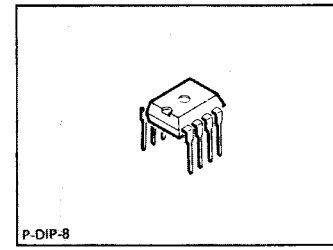
TLE 3101
TLE 3102
TLE 3103
TLE 3104

Bipolar IC

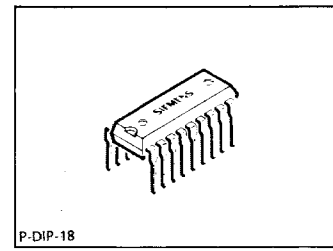
Features

- Direct supply from ac line possible
- Low power consumption, typically 2.4 mA
- Only one capacitor for trigger pulse width and phase angle
- Highly stabilized reference voltage
- Negative triac gate trigger current, 100 mA max.
- No triac drive pulses during supply undervoltage
- Optional voltage or current synchronization
- TLE 3101 with independent on-chip op amp OP and comparator K3


P-DIP-8

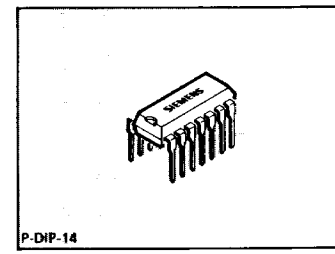
The following versions were produced from that basic IC:

- TLE 3102 without comparator K3
- TLE 3103 without op amp
- TLE 3104 without K3, enable input E/A, control input $V_{control}$, and without Z diode output


P-DIP-18

Type	Ordering Code	Package
TLE 3101	Q67000-A2337	P-DIP-18
■ TLE 3102	Q67000-A2338	P-DIP-14
■ TLE 3103	Q67000-A2339	P-DIP-14
TLE 3104	Q67000-A2312	P-DIP-8

■ = Not for new design


P-DIP-14

These simplified versions are provided for less complex low-cost applications.

These bipolar phase control ICs require, for most applications, only a minimum number of external components. Typical applications are motor control, brightness control, temperature control, cos φ optimization for squirrel-cage motors, and starting current limitation.

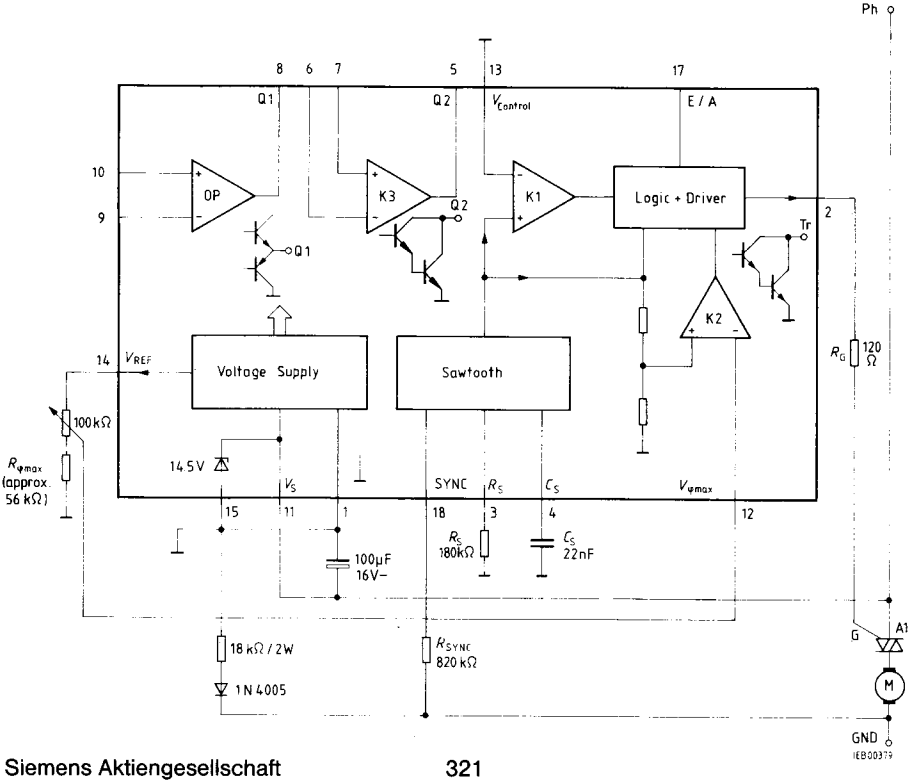
Thanks to their high efficiency, the TLE 310 x ICs are particularly suitable for consumer goods, such as kitchen appliances and washing machines, vacuum cleaners, electric irons and hobbyist appliances.

A special feature is the soft start which requires only straightforward wiring, and is e.g. used in portable drills for center punching.

Pin Definitions and Functions for TLE 3101

Pin	Function	Pin	Function
1	Ground	10	+input op amp
2	Triac trigger output	11	V_S
3	R_S	12	$V_{\varphi max}$
4	C_S	13	$V_{control}$, K1
5	Output Q2, K3	14	V_{REF}
6	−input K3	15	Z diode
7	+input K3	16	N.C.
8	Output Q1, op amp	17	Enable input E/A
9	−input op amp	18	Synchronization input (SYNC)

Block Diagram with External Components for Motor Control

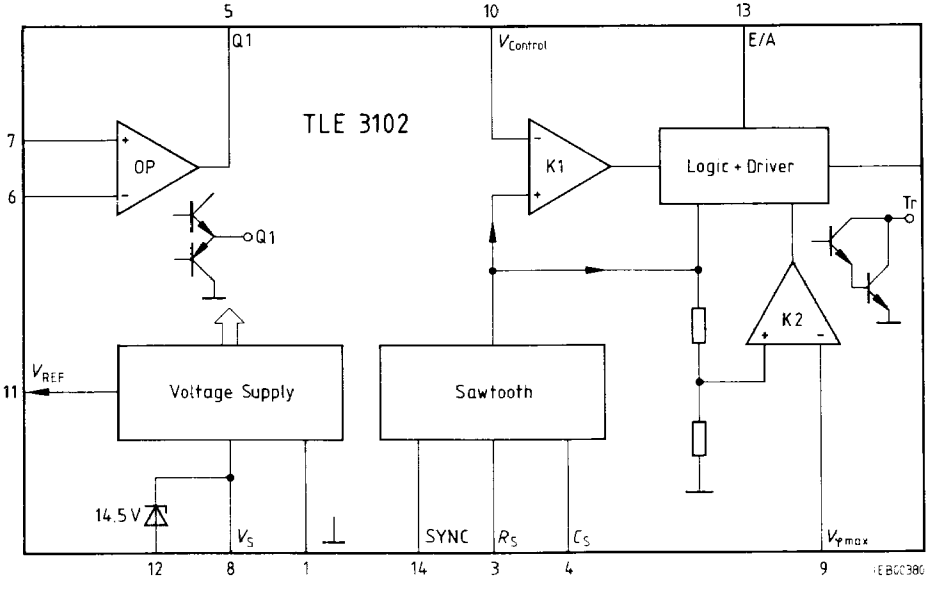


The **TLE 3102** with on-chip op amp for external use is particularly suitable as a speed controller with P, PI, or PID characteristic; the op amp serves as adjustable gain amplifier. An acutal value which is proportional to speed can be formed by rectification of the tacho amplitude.

Pin Definitions and Functions for TLE 3102

Pin	Function	Pin	Function
1	Ground	8	V_S
2	Triac trigger output	9	$V_{\varphi max}$
3	R_S	10	$V_{control}$, K1
4	C_S	11	V_{REF}
5	Output Q1, op amp	12	Z diode
6	−input op amp	13	Enable input E/A
7	+input op amp	14	Synchronization input (SYNC)

Block Diagram



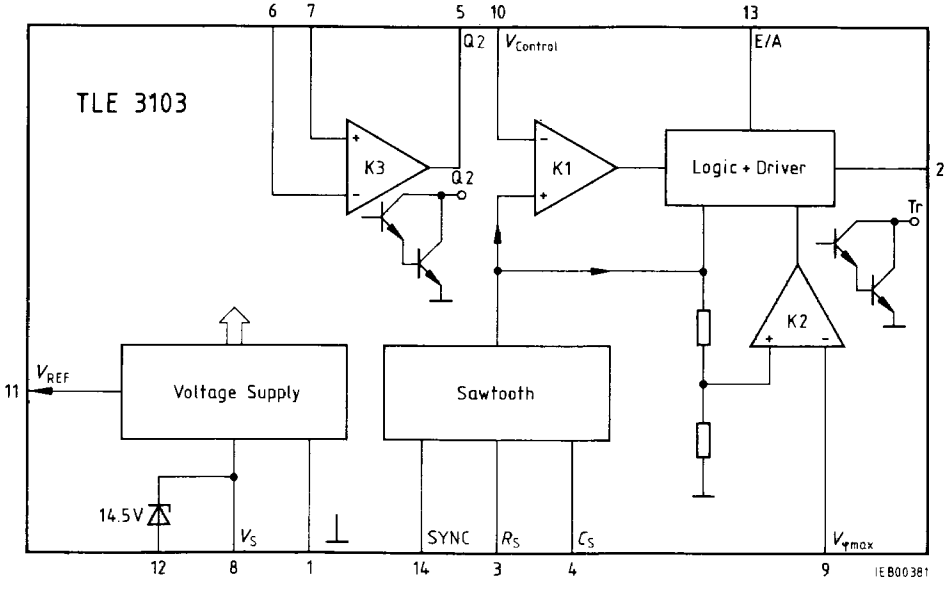
The **TLE 3103** with on-chip comparator for external use is particularly suitable for phase control systems in which special functions, such as blocking protection or overtemperature protection, are required.

Pin Definitions and Functions for TLE 3103

Pin	Function	Pin	Function
1	Ground	8	V_S
2	Triac trigger output	9	$V\varphi_{max}$
		10	$V_{control}$, K1
3	R_S	11	V_{REF}
4	C_S	12	Z diode
5	Output Q2, K3	13	Enable input E/A
6	−Input K3	14	Synchronization input (SYNC)
7	+Input K3		

5

Block Diagram

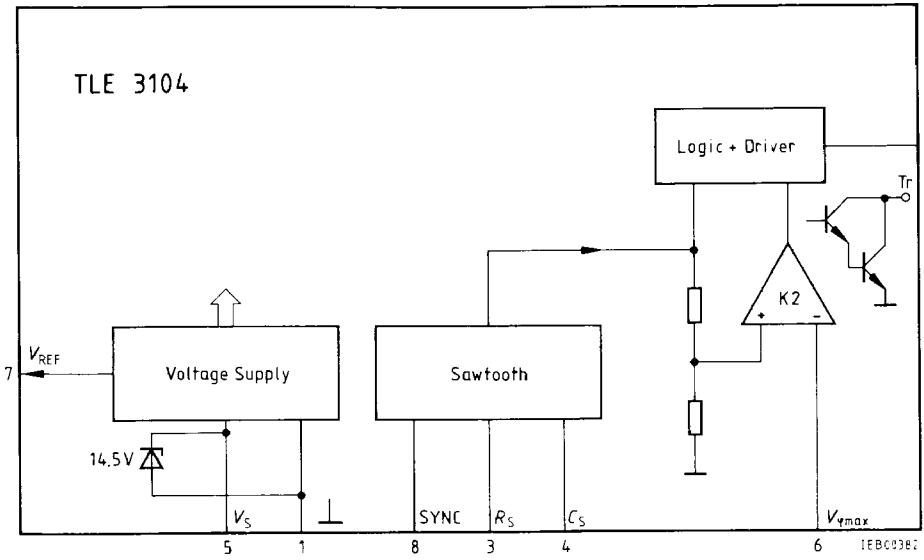


The **TLE 3104** ist particularly suitable for simple, low-cost phase control and motor control systems, in which the actual value is formed by rectification of the tacho amplitude.

Pin Definitions and Functions for TLE 3104

Pin	Function	Pin	Function
1	Ground	5	V_S
2	Triac trigger output	6	$V\varphi_{max}$
3	R_S	7	V_{REF}
4	C_S	8	Synchronization input (SYNC)

Block Diagram



Functional Description

The following is a description of the individual functional units (refer to block diagram) and their interactions:

Operational Amplifier op amp

Two inputs and the output are available. The op amp is internally compensated and has a push-pull output. Should the op amp not be required, the +input must be connected to ground (the TLE 3101 and TLE 3102 then consume minimum current).

Comparator K 3

Comparator K3 is not frequency-compensated. The output is an open NPN collector which in switching operation may drive an LED, for example. Should the comparator not be required, the −input must be connected to ground. K3 then has minimum current consumption.

Reference Voltage Source

A temperature-stabilized voltage source is available for control and regulating circuits.

Sawtooth Generator

In this unit, a sawtooth synchronized to the line is generated by the external R_S and C_S. The phase angle of the triac is determined by comparison of the sawtooth voltage and the control voltage. The trigger pulse width for the driver is provided by the falling edge of the sawtooth generator. The charge of C_S determines the trigger pulse width. A special circuit ensures the release of only one trigger pulse per line half period.

Comparators K1, K2

Sawtooth voltage and control voltage are compared by means of comparators K1 and K2. Comparator K2 receives only half the sawtooth voltage. The phase angle limit can be adjusted within the complete phase angle range by applying a reduced reference voltage to input "$V_{\varphi max}$". Comparator K2 provides starting current limitation and/or phase angle limitation for inductive loads. Both comparator outputs are fed to the logic and driver unit.

The comparator with the smaller conduction angle is the dominating one. With $V_{\varphi max}$ dominating, the trigger pulse width is doubled – compared with the trigger pulse width in case of a dominating $V_{control}$.

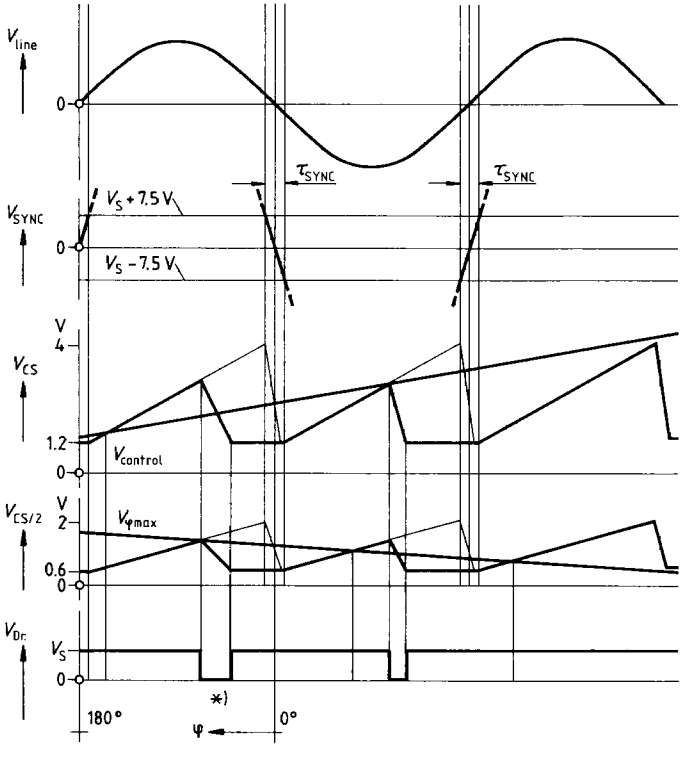
Logic + Driver

The logic and driver unit for triac triggering is controlled by comparators K1, K2, and the enable input E/A. The E/A input is TTL-compatible and may disable or enable the trigger pulse. Logic + driver obtain information on the trigger pulse width from the sawtooth. The undervoltage monitoring enables the driver output only if the IC's supply voltage has reached the permissible minimum value. The driver output to the triac supplies negative pulses.

Synchronization

At the sync input, the phase angle is synchronized to the zero crossing point of the line voltage. The sync pulse width τ_{SYNC} has to be twice as large as the trigger pulse width.

Pulse Diagram



Conduction angle (with resistive load)

*) With $V_{\varphi max}$ dominating, the trigger pulse width is doubled.

Absolute Maximum Ratings

$T_A = -25$ to 85 °C

Parameter	Symbol	Limit Values min.	Limit Values max.	Unit
Supply voltage	V_S	−0.3	33	V
Inputs op amp K3	V_I	−0.3	33	V
Output op amp	V_{Q1}	−0,3	V_S	V
	I_{Q1}	−5	3	mA
Output K3 (disabled)	V_{Q2}	−0.3	33	V
(enabled)	I_{Q2}	0	40	mA
Output V_{REF}	V_{REF}	−0.3	5	V
Z diode	I_Z	−35	35	mA
Input SYNC	I_{SYNC}	−10	10	mA
Input R_S	V_{RS}	−0.3	5	V
Input C_S	V_{CS}	−0.3	5	V
Input $V_{control}$	$V_{control}$	−0.3	V_S	V
Input $V\varphi_{max}$	$V\varphi_{max}$	−0.3	V_S	V
Enable input E/A	$V_{E/A}$	−0.3	33	V
Output driver (disabled)	$V_{Q\,dr}$	−0.3	33	V
(enabled)	$I_{Q\,dr}$	0	120	mA
Total power dissipation (time integral)	P_{tot}		700	mW
Junction temperature	T_j		150	°C
Storage temperature	T_{stg}	−55	125	°C
Thermal resistance				
system – air P-DIP- 8 – TLE 3104	$R_{th\,SA}$		100	K/W
P-DIP-14 – TLE 3102, TLE 3103	$R_{th\,SA}$		70	K/W
P-DIP-18 – TLE 3101	$R_{th\,SA}$		70	K/W

Operating Range

Supply voltage	V_S	10	30	V
Ambient temperature	T_A	−25	85	°C
Input SYNC	I_{SYNC}	−3.5	3.5	mA

Characteristics

$V_S = 10$ to 30 V, $T_V = -25$ to 85 °C

Parameter	Symbol	Limit Values min.	typ.	max.	Unit	Test Conditions
Current Consumption without output load at op amp, K3, driver, V_{REF}, without R_{SYNC} current	I_S		2.4	3.2	mA	$V_S = 14.5$ V
Reference voltage	V_{REF}	1.8	2.0	2.2	V	
Load current	$-I_L$	0		3	mA	
Stability $V_S = 10$ to 30 V	ΔV_{REF}			10	mV	
$I_{REF} = 0$ to 3 mA	ΔV_{REF}			20	mV	
Temperature coefficient	$\Delta V_{REF}/\Delta T$	−0.5		0.5	mV/K	
Operational Amplifier op amp						
Open-loop voltage gain	G_{V0}	60	90		dB	
Input offset voltage	V_{IO}	−10		10	mV	
Input current	$-I_I$			2	µA	
Common-mode input voltage range	V_{IC}	0		V_S-3	V	
Output current	I_{Q1}	−3		1.5	mA	
Transition frequency	f_T		2		MHz	
Transition phase	φ_T		120		deg.	
Output voltage	V_{Q1}	1.0		V_S-3	V	
Comparator K3						
Input current	$-I_I$			2	µA	
Input offset voltage	V_{IO}	−20		20	mV	
Output enabled	V_{Q2}		1.0	1.5	V	$I_{Q2} = 20$ mA
disabled	I_{Q2}			5	µA	$V_{Q2} = 30$ V
Common-mode input voltage range	V_{IC}	0		V_S-3	V	
Input K1 ($V_{control}$)						
Input current	$-I_S$			2	µA	
Control range:						
Conduction angle = 0° (dependent on R_S and C_S)			4		V	
Conduction angle = 175°			1.2		V	
Max. perm. conduction angle				SYNC pulse end −5	deg.	
Input K2 ($V\varphi_{max}$)						
Input current	$-I_S$			2	µA	
Control range:						
Conduction angle = 0° (dependent on R_S and C_S)			2		V	
Conduction angle = 175°			0.6		V	
Max. perm. conduction angle				SYNC pulse end −5	deg.	

Characteristics

$V_S = 10$ V to 30 V, $T_A = -25$ to 85 °C

Parameter	Symbol	Limit Values min.	typ.	max.	Unit	Test Conditions
Z Diode						
Z voltage	V_Z	13	14.5	16	V	$I_Z = 5$ mA
Enable Input E/A						
Input current	$-I_I$			2	µA	
H input voltage for driver output, active	V_{IH}	2.8			V	
L driver output disabled	V_{IL}			0.8	V	
Triac Trigger Output						
Output, enabled	V_L	1.4	2	2.5	V	$I_Q =$ 10 mA
		1.4	2	2.5	V	20 mA
		1.4	2	3.0	V	50 mA
		1.4	4	6.0	V	100 mA
Output, disabled	I_Q			10	µA	$V_Q = 30$ V
Input SYNC						
Switching current	I_{SYNC}		± 20		µA	
Switching threshold	V_{SYNC}		$V_S \pm 7.5$		V	
Output disconnection at V_S undervoltage	V_S	7.5	8	10	V	
Input R_S, C_S (refer to calculation formulae)						
Limit value C_S	C_S	5		100	nF	
Limit value R_S	R_S	33			kΩ	

5

Dimensioning notes and calculation formulae

1. Select trigger pulse width according to triac type and load.

2. **Calculate** C_S (for a $V_{control}$ domination)
   C_S (nF) = trigger pulse width (µs) x 0.2
   The formula yields the typical value
   e.g. T = 50 µs results in C_S = 10 nF

3. **Calculate** R_S (for 4 V max. sawtooth voltage)

$$R_S\ (k\Omega) = \frac{1}{\text{trigger pulse width } (\mu s)} \times 2 \times 10^4$$

   The formula yields the typical value
   e.g. T = 50 µs results in R_S = 400 kΩ

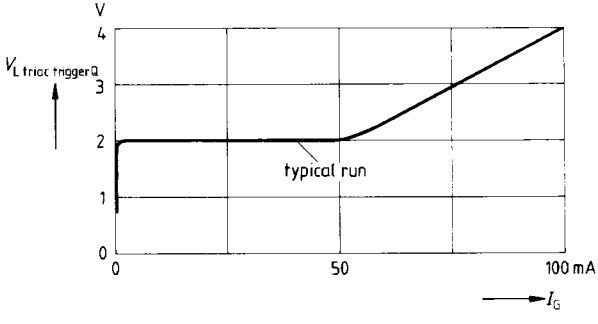
4. **Select R_{SYNC} resistance at SYNC input**
   The sync pulse width (from $V_S \pm 7.5$ V, $I_{SYNC} = \pm 20$ µA) has to be twice as large as the trigger pulse width.

4.1 Sync pulse width ≥ 2 x trigger pulse width x safety factor (according to component deviation and line voltage variation).

4.2 R_{SYNC} (kΩ) = [sync pulse width (µs) x line voltage (V rms) x 2.23×10^{-4} – 7.5] x 50
e.g. 560 µs sync pulse width and 220 V rms result in R_{SYNC} = 1 MΩ.
With 220 V rms line voltage, the minimum permissible resistance R_{SYNC} is 100 kΩ corresponding to a pulse width of 195 µs.

5. **Calculate** R_G

$$R_G = \frac{V_S - \text{triac gate voltage} - \text{low-voltage triac trigger output}}{I_G}$$



6. **Calculate** R_S

6.1 Calculation of R_S requires first of all the determination of the total current consumption. Insert the arithmetic mean values of the currents for one line cycle.

6.2 $\bar{I}_{tot} = \bar{I}_S = 3.2\ mA + \bar{I}(V_{ref}) + \bar{I}_{Q1}$ (OP) $+ \bar{I}_{Q2}$ (K3) $+ \bar{I}$ (driver output) $+ \bar{I}$ (additional external circuit currents) $+ |\bar{I}|$ (R_{SYNC}).

6.3 $R_S\ (k\Omega) = \dfrac{\text{rms line voltage (V)}}{\bar{I}_{tot}\ (mA)} \times 0.455 \times$ safety factor

(corresponding to component deviation and line voltage variation)

e.g. $\bar{I}_{tot} = 5$ mA und $V_{line} = 220$ V result in $R_S = 20\ k\Omega$.

Employing the internal Z diode reduces the IC's V_S voltage to 14.5 V.

7. **Calculate** C_G

7.1 Selection of the maximum permissible ripple at the V_S input, based on the desired functional quality and the special external components.

7.2 The ripple amplitude at the V_S input of the unit should not exceed $V_{pp} = 2$ V.

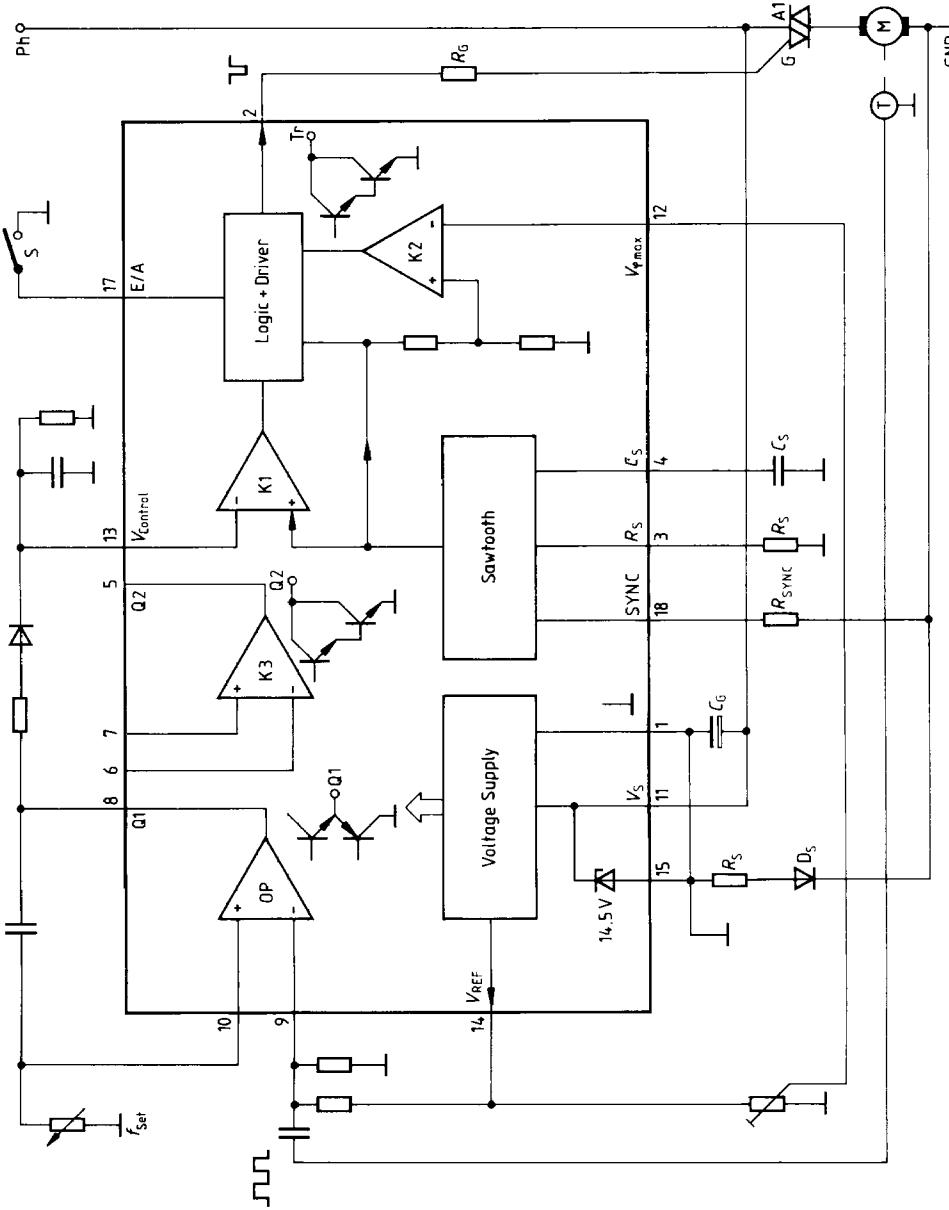
7.3 $C_G\ (\mu F) \geq \dfrac{\bar{I}_{tot}\ (mA)}{V_{pp}} \times 15$

e.g. ripple $V_{pp} = 0.75$ V; $\bar{I}_{tot} = 5$ mA results in $C_G = 100\ \mu F$

Application Examples

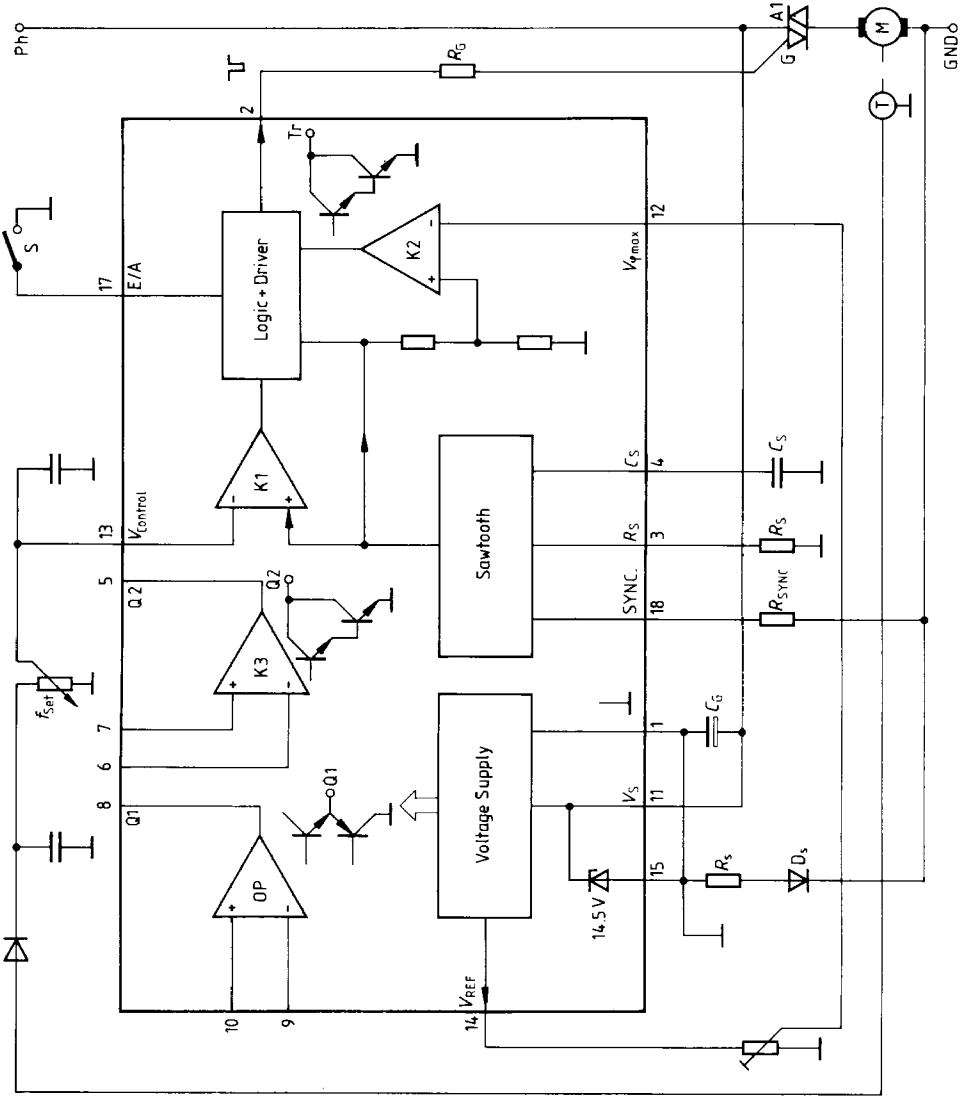
Schematic Circuit Diagram for Motor Control Using TLE 3101

The tachogenerator provides a **frequency** processed by the op amp (monoflop).

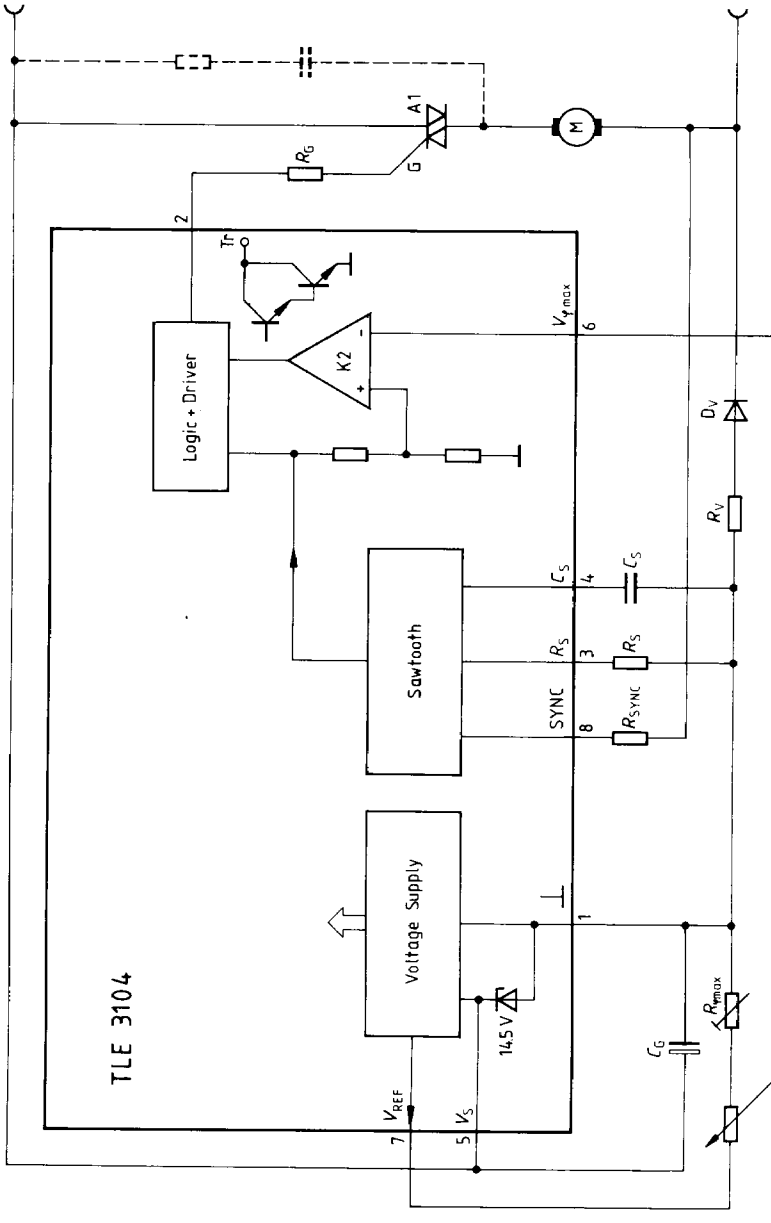


Schematic Circuit Diagram for Motor Control Using TLE 3101

The tachogenerator provides a **voltage** which is rectified and stabilized, and then fed to input $V_{control}$.

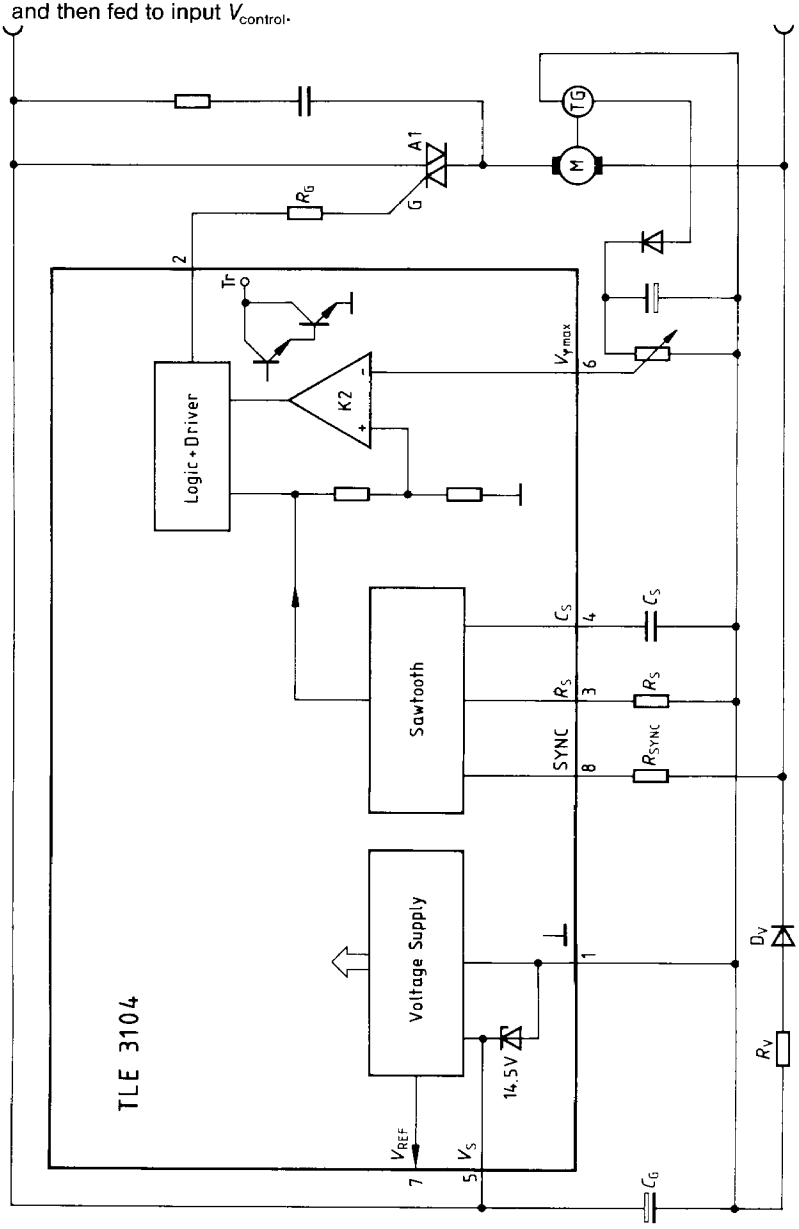


Schematic Circuit Diagram for Motor Control Using TLE 3104



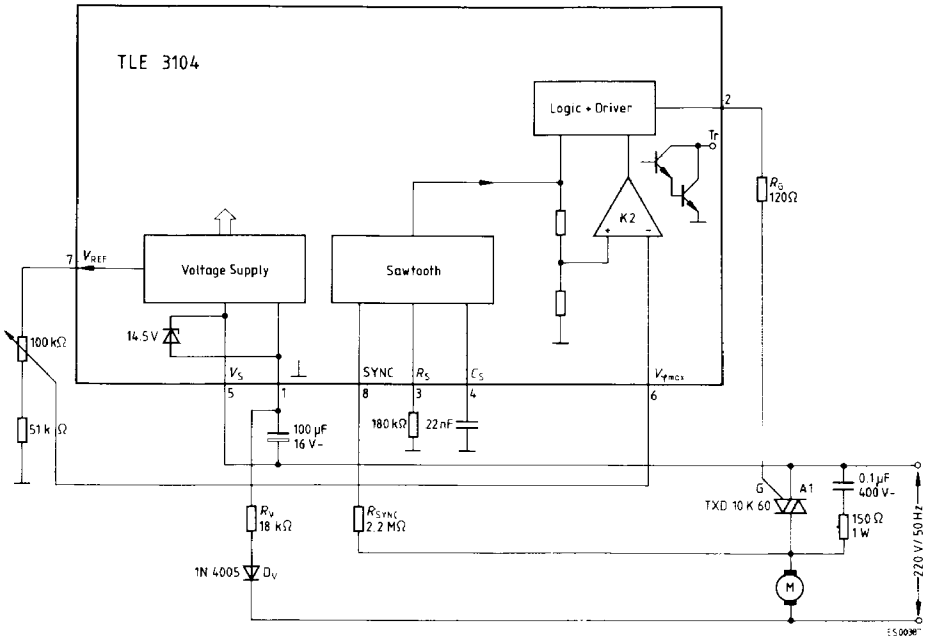
Schematic Circuit Diagram for Motor Control Using TLE 3104

The tachogenerator supplies a **voltage,** which is rectified and stabilized and then fed to input $V_{control}$.



Current Synchronization in Case of Inductive Load Control Using TLE 3104

Particularly in case of phase control of inductive loads, such as transformers and shaded-pole motors, there is a risk of half-wave operation as a result of the phase shift between voltage and current. In order to avoid this condition, the synchronization resistor is connected to A 2 of the triac (this method cannot be applied in the event of severe brush sparking of the motor).



Notes

The pulse width selected for the trigger pulse must be so great that the triac reaches its holding current, even with a great phase angle (critical: positive half-wave). For this reason, it may be necessary to select a lower value for the ac line series resistor.

The sync pulse must be at least twice as wide as the trigger pulse.