2576M3K-XX SIMPLE SWITCHER 3A Step-Down Voltage Regulator

August 2007-revised July 2010

GENERAL DESCRIPTION

The 2576M3K-XX series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 15V and adjustable output versions.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation and a fixed-frequency oscillator.

The 2576M3K series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required.

A standard series of inductors optimized for use with the 2576M3K is available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed ±4% tolerance on the output voltage within specified input voltages and output load conditions, and ±10% tolerance on the oscillator frequency. An external shutdown is included, featuring 50μA (typical) standby current. The output switch includes cycle-by-cycle current limiting, as well as a thermal shutdown for full protection under fault conditions.

FEATURES

- 3.3V, 5V, 12V, 15V and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V ± 3% max over line and load conditions
- Guaranteed 3A output current
- Wide input voltage range, 40V
- Requires only 4 external components
- 52 kHz fixed frequency oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

APPLICATIONS

- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

PIN ASSIGNMENT

TO-220, TO-263:	SOP-8L
(for $I_{LOAD} \leq 3A$)	(for $I_{LOAD} \leq 2A$)
1 - V_{IN}	1 - V_{IN}
2 - OUTPUT	2 - OUTPUT
3 - GND	3 - FEEDBACK (FB)
4 - FEEDBACK (FB)	4 - $\overline{\text{ON/OFF}}$
5 - $\overline{\text{ON/OFF}}$	5, 6, 7, 8 - GND

For the best thermal performance, generous amounts of printed circuit board copper should be used in the board layout.

TYPICAL APPLICATION (Fixed Output Voltage Versions)

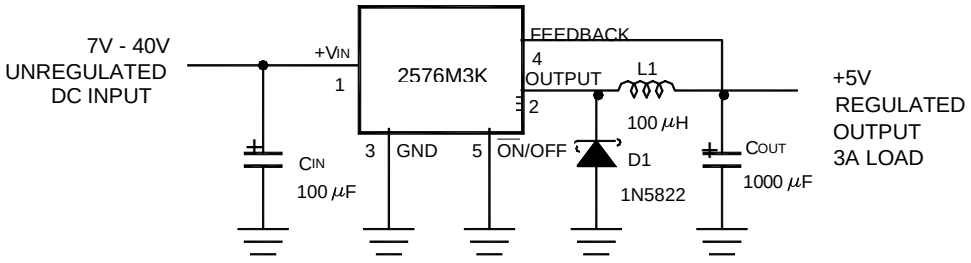

FIGURE 1

2576M3K-XX SIMPLE SWITCHER 3A Step-Down Voltage Regulator

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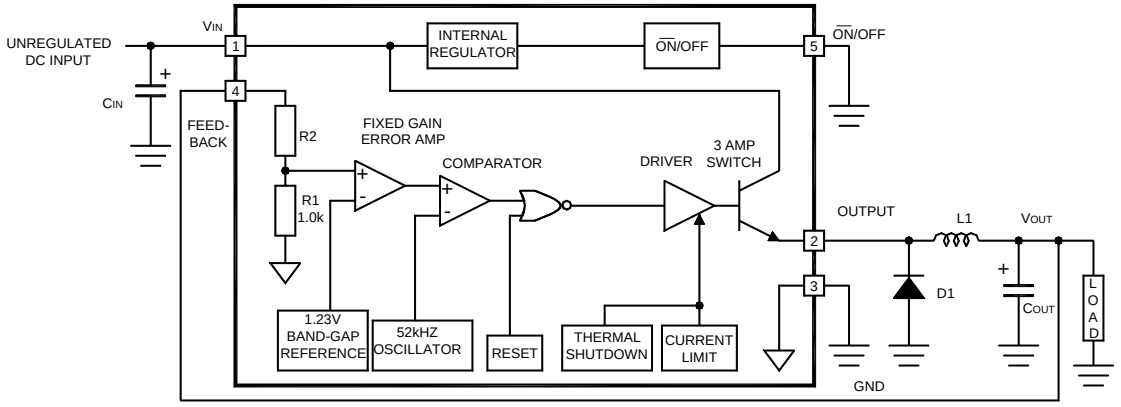
BLOCK DIAGRAM



Vo=3.3V, R2 = 1.7K
Vo=5V, R2 = 3.1K
Vo=12V, R2 = 8.84K
Vo=15V, R2 = 11.3K
For ADJ version R1 = Open, R2 =0Ω

ORDERING INFORMATION

Temperature Range	Output Voltage				
	3.3	**5.0**	**12**	**15**	**ADJ**
-40°C ≤ T_A≤ 125°C	2576M3K-3.3	2576M3K-5.0	2576M3K-12	2576M3K-15	2576M3K-ADJ

ABSOLUTE MAXIMUM RATING (Note 1)

Maximum supply voltage	45V
$\overline{ON}$/OFF pin input voltage	-0.3V≤V≤+V_{IN}
Output voltage to GND (Steady-state)	-0.8V
Power dissipation	Internally-limited
Storage temperature range	-65°C to +150°C
Maximum junction temperature	150°C
Maximum ESD rating (C=100pF, R=1.5kOhm)	2kV
Lead temperature (soldering, 10 seconds)	260°C
OPERATING RATINGS	
Temperature range	-40°C ≤ T_J ≤ +125°C
Supply voltage	40V

2576M3K-3.3
ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure2*					
V_{OUT}	Output voltage	V_{IN} =12V, I_{LOAD} =0.5A Circuit of *Figure 2*	3.3	3.234 3.366	V(Min) V(Max)
V_{OUT}	Output voltage	6V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	3.3	3.168/**3.135** 3.432/**3.465**	V(Min) V(Max)
η	Efficiency	V_{IN} =12V, I_{LOAD} =3A	75		%

2576M3K-5.0
ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_j = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output voltage	V_{IN} =12V, I_{LOAD} =0.5A Circuit of *Figure 2*	5.0	4.900 5.100	V(Min) V(Max)
V_{OUT}	Output voltage	8V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	5.0	4.800/**4.750** 5.200/**5.250**	V(Min) V(Max)
η	Efficiency	V_{IN} =12V, I_{LOAD} =3A	77		%

2576M3K-12

ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} =25V, I_{LOAD} =0.5A Circuit of *Figure 2*	12	11.76 12.24	V(Min) V(Max)
V_{OUT}	Output Voltage	15V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	12	11.52/**11.40** 12.48/**12.60**	V(Min) V(Max)
η	Efficiency	V_{IN} =15V, I_{LOAD} =3A	88		%

2576M3K-15

ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} =25V, I_{LOAD} =0.5A Circuit of *Figure 2*	15	14.70 15.30	V(Min) V(Max)
V_{OUT}	Output Voltage	18V≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	15	14.40/**14.25** 15.60/**15.75**	V(Min) V(Max)
η	Efficiency	V_{IN} =18V, I_{LOAD} =3A	88		%

2576M3K-ADJ

ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Feedback Voltage	V_{IN} =12V, I_{LOAD} =0.5A, V_{OUT} =5V Circuit of *Figure 2*	1.230	1.217 1.243	V(Min) V(Max)
V_{OUT}	Feedback Voltage	8V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A, V_{OUT} =5V Circuit of *Figure 2*	1.230	1.193/1**.180** 1.267/1**.280**	V(Min) V(Max)
η	Efficiency	V_{IN} =12V, I_{LOAD} =3A, V_{OUT} =5V	77		%

2576M3K-A1

ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for TJ = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Feedback voltage	V_{IN} =12V, I_{LOAD} =0.5A, V_{OUT} =5.05V Circuit of *Figure 2*	1.242	1.229 1.255	V(Min) V(Max)
V_{OUT}	Feedback voltage	8V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A, V_{OUT} =5.05V Circuit of *Figure 2*	1.242	1.205/**1.192** 1.279/**1.292**	V(Min) V(Max)
η	Efficiency	V_{IN} =12V, I_{LOAD} =3A, V_{OUT} =5.05V	77		%

2576M3K-A2

Electrical Characteristics

Specifications with standard type face are for TJ = 25°C, and those with **boldface type** apply over the full operating Temperature Range.

Symbol	Parameter	Conditions	Typ	Limit (Note 2)	Units (Limits)
SYSTEM PARAMETERS (Note 3) Test Circuit *Figure 2*					
V_{OUT}	Feedback voltage	V_{IN} =12V, I_{LOAD} =0.5A, V_{OUT} =4.975V Circuit of *Figure 2*	1.224	1.211 1.237	V(Min) V(Max)
V_{OUT}	Feedback voltage	8V ≤ V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A, V_{OUT} =4.975V Circuit of *Figure 2*	1.224	1.187/**1.174** 1.261/**1.274**	V(Min) V(Max)
η	Efficiency	V_{IN}=12V, I_{LOAD} =3A,V_{OUT} =4.975V	77		%

ALL OUTPUT VOLTAGE VERSIONS

ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range. Unless otherwise specified, V_{IN} =12V for the 3.3V, 5V and adjustable versions, V_{IN} =25V - for the 12V version, and V_{IN} =30V - for the 15V version, I_{LOAD} =500mA.

Symbol	Parameter	Conditions	2576M3K-XX		Units (Limits)
			Typ	Limit (Note 2)	
DEVICE PARAMETERS					
I_B	Feedback bias current	V_{OUT} =5V (adjustable version only)	50	100/**500**	nA
F_O	Oscillator frequency	**(Note 8)**	52	 47/**42** 58/**63**	kHz kHz (Min) kHz (Max)
V_{SAT}	Saturation voltage	I_{OUT} =3A **(Note 4)**	1.4	 1.6/1**.8**	V V(Max)
$DC_{(Max)}$	Max duty cycle (ON)	**(Note 5)**	98	 93	% %(Min)
I_{CL}	Current limit	**(Notes 4, 8)**	5.8	 4.2/**3.5** 6.9/**7.5**	A A(Min) A(Max)
I_L	Output leakage current	**(Notes 6, 7)**: Output = 0V Output = -0.8V Output = -0.8V	 7.5	2 30	mA(Max) mA mA(Max)

I_Q	Quiescent current	**(Note 6)**	5	10	mA mA(Max)
I_{STBY}	Standby quiescent current	$\overline{ON}$/OFF pin = 5V (OFF)	50	200	μA μA(Max)

ALL OUTPUT VOLTAGE VERSIONS

Electrical Characteristics (Continued)

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over the full operating Temperature Range. Unless otherwise specified, V_{IN} =12V is for the 3.3V, 5V, and Adjustable version, V_{IN} =25V for the 12V version, and V_{IN} =30V for the 15V version, I_{LOAD} =500mA.

Symbol	Parameter	Conditions	2576M3K-XX		Units (Limits)
			Typ	Limit (Note 2)	
$\overline{ON}$/OFF CONTROL					
V_{IH}	$\overline{ON}$/OFF pin logic input level	V_{OUT} = 0V	1.4	2.2/**2.4**	V(Min)
V_{IL}		V_{OUT} = nominal output voltage	1.2	1.0/**0.8**	V(Max)
I_{IH}	$\overline{ON}$/OFF pin input current	$\overline{ON}$/OFF pin = 5V (OFF)	12	30	μA μA(Max)
I_{IL}		$\overline{ON}$/OFF pin = 0V (ON)	0	10	μA μA(Max)

Note 1: The Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. The Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: All the Limits are guaranteed at room temperature (standard type face) and at temperature extremes (**boldface type**).

Note 3: External components such as catch diode, inductor, input and output capacitors can affect the switching regulator system performance. When the 2576M3K is used as shown in the *Figure 2* test circuit, the system performance will be as shown in the system parameters section of the Electrical Characteristics.

Note 4: OUTPUT pin sourcing current. No diode, inductor or capacitor connected to the OUTPUT.

Note 5: FEEDBACK pin is removed from the output and connected to 0V.

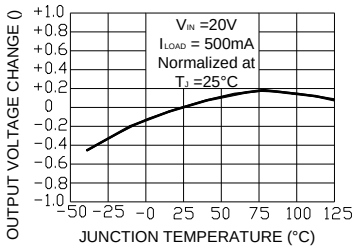
Note 6: FEEDBACK pin is removed from the output and connected to +12V for the adjustable, 3.3V, and 5V, versions, and +25V for the 12V and 15V versions, to force the output transistor OFF.

Note 7: V_{IN} =40V.

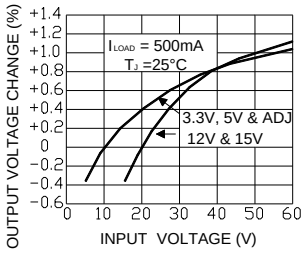
Note 8: The oscillator frequency reduces to approximately 11 kHz in the event of an output short or an overload, which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self-protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of *Figure 2*)

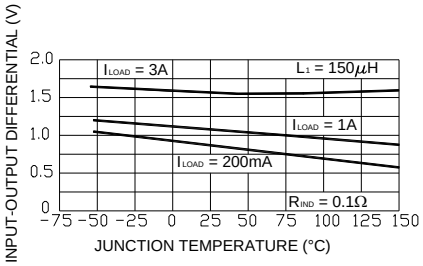
Normalized Output Voltage



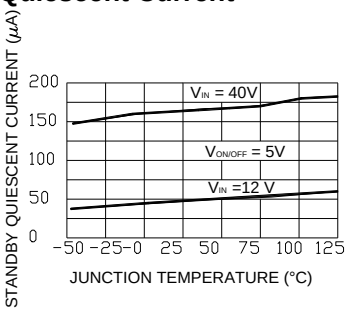
Line Regulation



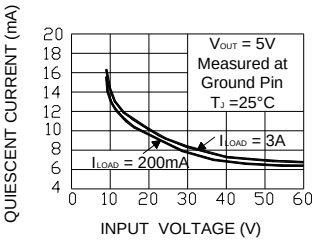
Dropout Voltage



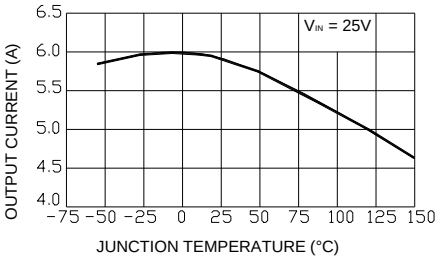
Standby Quiescent Current



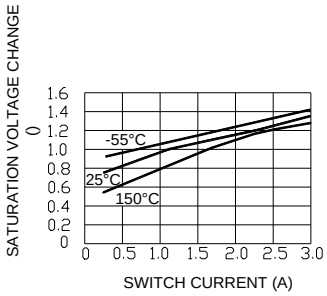
Quiescent Current



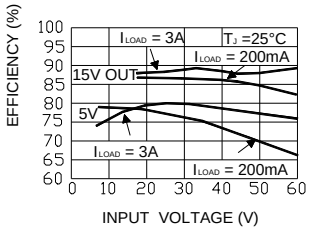
Current Limit



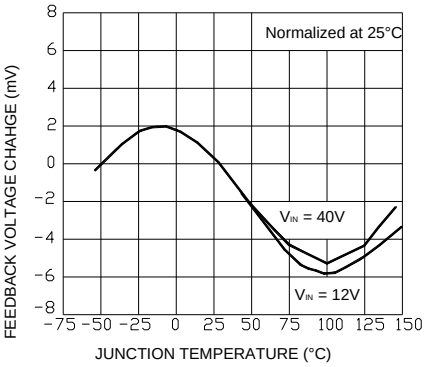
Switch Saturation Voltage



Efficiency

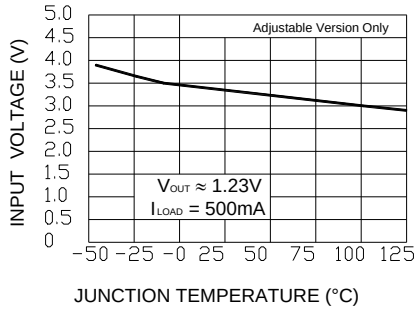


Oscilator Frequency

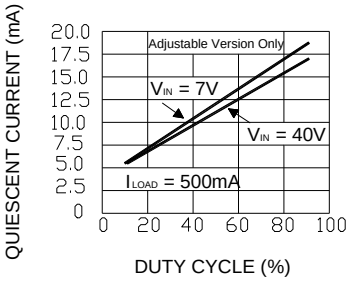


TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of *Figure 2*) (Continued)

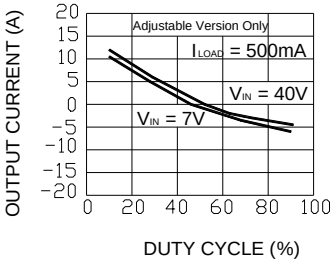
Minimum Operating Voltage



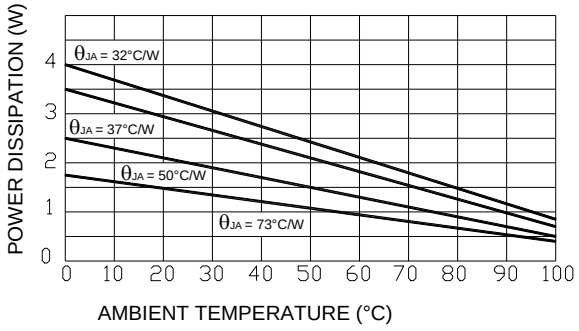
Quiescent Current vs Duty Cycle



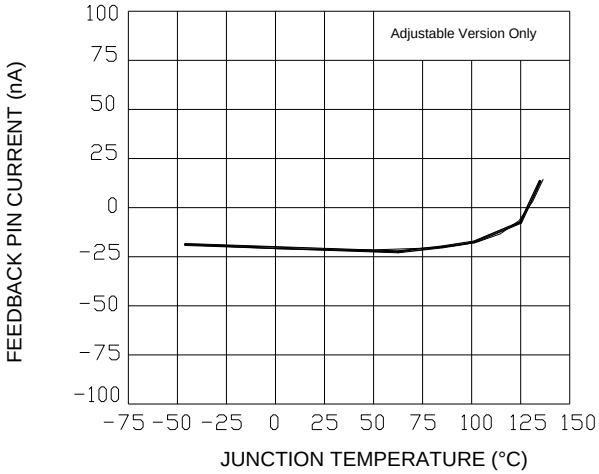
Feedback Voltage vs Duty Cycle



Maximum Power Dissipation (TO-263)

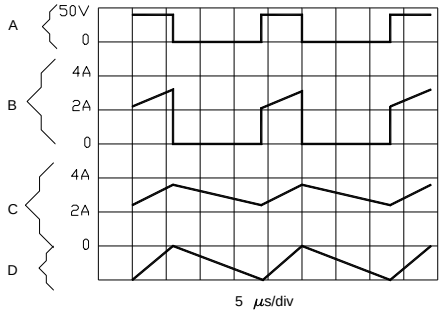


Feedback Pin Current

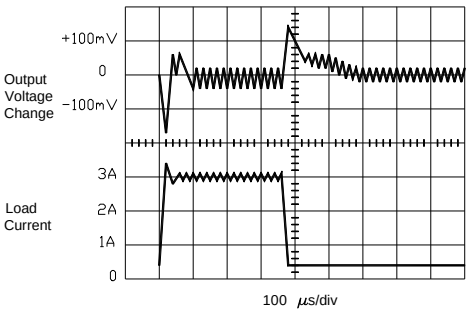


TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of *Figure 2*) (Continued)

Switching Waveforms



Load Transient Response



V_{OUT} =15V

A: OUTPUT pin voltage, 50V/div

B: OUTPUT pin current, 2A/div

C: Inductor current, 2A/div

D: Output ripple voltage, 50mV/div,

AC-coupled

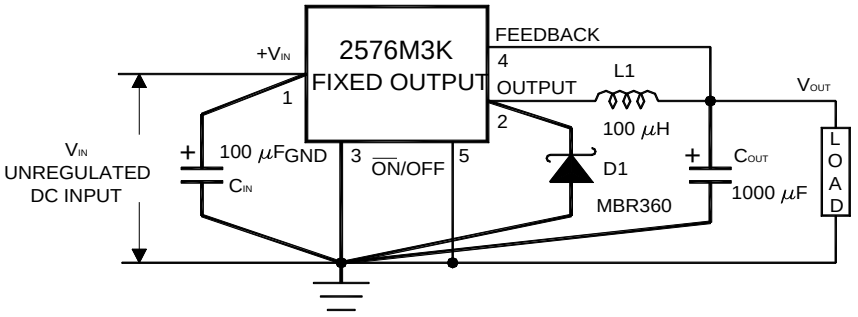
Horizontal Time Base: 5μs/div

Test Circuit and Layout Guidelines

As in any switching regulator, the layout is very important. Rapidly switching currents associated with the wiring inductance generate voltage transients, which can cause problems. For minimal inductance and ground loops, the length of leads indicated by heavy lines should be kept as short as possible.

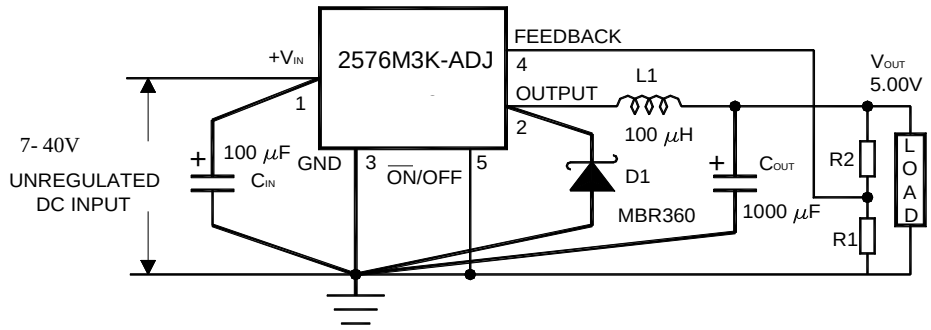
The single-point grounding (as indicated) or the ground plane construction should be used for best results. When using the Adjustable version, physically locate the programming resistors near the regulator, to keep the sensitive feedback wiring short.

FIXED OUTPUT VOLTAGE VERSIONS



C_{IN} — 100μF, 75V, aluminum electrolytic
C_{OUT} —1000μF, 25V, aluminum electrolytic
D1 — Schottky, MBR360
L_1 — 100μH, Pulse Eng. PE-92108
R_1 — 2k, 0.1%
R_2 — 6.12k, 0.1%

ADJUSTABLE OUTPUT VOLTAGE VERSION



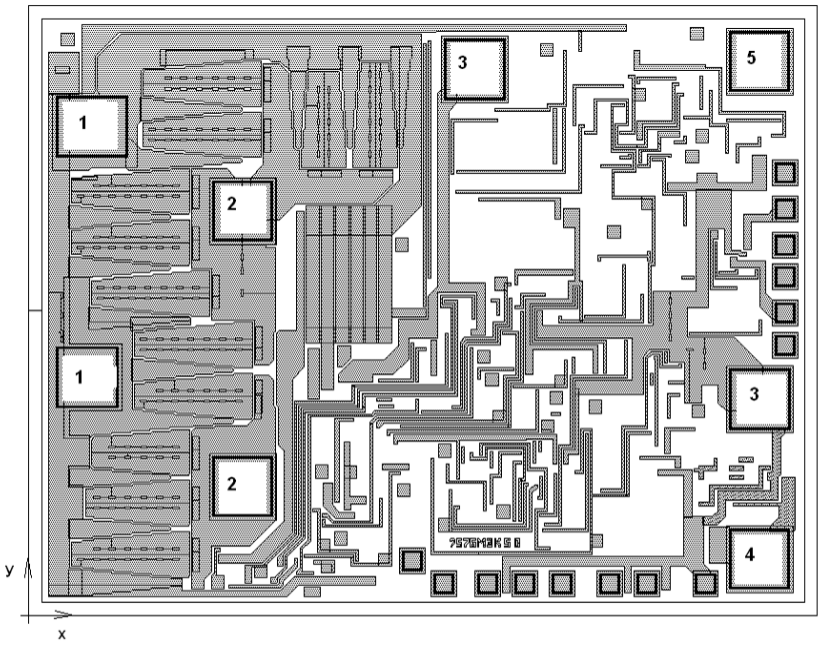
$$V_{OUT} = V_{REF}(1 + \frac{R_2}{R_1})$$

$$R_2 = R_1(\frac{V_{OUT}}{V_{REF}} - 1)$$

Where V_{REF} = 1.23V, R1 between 1k and 5k

FIGURE 2

PAD LOCATION



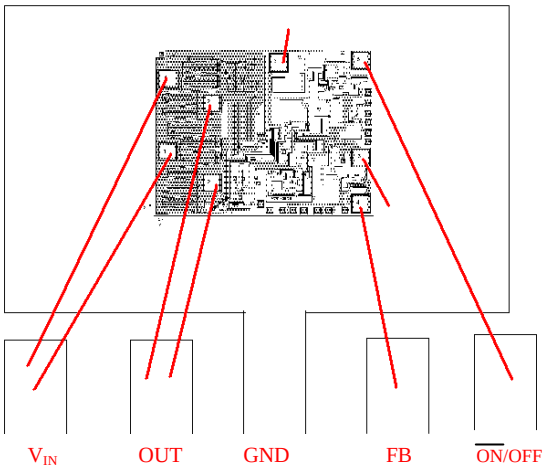
2576M3K-XX

Chip size: 2.47 x 1.91 mm^2

PAD LOCATION COORDINATES

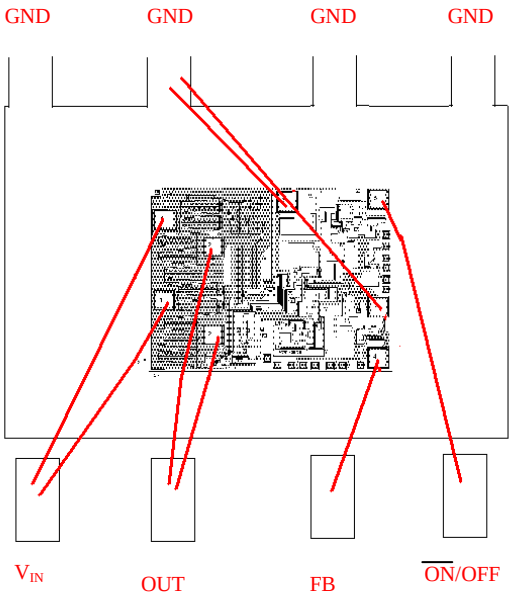
Pad	Coordinates (μm)		Pad size (μm × μm)
	X	Y	
1	196	1533	223x190
1	183	746	196x190
2	668	1267	190x190
2	668	405	190x190
3	1397	1711	190x190
3	2290	677	190x190
4	2290	177	190x190
5	2290	1735	190x190

BONDING DIAGRAM



2576M3K-XX

Package: TO-220, TO-263
Wire diameter: 75 µm



2576M3K-XX

Package: SO-8
Wire diameter: 50 µm

The appearance complies with the requirements of the company standards.