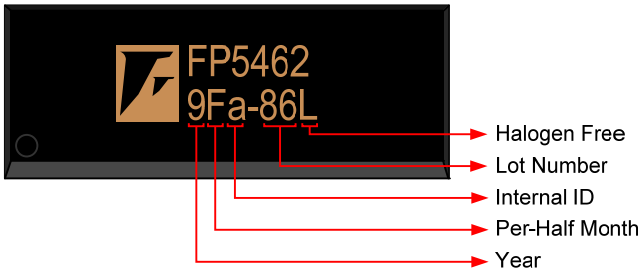
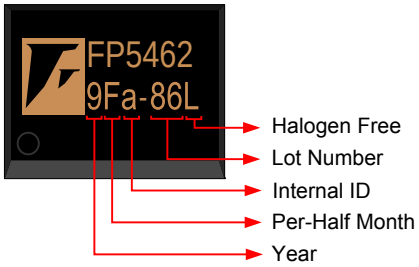
EA1+	3	I	Error Amplifier 1 Non-inverting Input
EA1-	4	I	Error Amplifier 1 Inverting Input
FB1	5	O	Error Amplifier 1 Output
DTC1	6	I	Output 1 Max. Duty Limit Pin
OUT1	7	O	Totem-pole Output 1
GND	8	P	IC Ground
V_{CC}	9	P	IC Power Supply
OUT2	10	O	Totem-pole Output 2
DTC2	11	I	Output 2 Max. Duty Limit Pin
FB2	12	O	Error Amplifier 2 Output
EA2-	13	I	Error Amplifier 2 Inverting Input
EA2+	14	I	Error Amplifier 2 Non-inverting Input
SCP	15	I	Short Circuit Protection Input
V_{REF}	16	O	2.5V Reference Voltage Output

Marking Information

SOP-16L



SSOP-16L



Halogen Free: Halogen free product indicator

Lot Number: Wafer lot number's last two digits

For Example: 132386TB → 86

Internal ID: Internal Identification Code

Per-Half Month: Production period indicated in half month time unit

For Example: January → A (Front Half Month), B (Last Half Month)

February → C (Front Half Month), D (Last Half Month)

Year: Production year's last digit

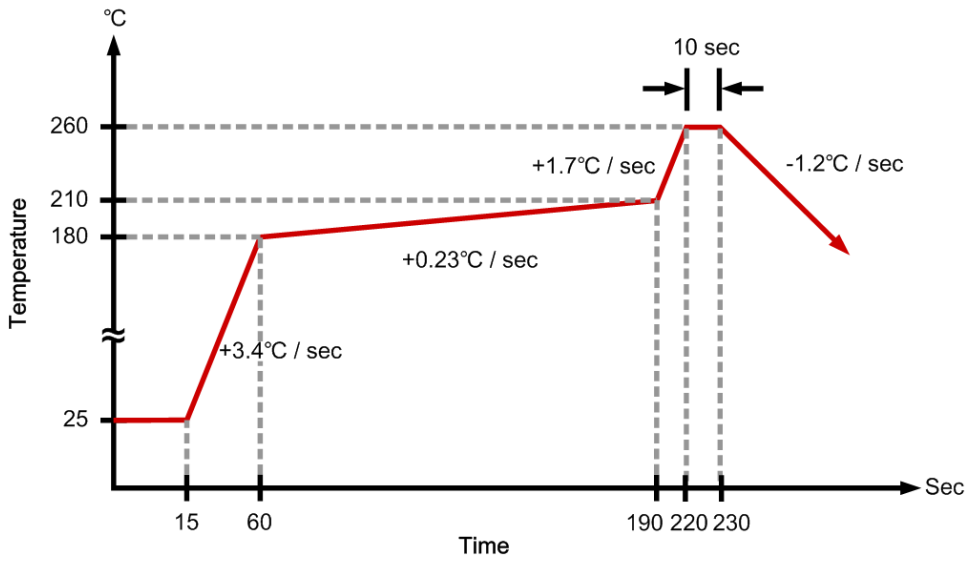
Ordering Information

Part Number	Operating Temperature	Package	MOQ	Description
FP5462DR-LF	-20°C ~ +85°C	SOP-16L	2500EA	Tape & Reel
FP5462RR-LF	-20°C ~ +85°C	SSOP-16L	2500EA	Tape & Reel

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power Supply Voltage	V_{CC}				40	V
Differential Input Voltage	V_{id}				20	V
Output Current	Io				150	mA
Maximum Junction Temperature	T_J				+150	°C
Thermal Resistance Junction to Ambient	θ_{JA}	SOP-16L			+150	°C / W
		SSOP-16L			+220	°C / W
Maximum Power Dissipation	P_D	SOP-16L , T_A=25℃			830	mW
		SOP-16L , T_A=70℃			530	mW
		SSOP-16L, T_A=25℃			570	W
		SSOP-16L, T_A=70℃			360	W
Storage Temperature Range			-65		+150	℃
Lead Temperature (soldering, 10 sec)					+260	℃

Suggested IR Re-flow Soldering Curve



Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage			3.6		40	V
Operating Temperature			-20		+85	℃

DC Electrical Characteristics (V_{CC}= 6V, f=200kHz, unless otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Reference section						
Output Voltage (pin 16)	V_{REF}	I_O=1mA	2.475	2.5	2.525	V
Output Voltage Change with Temperature		T_A=-20℃ to +25℃	-1	-0.1	+1	%
		T_A=+25℃ to +85℃	-1	-0.2	+1	%
Input Voltage Regulation	$\triangle V_{REF}$ / V_{REF}	V_{CC}=3.6V～40V		2	12.5	mV
Output Voltage Regulation	$\triangle V_{REF}$ / V_{REF}	Io = 0.1mA to 1 mA		1	7.5	mV
Short-circuit Output Current	I_{SHORT}	V_O=0	3	10	30	mA
Under Voltage Lockout Section						
Upper Threshold Voltage (V_{CC})	V_{UPPER}	$I_{O\ (REF)}$ = 0.1 mA, T_A=25℃		2.72		V
Lower Threshold Voltage (V_{CC})	V_{LOW}			2.6		V
Hysteresis (V_{CC})	V_{HYS}		80	120		mV
Reset Threshold Voltage(V_{CC})	V_{RESET}		1.5	1.9		V
Short-circuit Protection Control Section						
Input Threshold Voltage (SCP)	V_{TH}	T_A= 25℃	1.2	1.3	1.5	V
Standby Voltage (SCP)	$V_{STANDBY}$	No Pullup	220	265	300	mV
Latched Input Voltage (SCP)	V_{LATCH}	No Pullup		220	280	mV
Input (Source) Current	I_{SOURCE}	V_I=0.7V, T_A=25℃	-1	-2.0	-2.5	μA
Comparator Threshold Voltage (Feedback)	$V_{COMP\ (TH)}$			1.30		V
Oscillator Section						
Frequency	f	C_T=330pF, R_T=10K		200		KH_Z
Standard Deviation of Frequency	$\triangle$f	C_T=330pF, R_T=10K		10		%
Frequency Change with Voltage	$\triangle$f / $\triangle$V	V_{CC}=3.6V to 40V		1		%
Frequency Change with Temperature	$\triangle$f / $\triangle$T	T_A=-20℃ to 25℃	-2	-0.4	+2	%
		T_A=25℃ to 85℃	-2	-0.2	+2	%
Duty Control Section						
Input Bias Current (DTC)	I_{BIAS}				1	μA
Latch mode (Source) Current(DTC)	I_{SOURCE}	T_A=25℃	-80	-200		μA
Latched Input Voltage (DTC)	V_{LATCH}	I_O=40μA	2.3			V
Input Threshold Voltage at f=10kH_Z (DTC)	V_{TH}	Zero Duty Cycle		2.05	2.25	V
		Maximum Duty Cycle	1.2	1.45		V

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Error Amplifier Section						
Input Offset Voltage	V_{IO}	V_{FB}=1.25V	-6		+6	mV
Input Offset Current	I_{IO}	V_{FB}=1.25V	-100		+100	nA
Input Bias Current	I_{BIAS}	V_{FB}=1.25V		160	500	nA
Common Mode Input Voltage Range	V_{ICM}	V_{CC}=3.6V to 40V	0.3		1.6	nA
Open Loop Voltage Gain	A_{VO}	R_F=200KΩ	70	80		dB
Unity Gain Bandwidth	BW			1.5		MH_Z
Common Mode Rejection Ratio	CMRR		60	80		dB
Positive Output Voltage Swing	V_{POS}		V_{REF}-0.3			V
Negative Output Voltage Swing	V_{NEG}				1	V
Output (Sink) Current (Feedback Pin)	I_{SINK}	V_{ID}= -0.1V, V_O=1.25V	1	4.0		mA
Output (Source) Current (Feedback Pin)	I_{SOURCE}	V_{ID}=0.1V, V_O=1.25V	-40	-90		μA
Output Section						
V_{OUT} Low Voltage	V_{OL}	I_{SINK}=20mA		0.8	1.2	V
		I_{SINK} =130mA, V_{CC}=15V		1.6	2.2	V
V_{OUT} High Voltage	V_{OH}	I_{SOURCE} =20mA	4.0	4.5		V
		I_{SOURCE} =130mA, V_{CC}=15V	13	13.5		V
Rise Time	t_R	T_J=25°C, C_L=1nF		80	120	nS
Fall Time	t_F	T_J=25°C, C_L=1nF		30	60	nS
PWM Comparator Section						
Input Threshold Voltage at f=10kHz (Feedback)	V_{TH}	Zero Duty Cycle		2.05	2.25	V
		Maximum Duty Cycle	1.2	1.45		V
Total Device						
Standby Supply Current	$I_{STANDBY}$	Off State		2.3	3.0	mA
Average Supply Current	I_{AVE}	R_T=10KΩ		2.8	3.5	mA

Typical Operating Characteristics

TRIANGLE OSCILLATOR FREQUENCY
VS
TIMING RESISTANCE

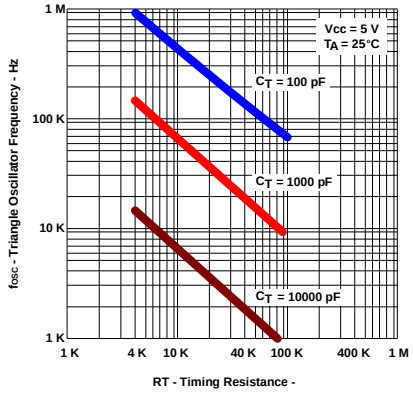


Figure 1

OSCILLATOR FREQUENCY VARIATION
VS
FREE-AIR TEMPERATURE

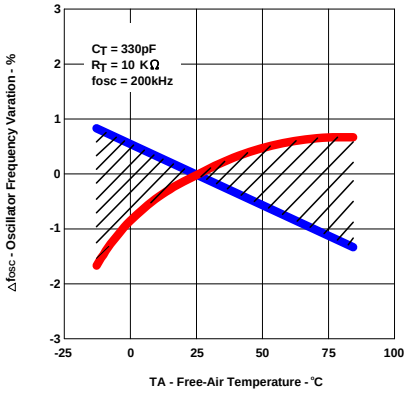


Figure 2

TRIANGLE WAVEFORM SWING VOLTAGE
VS
TIMING CAPACITANCE

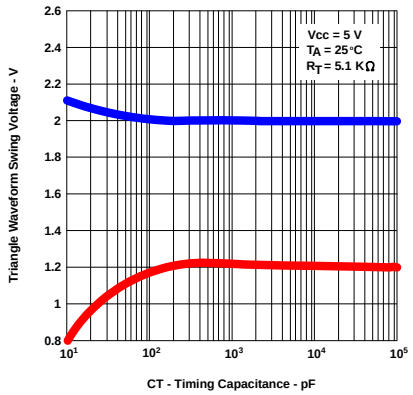


Figure 3

TRIANGLE WAVEFORM PERIOD
VS
TIMING CAPACITANCE

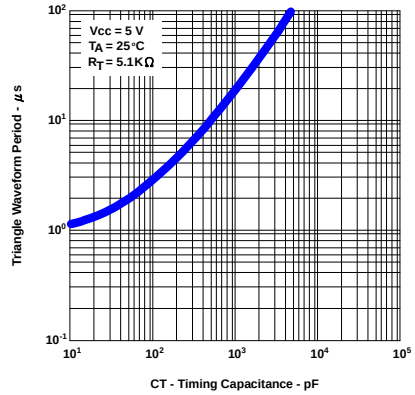


Figure 4

REFERENCE OUTPUT VOLTAGE VARIATION
VS
FREE-AIR TEMPERATURE

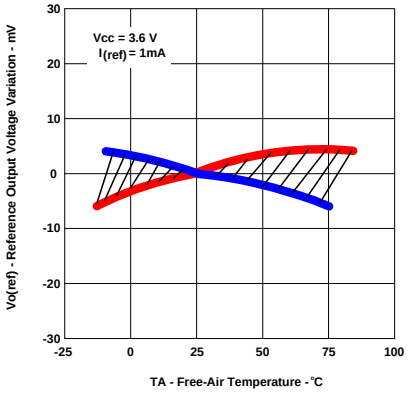


Figure 5

REFERENCE OUTPUT VOLTAGE VARIATION
VS
FREE-AIR TEMPERATURE

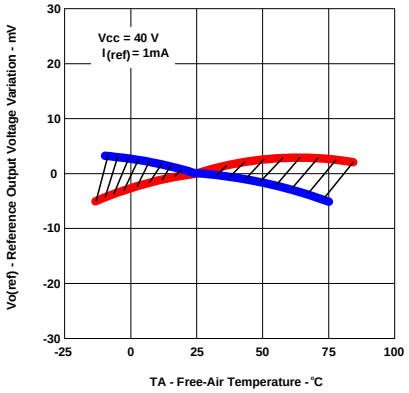


Figure 6

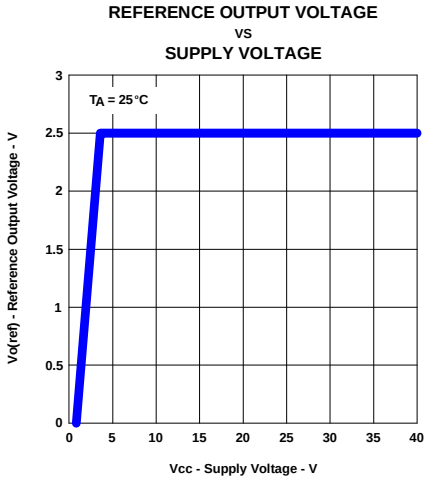


Figure 7

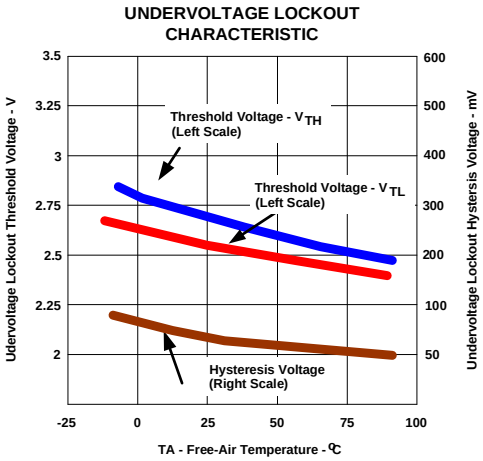


Figure 8

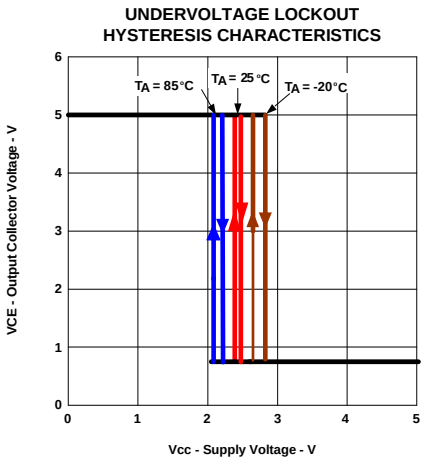


Figure 9

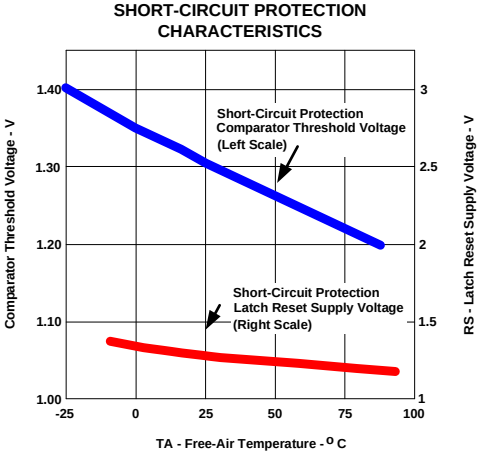


Figure 10

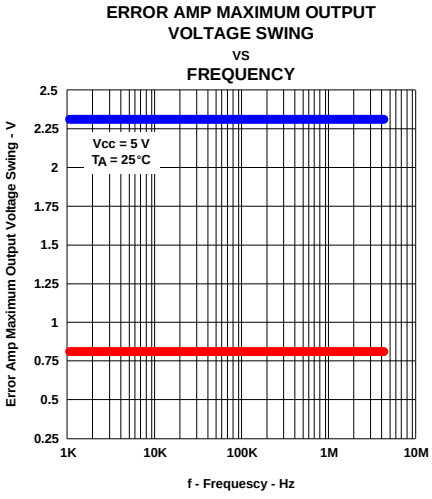
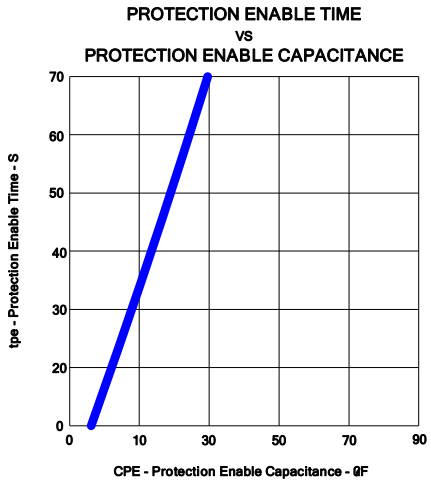


Figure 11


PROTECTION ENABLE TIME
VS
PROTECTION ENABLE CAPACITANCE
tpe - Protection Enable Time - S
70
60
50
40
30
20
0
0
10
30
50
70
90
CPE - Protection Enable Capacitance - ΩF

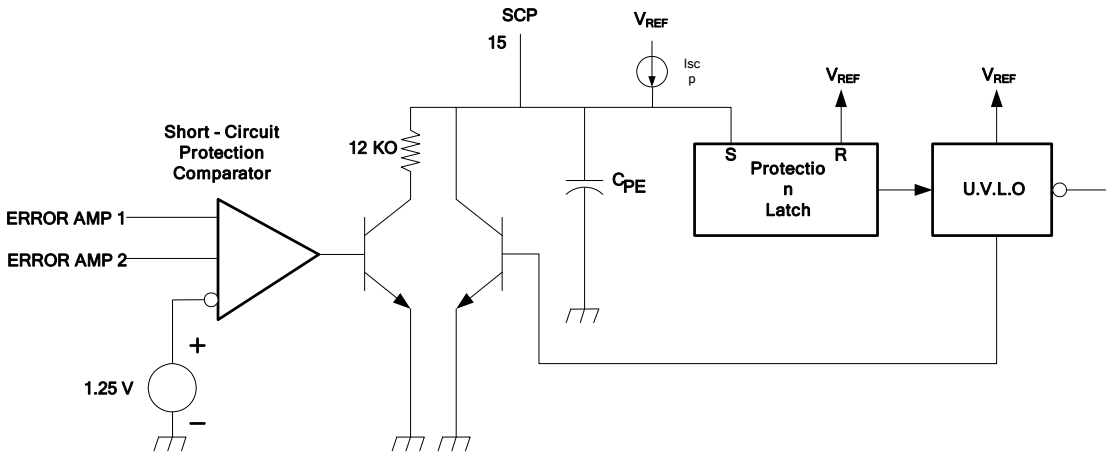

SCP
15
VREF
Isc
p
VREF
VREF
Short - Circuit
Protection
Comparator
12 KO
CPE
S
R
Protectio
n
Latch
U.V.L.O
ERROR AMP 1
ERROR AMP 2
+
1.25 V
−

Figure 12

OUTPUT TRANSISTOR ON DUTY CYCLE
VS
DEAD - TIME INPUT VOLTAGE

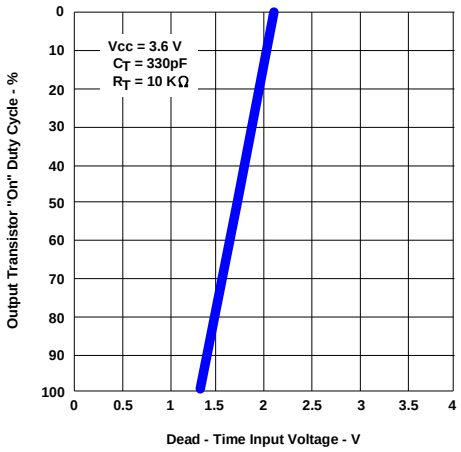


Figure 13

STANDBY CURRENT
VS
SUPPLY VOLTAGE

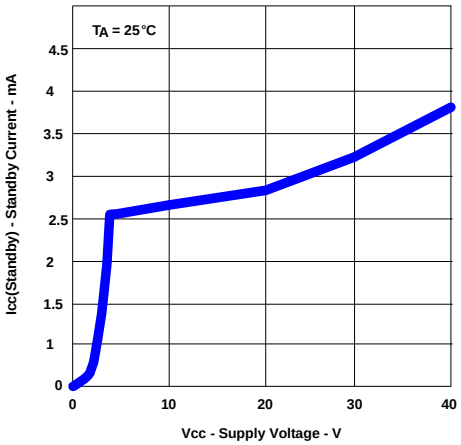


Figure 14

STANDBY CURRENT
VS
FREE - AIR TEMPERATURE

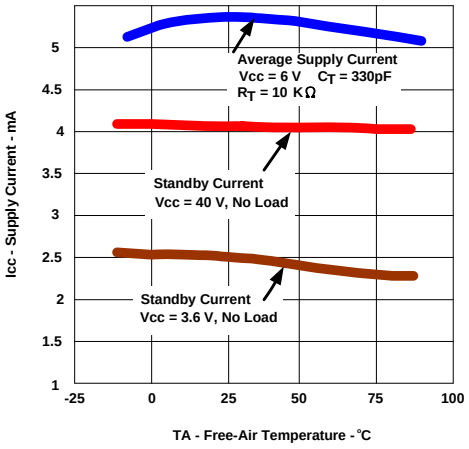


Figure 15

GAIN (AMPLIFIER IN UNITY-GAIN CONFIGURATION)
VS
FREQUENCY

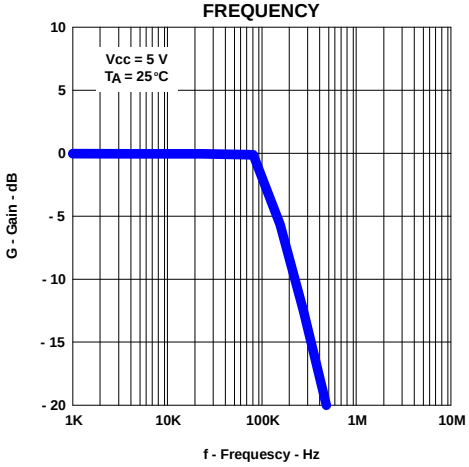
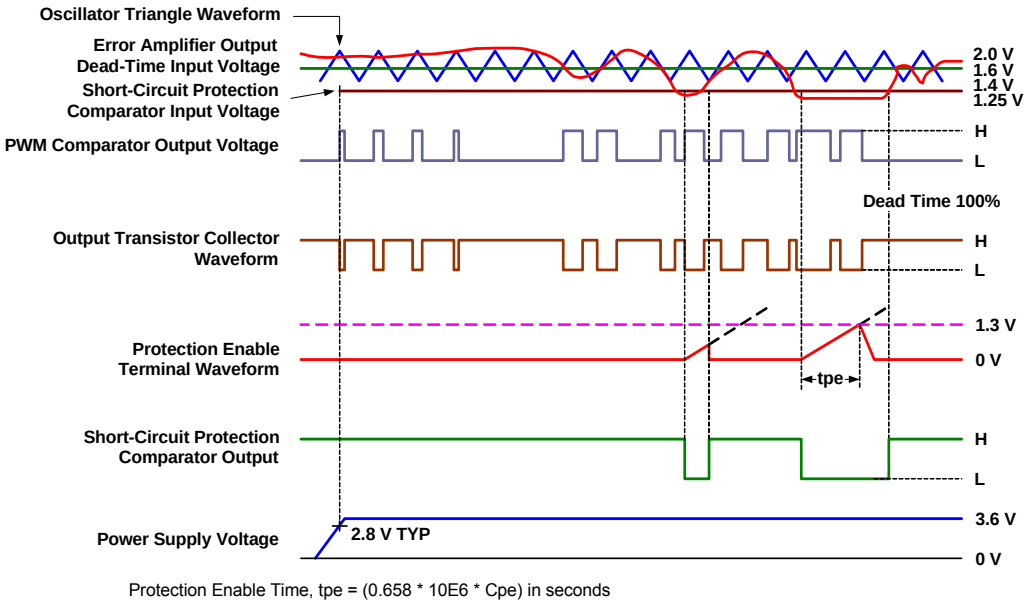


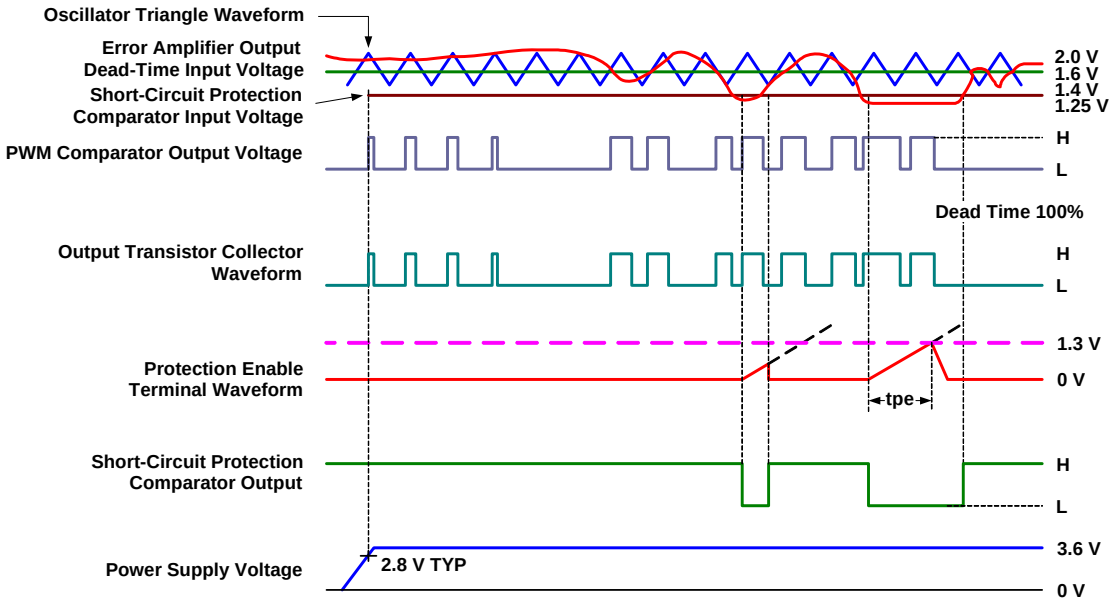
Figure 16

Timing Waveform



Protection Enable Time, tpe = (0.658 * 10E6 * Cpe) in seconds

Figure 17 FP5462 CH1 Timing Diagram



Protection Enable Time, tpe = (0.658 * 10E6 * Cpe) in seconds

Figure 18 FP5462 CH2 Timing Diagram

Function Description

Voltage Reference

FP5462 includes an internal 2.5V reference regulator to provide its internal circuits' voltage bias. It also can be used with external resistive divider which connecting to the IC error amplifier inverting input to provide output feedback reference (see Fig 19).

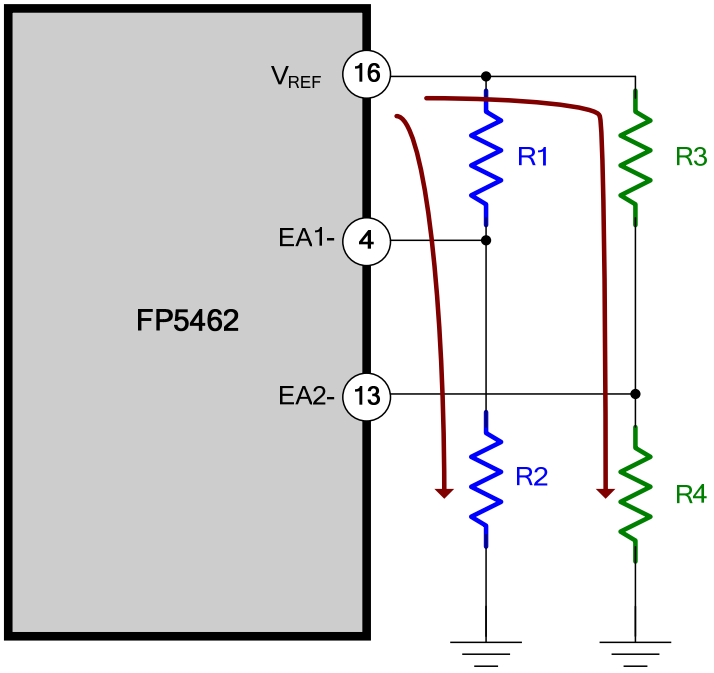


Figure 19 Reference and Error Amplifiers with Resistive Dividers

The error amplifier inverting input (EA1- or EA2-) reference voltage equations are shown as followings:

$$V_{EA1-} = V_{REF}(2.5V) \times \frac{R2}{R1+R2}$$

$$V_{EA2-} = V_{REF}(2.5V) \times \frac{R4}{R3+R4}$$

Error Amplifier

The error amplifiers of FP5462 compare the feedback voltage from the resistive dividers of DC-DC converter's output with the reference bias (see Fig 20) and generate the error signal for the PWM comparator.

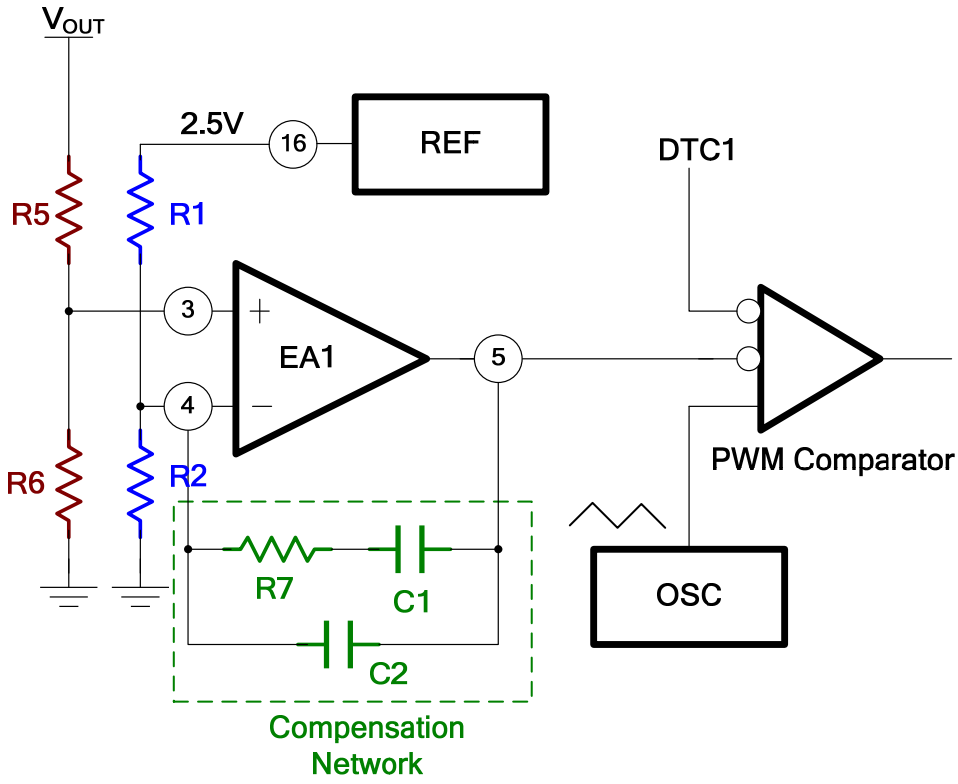


Figure 20 Error Amplifier with Feedback / Compensation Circuits

The Buck converter output voltage:

$$V_{OUT} = \left(1+\frac{R5}{R6}\right)\times\left(\frac{R2}{R1+R2}\right)\times 2.5V$$

Error Amplifier Gain:

$$Av = 1+\frac{1+sR7C1}{sRi(C1+C2)(1+sR7C2)} \quad , Ri=R1//R2$$

Error Amplifier Zero and Pole Frequency:

$$F_z = \frac{1}{2\pi R7C1}, \qquad Fp = \frac{1}{2\pi R7C2}$$

Oscillator / PWM Comparator

The oscillator frequency can be adjusted from 20KHz to 500KHz by the capacitor (CT) and resistor (RT) which are connected with pin1 and pin2 of FP5462 respectively. The tri-angular waveform on CT pin would be compared with output signal of the error amplifier and duty control voltage. Figure 21 shows the relationship of oscillator, error amplifier and PWM comparator. Figure 22 shows the FP5462 pin waveforms.

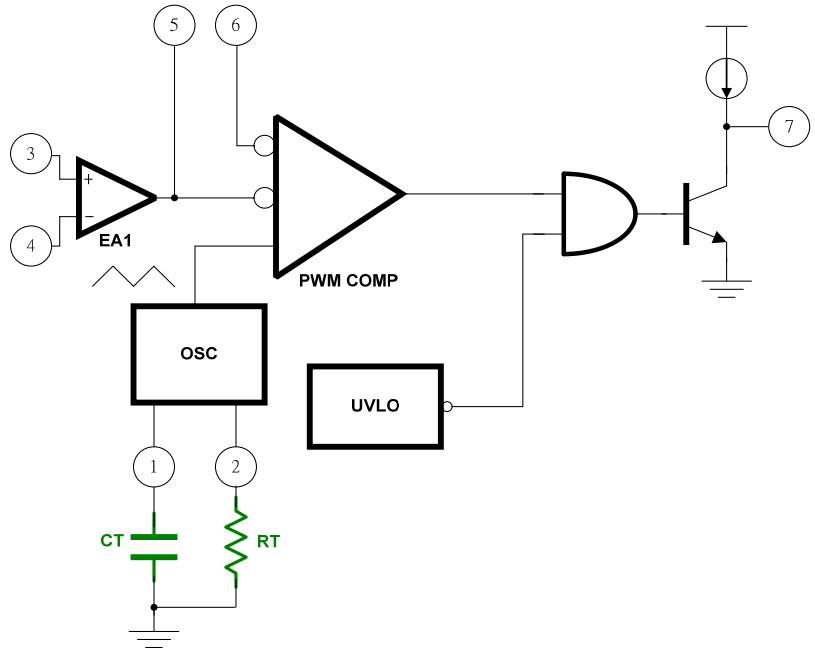


Figure 21 Oscillator / PWM Comparator with Frequency RC circuits

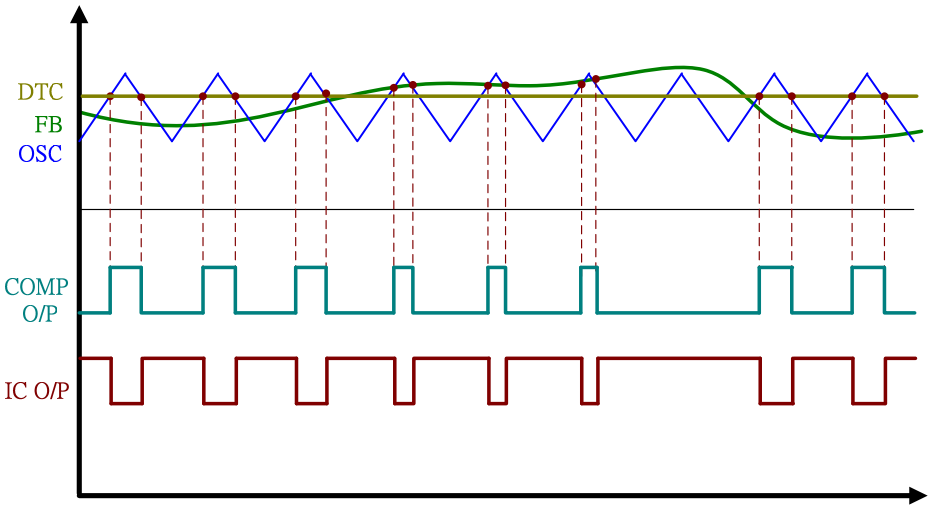


Figure 22 FP5462 Timing Waveforms

The relationship of oscillator waveform and duty control voltage is shown below (see Fig 23):

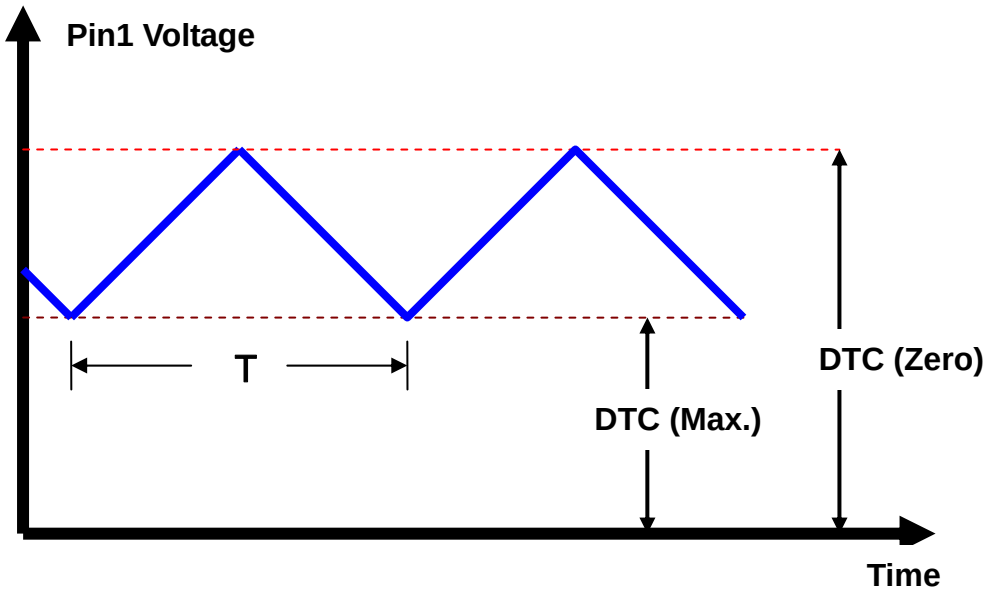


Figure 23 Oscillator Frequency with DTC voltage

The oscillator frequency can be calculated by:

$$f = \frac{VT}{2 \times CT \times RT \times (Vzero - V\,max.)}$$

Duty Control / Soft-Start

The duty control (DTC) is a function for the PWM duty cycle limitation. If the DTC voltage is lower than DTC maximum voltage (1.35V typically), the PWM duty cycle can be as large as 100% cycle. If the DTC voltage is higher than DTC zero voltage (2.05V typically), the PWM duty cycle will always be turned-off (zero duty).

The system of DC-DC converters can use DTC function with an external RC for Power-On soft-start (see Figure 24).

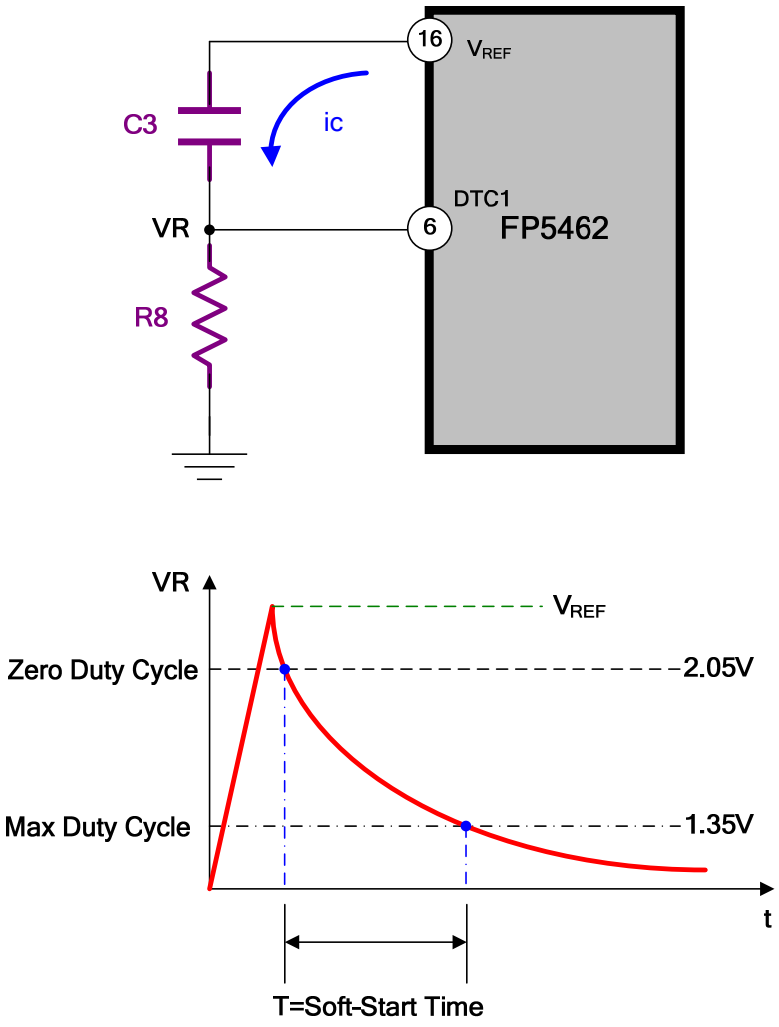


Figure 24 DTC Soft-start RC Circuit and Waveform

The soft-start time equation:

$$t = 0.616 \times R8 \times C3$$

Short Circuit Protection

FP5462 has a protection function for short circuit condition. When the DC-DC converter output voltage drops to a very low voltage, the error amplifier IN+ pin would also have a low feedback voltage. The error amplifier will pull its output to a low voltage state. This output voltage is compared with a 1.25V reference voltage by the SCP comparator. The SCP comparator then turns off transistor Q1 and SCP capacitor is charged up. When SCP voltage is higher than a threshold voltage (1.3V typically), this SCP state is latched. The DTC pins are charged up to disable PWM output (zero duty) and the SCP pin voltage is discharged by Q2 transistor.

Once SCP state is latched, the controller no longer output PWM control pulses. It can only be reset by reducing the input power supply voltage to below UVLO trigger point (2.6V) (see Fig 25).

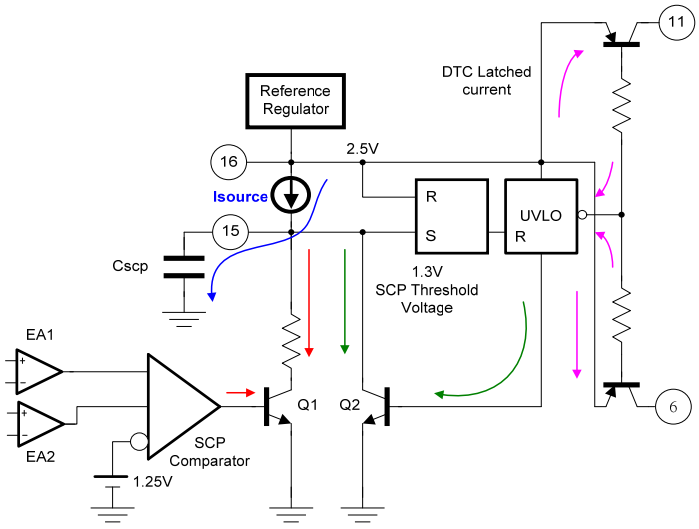


Figure 25 Internal SCP Detection / Control Circuits

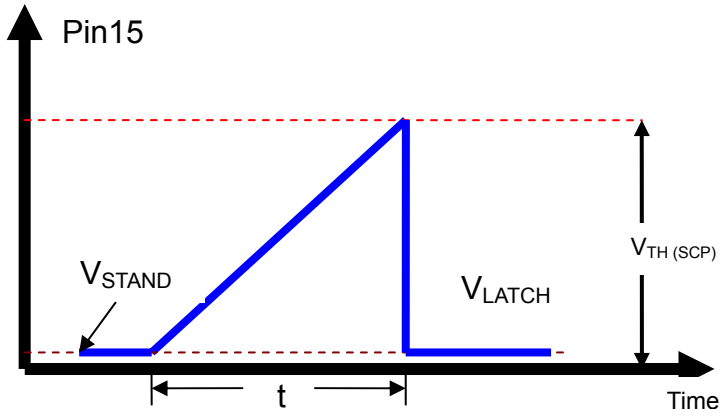


Figure 26 SCP Waveform (SCP active)

The SCP time equation is:

$$t = \frac{C_{SCP} \times \left(V_{th(scp)} - V_{sb}\right)}{I_{source}}$$

Application Information

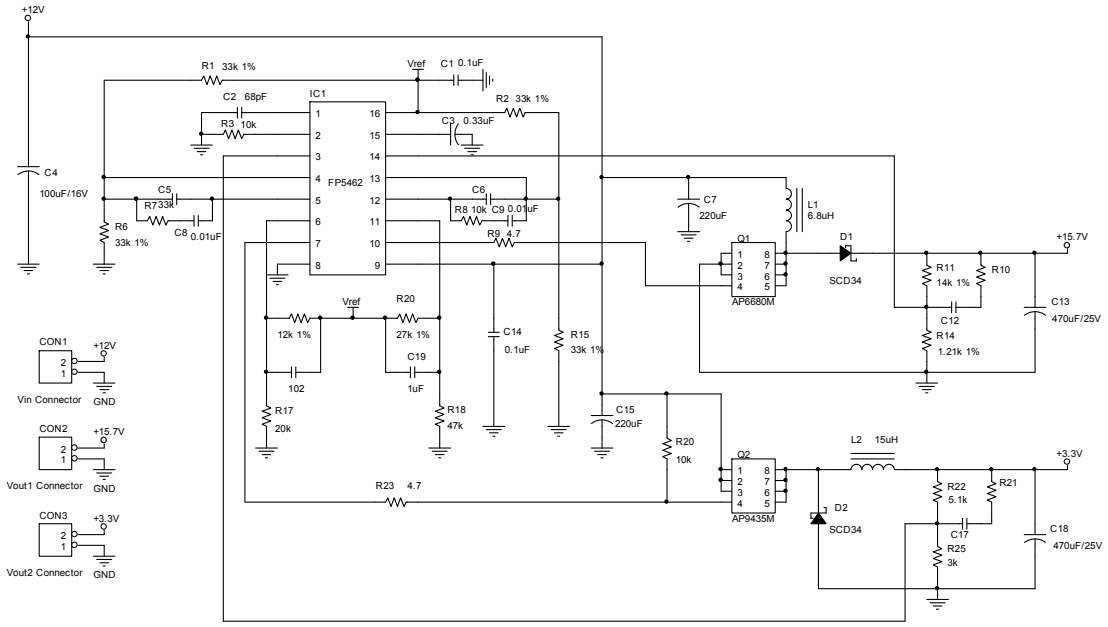


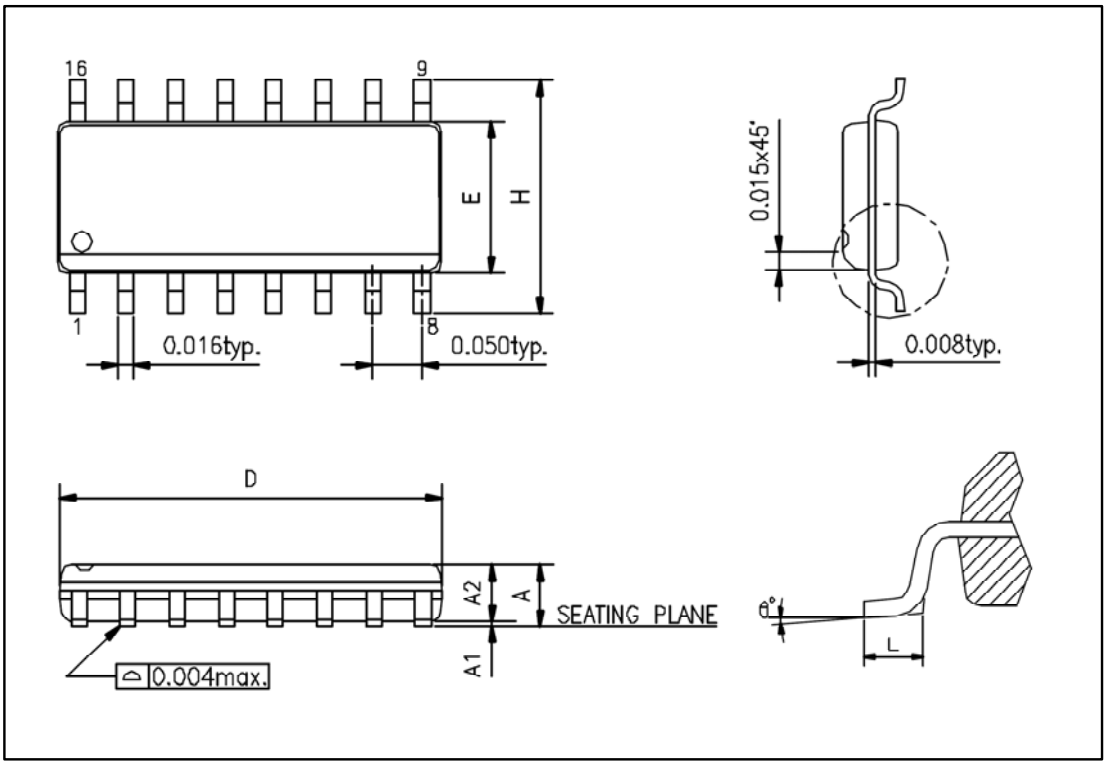
Figure 23. 2-Channel DC-DC Converter Circuit

Note:

1. The IN1- and IN2- is 1.25V, half of V_{REF} voltage, because R1=R6 and R2=R15.
2. The R18, R20 and C19 compose a DTC circuits during boost regulator power-on.
3. The R11 and R14 are the boost regulator output voltage feedback resistors.
4. The R22 and R25 are the buck regulator output voltage feedback resistors.
5. The R7, C5 and C8 compose the compensation circuit for FP5462 error amplifier 1.
6. The R8, C6 and C9 compose the compensation circuit for FP5462 error amplifier 2.
7. The R3 and C2 compose an external RC circuit for FP5462 internal oscillator.
8. The C3 is FP5462 short circuit protection delay time capacitor.

Package Outline

SOP-16L



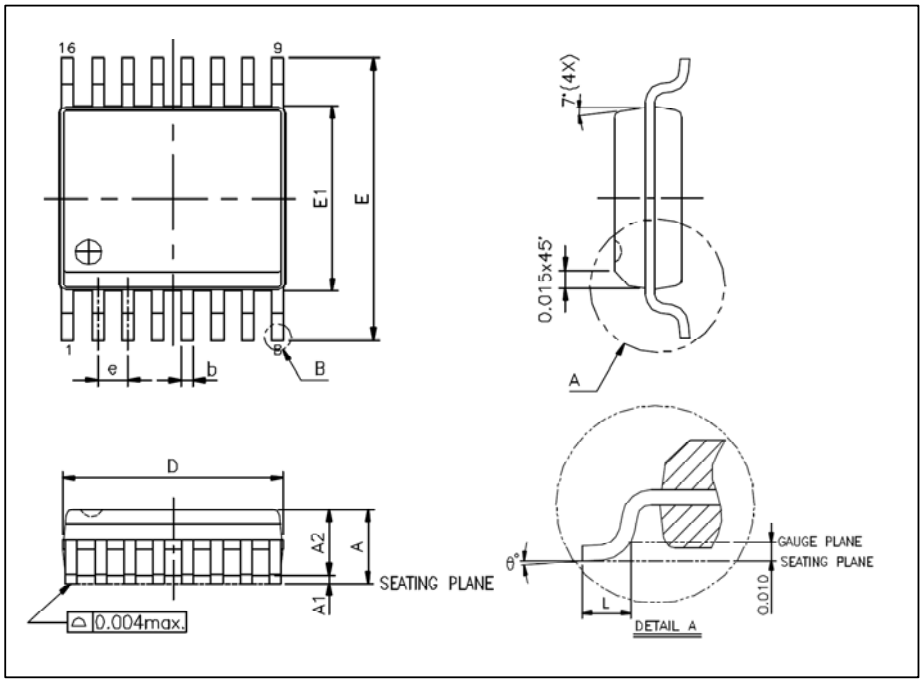
UNIT: mm

Symbols	Min. (mm)	Max. (mm)
A	1.346	1.752
A1	0.101	0.254
A2	1.244	1.651
D	9.804	10.007
E	3.810	3.987
H	5.791	6.197
L	0.406	1.270
θ°	0°	8°

Note:

1. Package dimensions are in compliance with JEDEC outline: MS-012 AC.
2. Dimension “D” does not include molding flash, protrusions or gate burrs.
3. Dimension “E” does not include inter-lead flash or protrusions.

SSOP-16L



UNIT: mm

Symbols	Min. (mm)	Max. (mm)
A	1.346	1.752
A1	0.101	0.254
A2		1.498
b	0.203	0.304
b1	0.203	0.279
c	0.177	0.254
c1	0.177	0.228
D	4.800	5.003
E1	3.810	3.987
E	5.791	6.197
L	0.406	1.270
e	0.635 BASIC	
θ°	0°	8°

Note:

1. Package dimensions are in compliance with JEDEC outline: MO-137 AB.
2. Dimension “D” does not include molding flash, protrusions or gate burrs.
3. Dimension “E” does not include inter-lead flash or protrusions