Signetics

TEA1039
Control Circuit for Switched-Mode Power Supply

Product Specification

Linear Products

DESCRIPTION

The TEA1039 is a bipolar integrated circuit intended for the control of a switched-mode power supply. Together with an external error amplifier and a voltage regulator (e.g., a regulator diode) it forms a complete control system. The circuit is capable of directly driving the SMPS power transistor in small SMPS systems.

FEATURES

- **Wide frequency range**
- **Adjustable input sensitivity**
- **Adjustable minimum frequency or maximum duty factor limit**
- **Adjustable overcurrent protection limit**
- **Supply voltage out-of-range protection**
- **Slow-start facility**

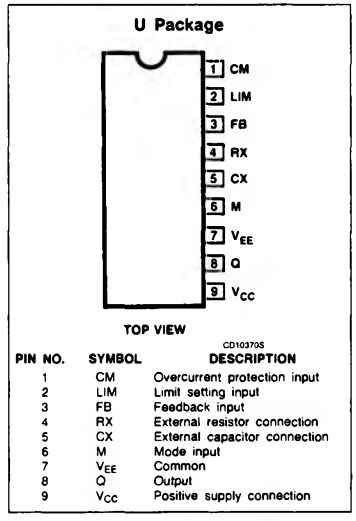
APPLICATIONS

- **Home appliances**
- **Frequency regulation**
- **Flyback converters**
- **Forward converters**

ORDERING INFORMATION

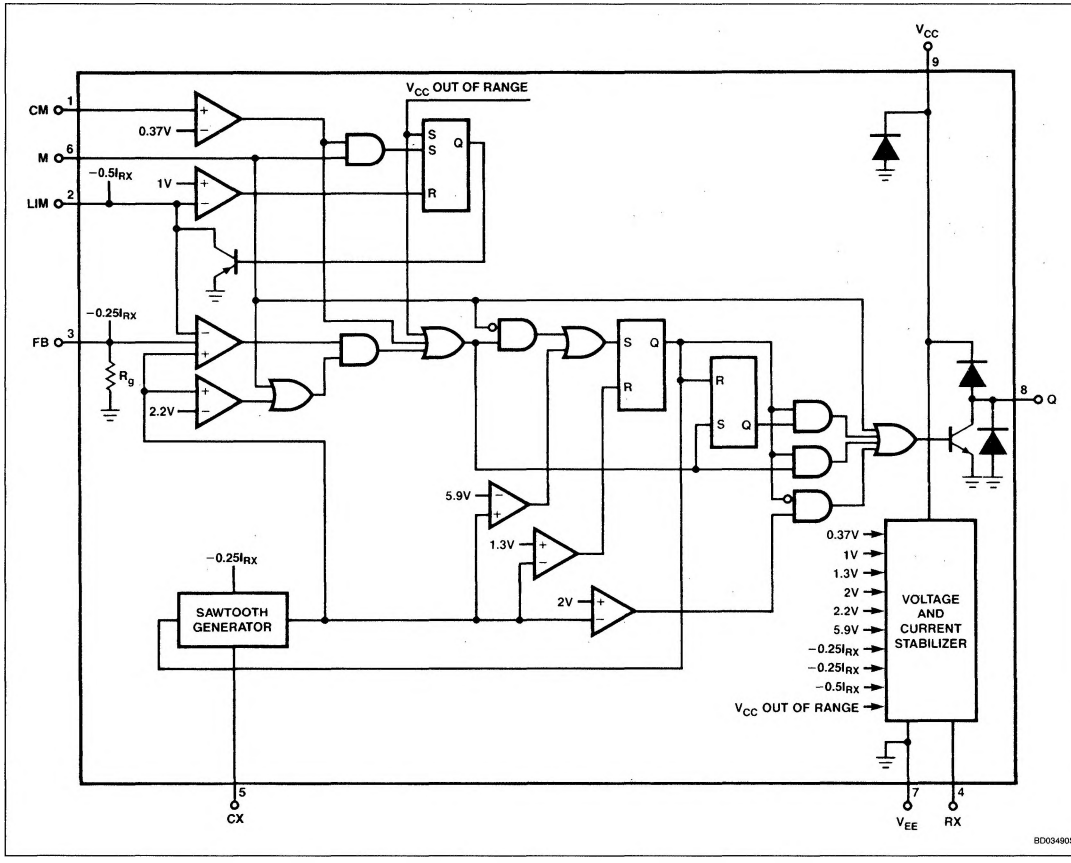
DESCRIPTION	TEMPERATURE RANGE	ORDER CODE
9-Pin Plastic SIP	−25°C to +125°C	TEA1039U

PIN CONFIGURATION



PIN NO.	SYMBOL	DESCRIPTION
1	CM	Overcurrent protection input
2	LIM	Limit setting input
3	FB	Feedback input
4	RX	External resistor connection
5	CX	External capacitor connection
6	M	Mode input
7	V_{EE}	Common
8	Q	Output
9	V_{CC}	Positive supply connection

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage range, voltage source	−0.3 to +20	V
I_{CC}	Supply current range, current source	−30 to +30	mA
V_I	Input voltage range, all inputs	−0.3 to +6	V
I_I	Input current range, all inputs	−5 to +5	mA
V_{8-7}	Output voltage range	−0.3 to +20	V
I_8 I_8	Output current range output transistor ON output transistor OFF	 0 to 1 −100 to +50	 A mA
T_{STG}	Storage temperature range	−65 to +150	°C
T_A	Operating ambient temperature range (see Figure 1)	−25 to +125	°C
F_D	Power dissipation (see Figure 1)	max. 2	W

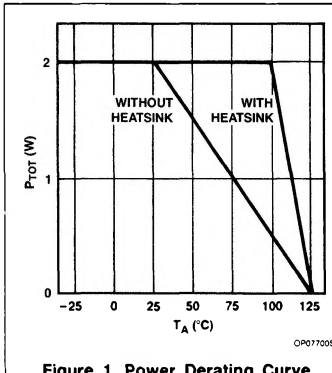


Figure 1. Power Derating Curve

DC AND AC ELECTRICAL CHARACTERISTICS V_{CC} = 14, T_A = 25°C, unless otherwise specified.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
Supply V_{CC} (Pin 9)					
V_{CC}	Supply voltage, operating	11	14	20	V
	Supply current				
I_{CC}	at V_{CC} = 11V		7.5	11	mA
I_{CC}	at V_{CC} = 20V		9	12	mA
$\frac{\Delta I_{CC}/I_{CC}}{\Delta T}$	variation with temperature		−0.3		%/°C
	Supply voltage, internally limited				
V_{CC}	at I_{CC} = 30mA	23.5		28.5	V
$\Delta V_{CC}/\Delta T$	variation with temperature		18		mV/°C
V_{CCmin}	Low supply threshold voltage	9	10	11	V
$\Delta V_{CC}/\Delta T$	variation with temperature		−5		mV/°C
V_{CCmax}	High supply threshold voltage	21	23	24.6	V
$\Delta V_{CC}/\Delta T$	variation with temperature		10		mV/°C
Feedback input FB (Pin 3)					
$V_{3\ 7}$	Input voltage for duty factor = 0; M input open	0		0.3	V
$-I_{FB}$	Internal reference current		0.5 I_{RX}		mA
R_g	Internal resistor R_g		130		kΩ
Limit setting input LIM (Pin 2)					
$V_{2\ 7}$	Threshold voltage		1		V
$-I_{LIM}$	Internal reference current		0.25 I_{RX}		mA
Overcurrent protection input CM (Pin 1)					
$V_{1\ 7}$	Threshold voltage	300	370	420	mV
$\Delta V_{1\ 7}/\Delta T$	variation with temperature		0.2		mV/°C
t_{PHL}	Propagation delay, CM input to output		500		ns
Oscillator connections RX and CX (Pins 4 and 5)					
	Voltage at RX connection				
$V_{4\ 7}$	at $-I_4$ = 0.15 to 1mA	6.2	7.2	8.1	V
$\Delta V_{4\ 7}/\Delta T$	variation with temperature		2.1		mV/°C
V_{LS}	Lower sawtooth level		1.3		V
V_{FT}	Threshold voltage for output H to L transition in F mode		2		V
V_{FM}	Threshold voltage for maximum frequency in F mode		2.2		V
V_{HS}	Higher sawtooth level		5.9		V
$-I_{CX}$	Internal capacitor charging current, CX connection		0.25 I_{RX}		mA
f_{OSC}	Oscillator frequency (output pulse repetition frequency)	1		10^5	Hz
	Minimum frequency in F mode,				
$\Delta f/f$	initial deviation	−10		10	%
$\frac{\Delta f/f}{\Delta T}$	variation with temperature		0.034		%/°C
	Maximum frequency in F mode,				
$\Delta f/f$	initial deviation	−15		15	%
$\frac{\Delta f/f}{\Delta T}$	variation with temperature		−0.16		%/°C

DC AND AC ELECTRICAL CHARACTERISTICS (Continued) V_{CC} = 14, T_A = 25°C, unless otherwise specified.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
$\frac{\Delta t/t}{\Delta T}$	Output LOW time in F mode, initial deviation variation with temperature	−15	 0.2	15	% %/°C
$\frac{\Delta f/f}{\Delta T}$	Pulse repetition frequency in D mode, initial deviation variation with temperature	−10	 0.034	10	% %/°C
t_{OLmin} $\frac{\Delta t/t}{\Delta T}$	Minimum output LOW time in D mode at C_5 = 3.6nF variation with temperature		1 0.2		µs %/°C
Output Q (Pin 8)					
$V_{8\ 7}$ $\Delta V_{8\ 7}/\Delta T$	Output voltage LOW at I_8 = 100mA variation with temperature		0.8 1.5	1.2	V mV/°C
$V_{8\ 7}$ $\Delta V_{8\ 7}/\Delta T$	Output voltage LOW at I_8 = 1A variation with temperature		1.7 −1.4	2.1	V mV/°C

FUNCTIONAL DESCRIPTION

The TEA1039 produces pulses to drive the transistor in a switched-mode power supply. These pulses may be varied either in frequency (frequency regulation mode) or in width (duty factor regulation mode).

The usual arrangement is such that the transistor in the SMPS is ON when the output of the TEA1039 is HIGH, i.e., when the open-collector output transistor is OFF. The duty factor of the SMPS is the time that the output of the TEA1039 is HIGH divided by the pulse repetition time.

Supply V_{CC} (Pin 9)

The circuit is usually supplied from the SMPS that it regulates. It may be supplied either from its primary DC voltage or from its output voltage. In the latter case an auxiliary starting supply is necessary.

The circuit has an internal V_{CC} out-of-range protection. In the frequency regulation mode the oscillator is stopped; in the duty factor regulation mode the duty factor is made zero. When the supply voltage returns within its range, the circuit is started with the slow-start procedure.

When the circuit is supplied from the SMPS itself, the out-of-range protection also provides an effective protection against any interruption in the feedback loop.

Mode Input M (Pin 6)

The circuit works in the frequency regulation mode when the mode input M is connected to ground (V_{EE}, Pin 7). In this mode the circuit produces output pulses of a constant width but with a variable pulse repetition time.

The circuit works in the duty factor regulation mode when the mode input M is left open. In this mode the circuit produces output pulses with a variable width but with a constant pulse repetition time.

Oscillator Resistor and Capacitor Connections RX and CX (Pins 4 and 5)

The output pulse repetition frequency is set by an oscillator whose frequency is determined by an external capacitor C5 connected between the CX connection (Pin 5) and ground (V_{EE}, Pin 7), and an external resistor R4 connected between the RX connection (Pin 4) and ground. The capacitor C5 is charged by an internal current source, whose current level is determined by the resistor R4. In the frequency regulation mode these two external components determine the minimum frequency; in the duty factor regulation mode they determine the working frequency (see Figure 2). The output pulse repetition frequency varies less than 1% with the supply voltage over the supply voltage range.

In the frequency regulation mode the output is LOW from the start of the cycle until the voltage on the capacitor reaches 2V. The capacitor is further charged until its voltage reaches the voltage on either the feedback input FB or the limit setting input LIM, provided it has exceeded 2.2V. As soon as the capacitor voltage reaches 5.9V the capacitor is discharged rapidly to 1.3V and a new cycle is initiated (see Figures 3 and 4).

For voltages on the FB and LIM inputs lower than 2.2V, the capacitor is charged until this voltage is reached; this sets an internal maximum frequency limit.

In the duty factor regulation mode the capacitor is charged from 1.3V to 5.9V and discharged again at a constant rate. The output is HIGH until the voltage on the capacitor exceeds the voltage on the feedback input FB; it becomes HIGH again after discharge of the capacitor (see Figures 5 and 6). An internal maximum limit is set to the duty factor of the SMPS by the discharging time of the capacitor.

Feedback Input FB (Pin 3)

The feedback input compares the input current with an internal current source whose current level is set by the external resistor R4. In the frequency regulation mode, the higher the voltage on the FB input, the longer the external capacitor C5 is charged, and the lower the frequency will be. In the duty factor regulation mode external capacitor C5 is charged and discharged at a constant rate, the voltage on the FB input now determines the moment that the output will become LOW. The higher the voltage on the FB input, the longer the output remains HIGH, and the higher the duty factor of the SMPS.

Limit Setting Input LIM (Pin 2)

In the frequency regulation mode this input sets the minimum frequency, in the duty factor regulation mode it sets the maximum duty factor of the SMPS. The limit is set by an external resistor R2 connected from the LIM input to ground (Pin 7) and by an internal current source, whose current level is determined by external resistor R4.

A slow-start procedure is obtained by connecting a capacitor between the LIM input and ground. In the frequency regulation mode the frequency slowly decreases from f_{MAX} to the working frequency. In the duty factor regulation mode the duty factor slowly increases from zero to the working duty factor.

Overcurrent Protection Input CM (Pin 1)

A voltage on the CM input exceeding 0.37V causes an immediate termination of the output pulse. In the duty factor regulation mode the circuit starts again with the slow-start procedure.

Output Q (Pin 8)

The output is an open-collector NPN transistor, only capable of sinking current. It requires an external resistor to drive an NPN transistor in the SMPS (see Figures 7 and 8).

The output is protected by two diodes, one to ground and one to the supply.

At high output currents the dissipation in the output transistor may necessitate a heatsink. See the power derating curve (Figure 1).

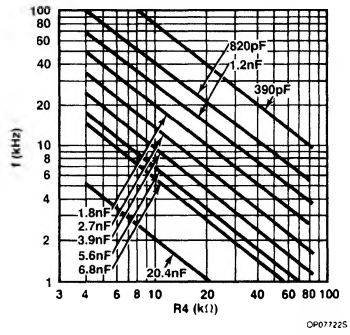
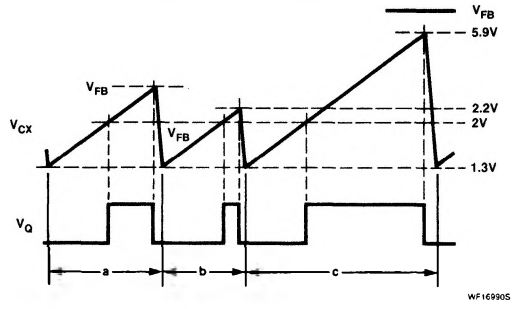
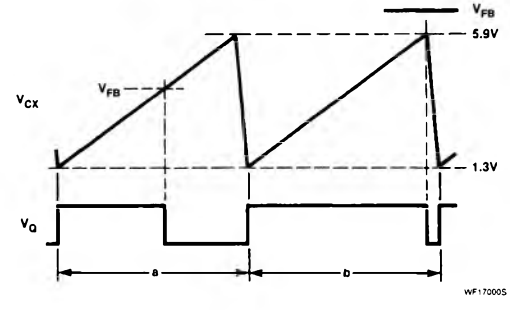


Figure 2. Minimum Pulse Repetition Frequency in the Frequency Regulation Mode, and Working Pulse Repetition Frequency in the Duty Factor Regulation Mode, as a Function of External Resistor R4 Connected Between RX and Ground with External Capacitor C5 Connected Between CX and Ground as a Parameter



NOTES:
a. The voltages on inputs FB or LIM are between 2.2V and 5.9V. The circuit is in its normal regulation mode.
b. The voltage on input FB or input LIM is lower than 2.2V. The circuit works at its maximum frequency.
c. The voltages on inputs FB and LIM are higher than 5.9V. The circuit works at its minimum frequency.

Figure 3. Timing Diagram for the Frequency Regulation Mode Showing the Voltage on External Capacitor C5 Connected between CX and Ground and the Output Voltage as a Function of Time for Three Combinations of Input Signals



NOTES:
a. The voltages on inputs FB or LIM are below 5.9V. The circuit is in its normal regulation range.
b. The voltages on inputs FB and LIM are higher than 5.9V. The circuit produces its minimum output LOW time, giving the maximum duty factor of the SMPS.

Figure 5. Timing Diagram for the Duty Factor Regulation Mode Showing the Voltage on External Capacitor C5 Connected Between CX and Ground and the Output Voltage as a Function of Time for Two Combinations of Input Signals

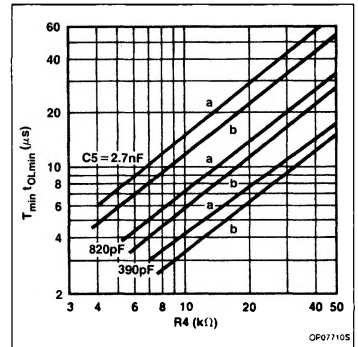


Figure 4. Minimum Output Pulse Repetition Time t_{MIN} (Curves a) and Minimum Output LOW Time t_{OLmin} (Curves b) in the Frequency Regulation Mode as a Function of External Resistor R4 Connected Between RX and Ground with External Capacitor C5 Connected Between CX and Ground as a Parameter

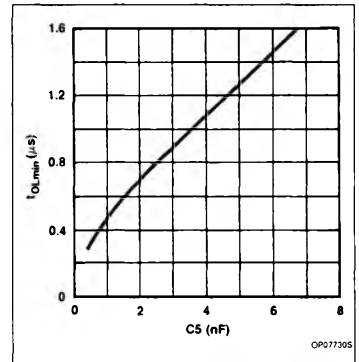
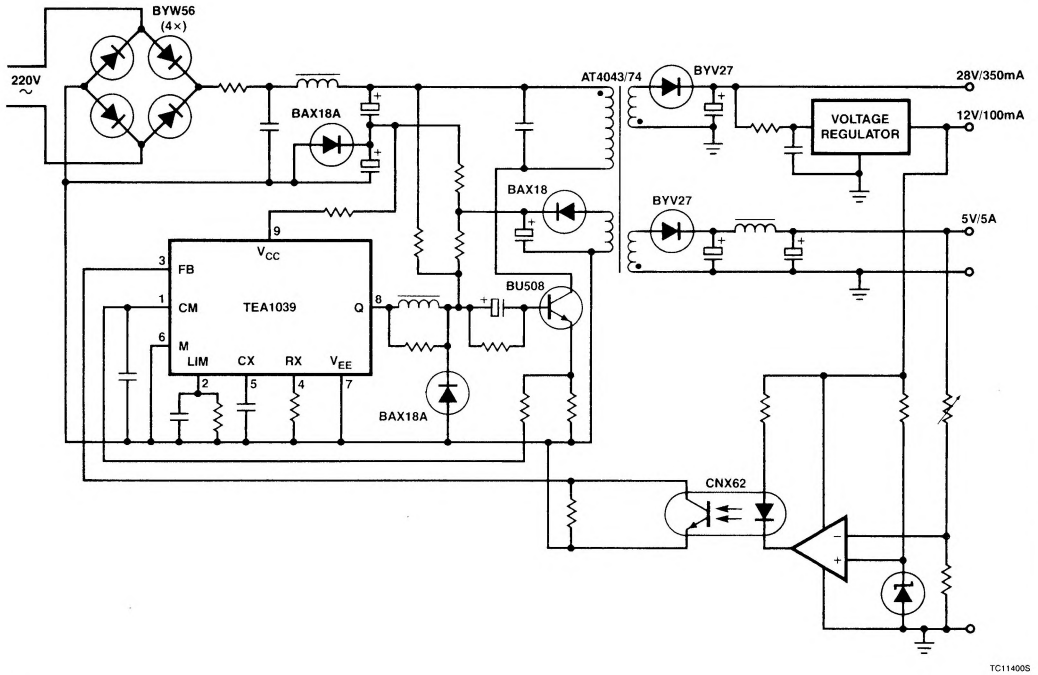
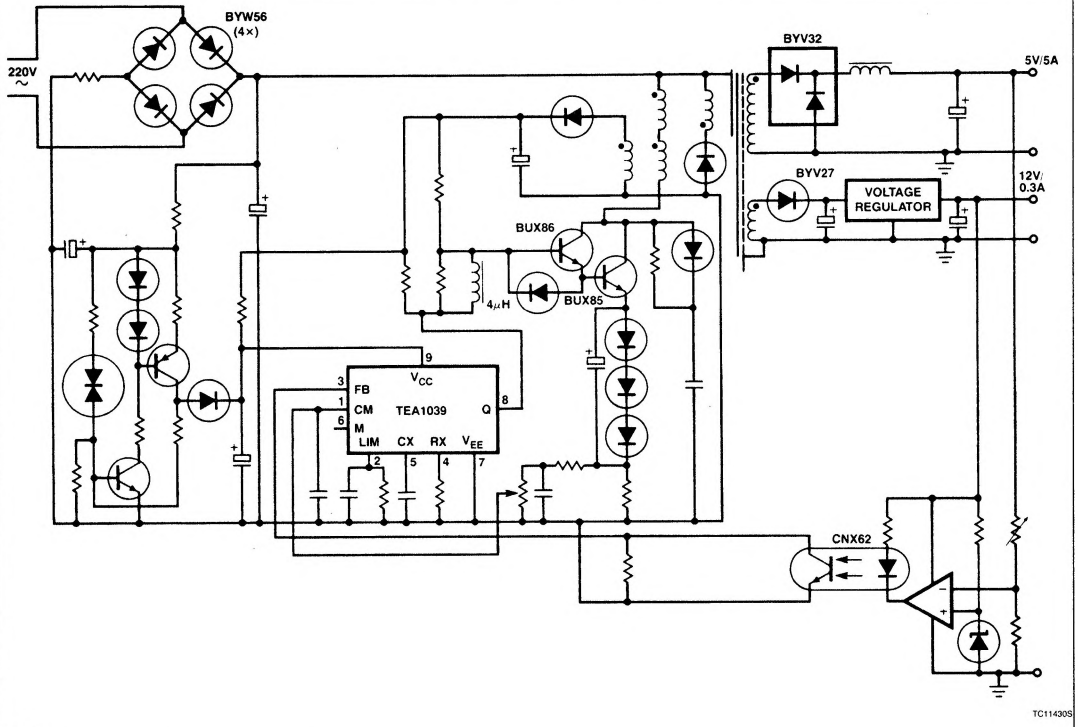


Figure 6. Minimum Output LOW Time t_{OLmin} in the Duty Factor Regulation Mode as a Function of External Capacitor C5 Connected Between CX and Ground. In This Mode the Minimum Output LOW Time is Independent of R4 for Values of R4 Between 4kΩ and 80kΩ



NOTE:
An Optocoupler CNX62 is Used for Voltage Separation.

Figure 7. Typical Application of the TEA1039 in a Variable-Frequency Flyback Converter Switched-Mode Power Supply



NOTE:
An Optocoupler CNX62 is Used for Voltage Separation.

Figure 8. Typical Application of the TEA21039 in a Fixed-Frequency Variable Duty Factor Forward Converter Switched-Mode Power Supply