

#### 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

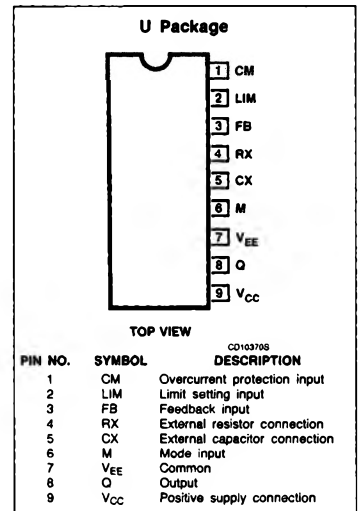
#### APPLICATIONS

- 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

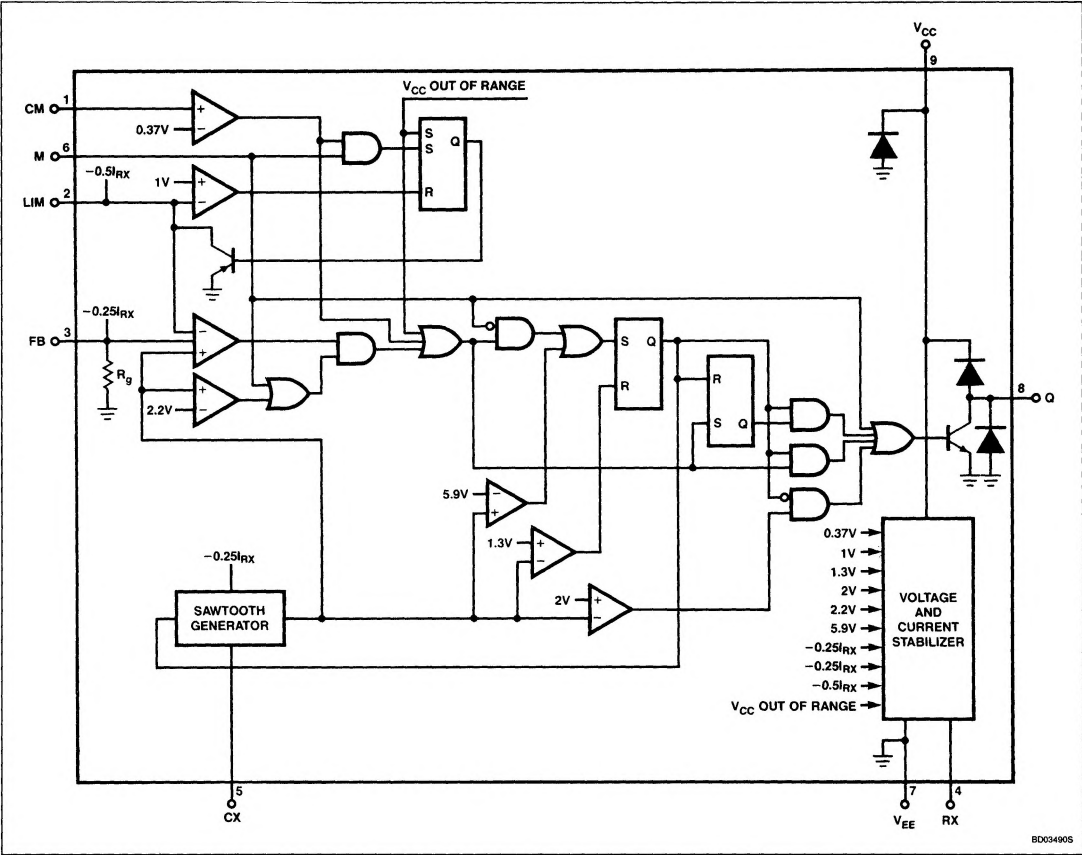
#### PIN CONFIGURATION



Control Circuit for Switched-Mode Power Supply

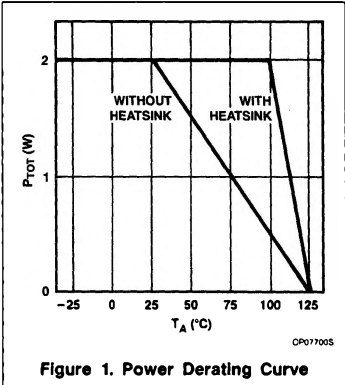
TEA1039

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
$I_{\delta}$ $I_{\delta}$	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



## Control Circuit for Switched-Mode Power Supply

TEA1039

**DC ELECTRICAL CHARACTERISTICS**  $V_{CC} = 14$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
<b>Supply <math>V_{CC}</math> (Pin 9)</b>					
$V_{CC}$	Supply voltage, operating	11	14	20	V
$I_{CC}$	Supply current at $V_{CC} = 11\text{V}$		7.5	11	mA
$I_{CC}$	at $V_{CC} = 20\text{V}$		9	12	mA
$\frac{\Delta I_{CC}/I_{CC}}{\Delta T}$	variation with temperature		-0.3		%/ $^\circ\text{C}$
$V_{CC}$ $\Delta V_{CC}/\Delta T$	Supply voltage, internally limited at $I_{CC} = 30\text{mA}$ variation with temperature	23.5	18	28.5	V mV/ $^\circ\text{C}$
$V_{CCmin}$ $\Delta V_{CC}/\Delta T$	Low supply threshold voltage variation with temperature	9	10 -5	11	V mV/ $^\circ\text{C}$
$V_{CCmax}$ $\Delta V_{CC}/\Delta T$	High supply threshold voltage variation with temperature	21	23 10	24.6	V mV/ $^\circ\text{C}$
<b>Feedback input FB (Pin 3)</b>					
$V_3$	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		k $\Omega$
<b>Limit setting input LIM (Pin 2)</b>					
$V_2$	Threshold voltage		1		V
$-I_{LIM}$	Internal reference current		0.25 $I_{RX}$		mA
<b>Overcurrent protection input CM (Pin 1)</b>					
$V_1$	Threshold voltage	300	370	420	mV
$\Delta V_1/\Delta T$	variation with temperature		0.2		mV/ $^\circ\text{C}$
$t_{PHL}$	Propagation delay, CM input to output		500		ns
<b>Oscillator connections RX and CX (Pins 4 and 5)</b>					
$V_4$	Voltage at RX connection at $-I_4 = 0.15$ to $1\text{mA}$	6.2	7.2	8.1	V
$\Delta V_4/\Delta T$	variation with temperature		2.1		mV/ $^\circ\text{C}$
$V_{LS}$	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
$\frac{\Delta f/f}{\Delta T}$	Minimum frequency in F mode, initial deviation variation with temperature	-10	0.034	10	% %/ $^\circ\text{C}$
$\frac{\Delta f/f}{\Delta T}$	Maximum frequency in F mode, initial deviation variation with temperature	-15	-0.16	15	% %/ $^\circ\text{C}$

## Control Circuit for Switched-Mode Power Supply

TEA1039

DC ELECTRICAL CHARACTERISTICS (Continued)  $V_{CC} = 14$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
$\frac{\Delta t/t}{\Delta T}$	Output LOW time in F mode, initial deviation	-15		15	%
$\frac{\Delta t/t}{\Delta T}$	variation with temperature		0.2		%/ $^\circ\text{C}$
$\frac{\Delta f/f}{\Delta T}$	Pulse repetition frequency in D mode, initial deviation	-10		10	%
$\frac{\Delta f/f}{\Delta T}$	variation with temperature		0.034		%/ $^\circ\text{C}$
$\frac{t_{OLmin}}{\Delta T}$	Minimum output LOW time in D mode at $C_5 = 3.6\text{nF}$		1		$\mu\text{s}$
$\frac{\Delta t/t}{\Delta T}$	variation with temperature		0.2		%/ $^\circ\text{C}$
<b>Output Q (Pin 8)</b>					
$V_8$	Output voltage LOW at $I_B = 100\text{mA}$		0.8	1.2	V
$\frac{\Delta V_8}{\Delta T}$	variation with temperature		1.5		mV/ $^\circ\text{C}$
$V_8$	Output voltage LOW at $I_B = 1\text{A}$		1.7	2.1	V
$\frac{\Delta V_8}{\Delta T}$	variation with temperature		-1.4		mV/ $^\circ\text{C}$

## 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  $C_5$  connected between the CX connection (Pin 5) and ground ( $V_{EE}$ , Pin 7), and an external resistor  $R_4$  connected between the RX connection (Pin 4) and ground. The capacitor  $C_5$  is charged by an internal current source, whose current level is determined by the resistor  $R_4$ . 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  $R_4$ . In the frequency regulation mode, the higher the voltage on the FB input, the longer the external capacitor  $C_5$  is charged, and the lower the frequency will be. In the duty factor regulation mode external capacitor  $C_5$  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  $R_2$  connected from the LIM input to ground (Pin 7) and by an internal current source, whose current level is determined by external resistor  $R_4$ .

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.

## Control Circuit for Switched-Mode Power Supply

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**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).

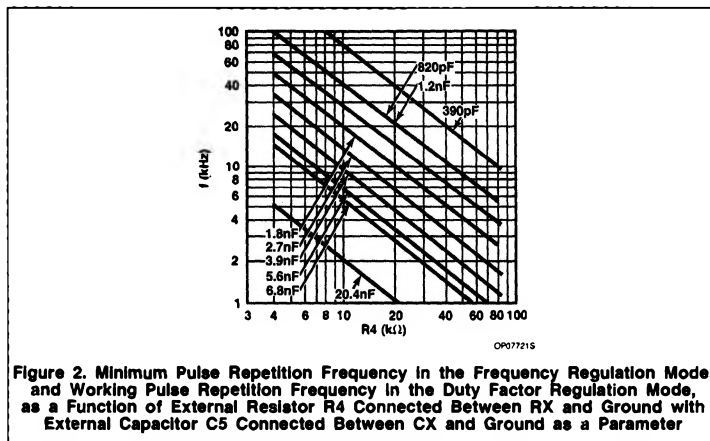
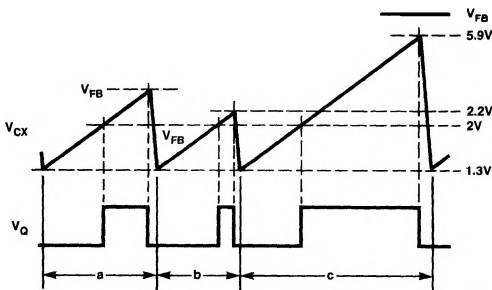


Figure 2. Minimum Pulse Repetition Frequency in the Frequency Regulation Mode, and Working Pulse Repetition Frequency in the Duty Factor Regulation Mode, as a Function of External Resistor  $R_4$  Connected Between RX and Ground with External Capacitor  $C_5$  Connected Between CX and Ground as a Parameter

Control Circuit for Switched-Mode Power Supply

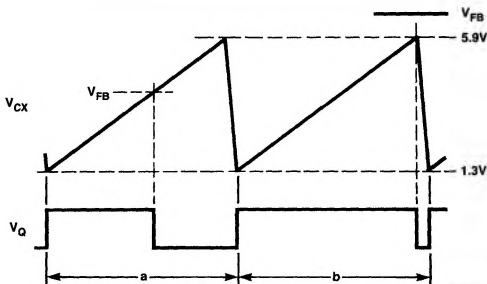
TEA1039



WF16990S

- 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.

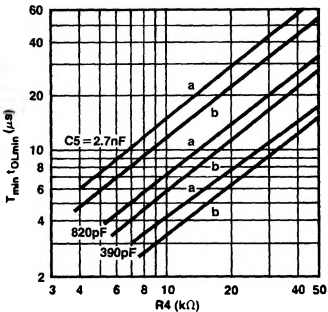
Figure 3. Timing Diagram for the Frequency Regulation Mode Showing the Voltage on External Capacitor C5 Connected Between CX and Ground and the Output Voltage as a Function of Time for Three Combinations of Input Signals



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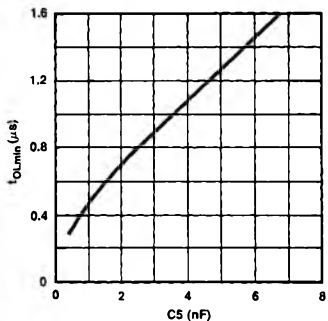
- NOTES:
- a. The voltages on inputs FB or LIM are below 5.9V. The circuit is in its normal regulation range.
  - b. The voltages on inputs FB and LIM are higher than 5.9V. The circuit produces its minimum output LOW time, giving the maximum duty factor of the SMPS.

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



OP07710S

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

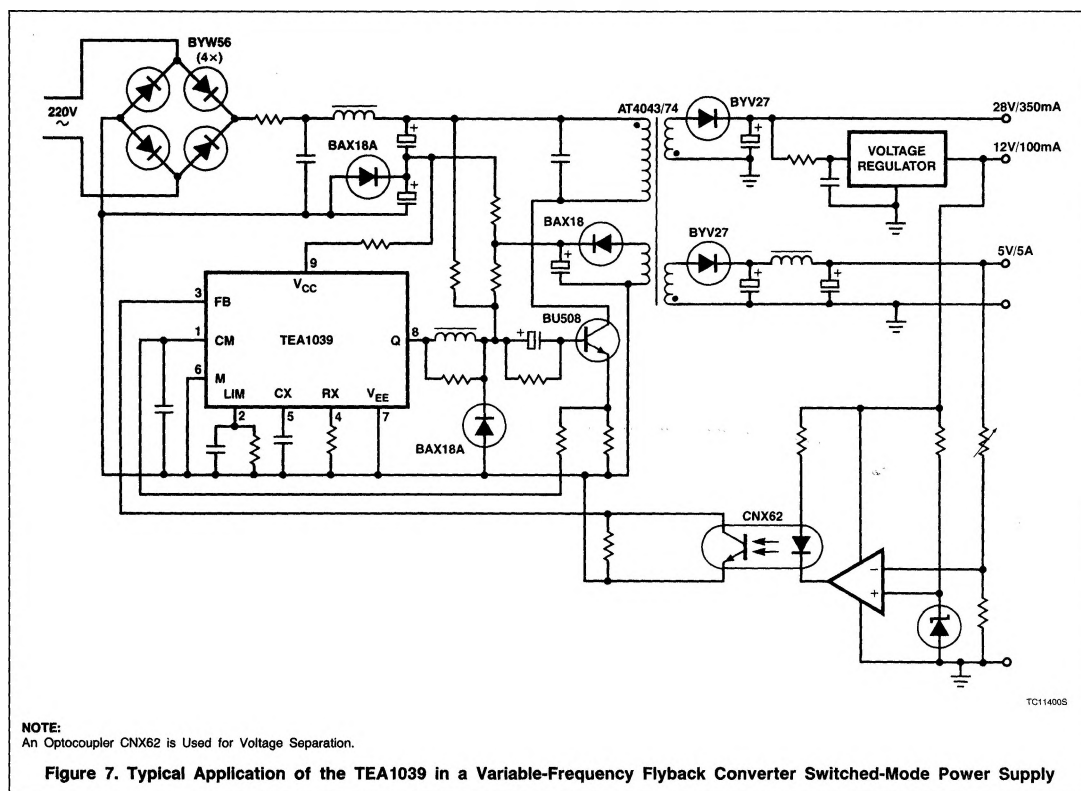


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Figure 6. Minimum Output LOW Time  $t_{OLmin}$  in the Duty Factor Regulation Mode as a Function of External Capacitor C5 Connected Between CX and Ground. In This Mode the Minimum Output LOW Time is Independent of R4 for Values of R4 Between  $4k\Omega$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

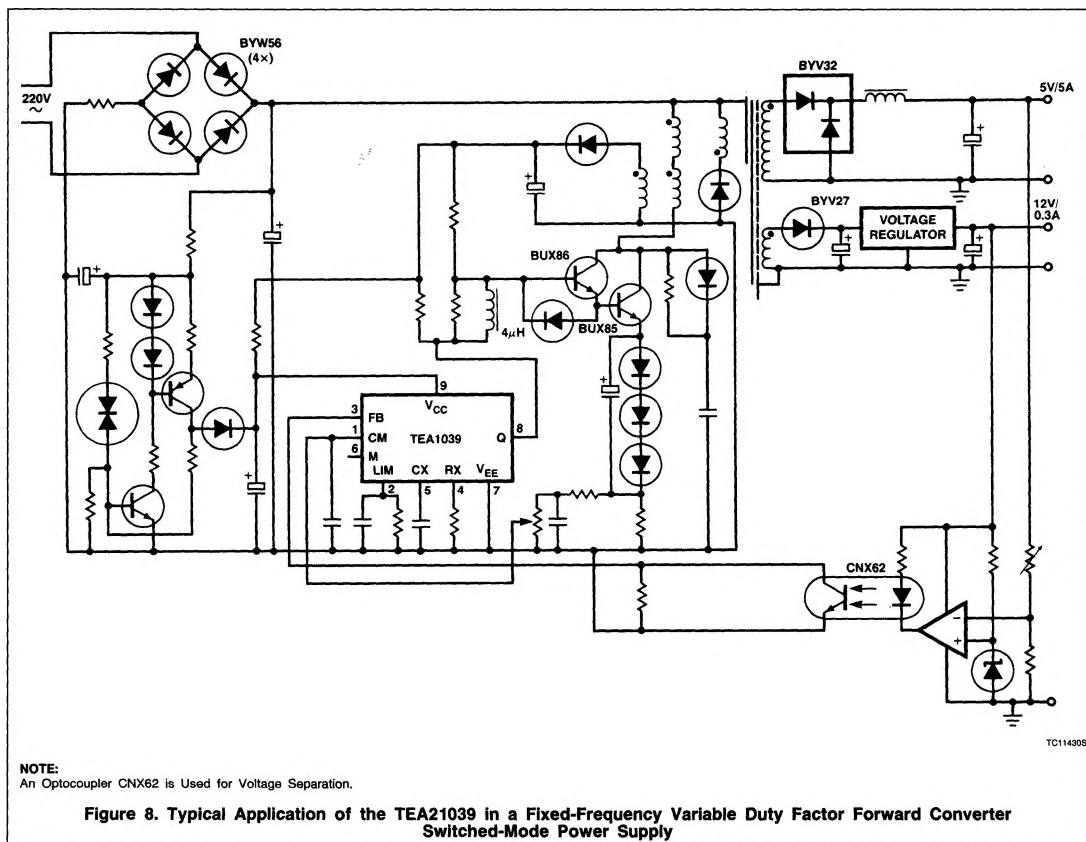
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TEA1039



## Control Circuit for Switched-Mode Power Supply

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