PLESSEY
Semiconductors

T-52-13-25

ZN410E

MOTOR SPEED CONTROLLER CIRCUIT

The ZN410E is a monolithic silicon integrated circuit which has been developed to offer a low cost speed controller of universal motors (AC series). The circuit contains all the functions required for the phase control of universal motors in closed loop systems. It incorporates a tacho input designed for a magnetic coil pickup and the IC requires a minimum of external components.

FEATURES

- Direct Supply from AC Mains or DC Power Source
- Low External Component Count
- On-Chip Shunt Regulator
- Soft Start Ramp Circuit
- Optional Current Limit or Trip
- Magnetic Pickup Tacho Input
- Circuit Reset on Power Down
- Guaranteed Full Cycle Conduction with Inductive Load
- Negative Firing Triac Pulses
- Low Cost

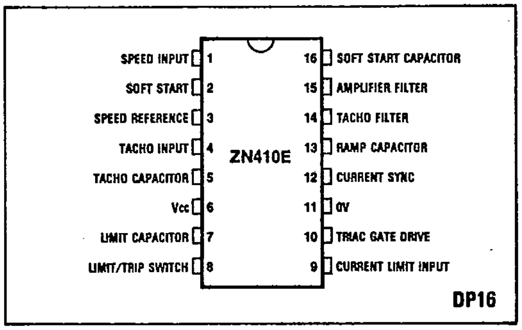

Fig.1 Pin connections - top view

ABSOLUTE MAXIMUM RATINGS

Shunt regulator current	25mA
Input voltage (pin 9 w.r.t. pin 6)	+5V max.
	-5V min.
Maximum input current (pins 4, 12)	±2mA
Output voltage (pin 10)	+7.5V max.
	-0.5V min.
Operating temperature range	0°C to 70°C
Storage temperature range	-55°C to +125°C

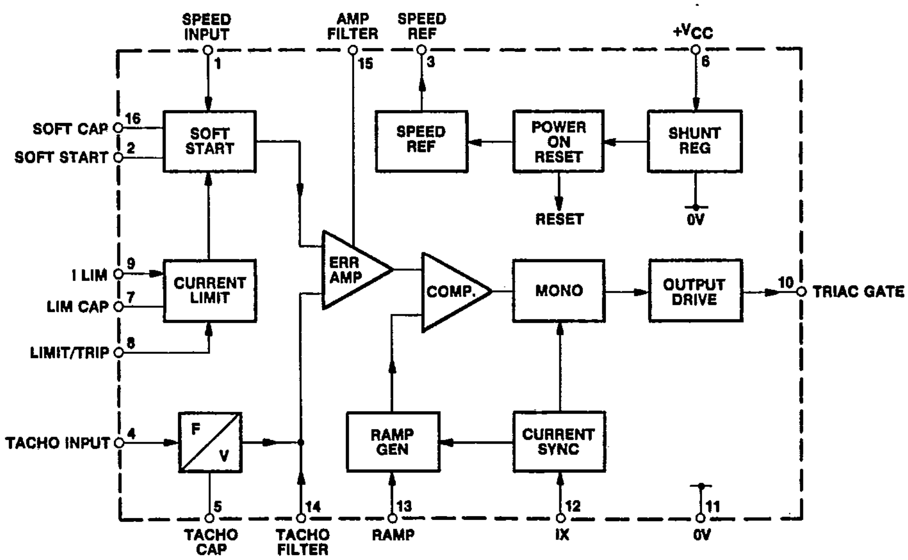

Fig.2 Block diagram of ZN410E

ELECTRICAL CHARACTERISTICS

Test conditions (unless otherwise stated):
T_{amb} = 25°C

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Characteristic	Value Min.	Value Typ.	Value Max.	Units	Conditions
Voltage regulator					
Shunt regulator voltage (V_{REG})	4.7	-	5.6	V	I_{CC} = 5.5mA
Shunt regulator slope resistance	-	-	20	Ω	I_{CC} = 5.5mA
Supply current	3.5	-	25	mA	
F/V converter					
Tacho input threshold voltage	-	±100	-	mV	
Tacho input current	-	500	-	nA	$V_{pin\ 4}$ = Vcc
Tacho maximum input frequency	20	100	-	kHz	
Speed control					
Speed reference voltage (w.r.t. pin 6)	-	-1.28	-	V	I_{IN} = 12.8μA
Speed reference input current	-	-	25	μA	
Speed input voltage range (w.r.t. pin 6)	$-V_{pin\ 3}$	-	0	V	
Speed input current	-	0.05	1.0	μA	$V_{pin\ 1}$ = 5.0V
Soft start capacitor charge current	5.3	7.5	12.0	μA	
Current limit					
Current limit input threshold	(330)	425	465	mV	½ cycle mean AC
Limit capacitor time constant	75C	150C	300C	ms	$C_{pin\ 7}$ in μF
Current sync					
Current sync threshold current	-	±120	±165	μA	
Current sync asymmetry	-	-	±10	μA	
Current sync clamp voltage (w.r.t. pin 6)	-	±1450	-	mV	I_{IN} = ±1mA
Ramp generator					
Ramp input charge current	35	50	70	μA	V_{IN} = 0V w.r.t. pin 6
Ramp input optimum max. negative level	-	-1.45	-	V	w.r.t. pin 6
Ramp input discharge voltage		-0.75	-	V	w.r.t. pin 6
Ramp input discharge current	-	10	-	mA	$V_{pin\ 13}$ = -1.45V (w.r.t. pin 6)
Triac gate drive					
Output current (on state)	65	100	130	mA	$V_{pin\ 10}$ = 2.0V
Output current (off state)	-	-	20	μA	$V_{pin\ 10}$ = 5.0V
Output pulse width	50	100	150	μs	R_L = 100Ω, 50% level
Error amplifier					
Phase angle/error voltage relationship ($V_{pin\ 1}$ - $V_{pin\ 14}$)	-	2	-	°/mV	Ramp $V_{pin\ 13}$ = 500mV
Tacho filter input voltage range (w.r.t. pin 6)	-	-	-1.5	V	
Amplifier filter time constant	35C	50C	65C	ms	$C_{pin\ 13}$ in μF

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CIRCUIT DESCRIPTION (See Fig.2)

The basis of operation of the ZN410 is that two signals representing the demanded motor speed and actual motor speed are compared and the difference signal is used to define the conduction angle of a triac controlling the AC supply to the load. The speed demand signal is a voltage level input derived from a potentiometer connected between the positive supply rail and an on-chip reference voltage at pin 3. Zero speed corresponds to the pot wiper at the positive rail and maximum speed to the wiper at pin 3 end. The IC is designed to operate with a potentiometer of nominally 100kΩ.

The actual speed signal is an alternating voltage connected to pin 4, usually derived from a magnetic pickup type tacho with the magnetic rotor mounted on the motor armature, where the signal frequency is directly proportional to the angular velocity of the armature. The tacho signal is converted to a d.c. voltage level by the Frequency to Voltage converter stage. This voltage is compared with the signal from the speed potentiometer, and the difference signal is amplified by the Error Amplifier, the output of which is fed to the one input of the Ramp Comparator. A reference sawtooth ramp signal which is synchronised to the AC mains cycle is fed to the other comparator input. The point in the mains cycle where these two signals coincide defines the firing point for the triac. The Ramp Comparator output triggers a Monostable circuit which defines the gate pulse width for the triac. This signal is buffered to produce a negative going constant current pulse on the Triac Gate Drive output, pin 10, suitable for most low-medium power triacs.

The circuit together with the motor and tacho form a closed loop system which attempts to keep the motor speed constant irrespective of changes in the mechanical loading on the motor. For example as the load increases the motor speed will tend to drop. This is refelected as a reduction in frequency of the tacho signal on pin 4 and produces a corresponding positive going rise in voltage at the f/V output on pin 14. The Error Amplifier amplifies this to produce a much larger increase in voltage at the inverting input of the Ramp Comparator. The sawtooth reference timing ramp fed to the non-inverting comparator input is a negative going slope which starts shortly after the mains cycle crosses zero. Hence the comparator output will now switch low earlier in the mains cycle resulting in an increase in the triac conduction angle, thereby applying more power to the motor in an attempt to maintain the original speed. In actual fact due to the finite gain of the system a reduction in speed with increased load is inevitable, otherwise the system would be unstable. This is a measure of the speed regulation of the system. The circuit gain could be increased to improve the regulation, but a point is reached where, dependent upon the mechanical dynamics of the system it becomes unstable. Hence a compromise has to be found between speed regulation and dynamic performance.

The ZN410 features an on-chip shunt regulator which allows operation of the IC directly from the AC mains supply in conjunction with either a resistive or reactive dropper. A soft-start function is also incorporated, the purpose of which is to produce a smooth acceleration of the motor whenever the power is applied or the speed input is rapidly increased. In association with the Power-On Reset circuit this function performs a controlled power-up sequence whenever the supply is interrupted. The Current Limit circuit senses the load current via a low value series resistor in the motor circuit. This signal is integrated to produce a level proportional to the average load current, and can either limit the load current by reducing the triac condition angle hence providing a constant current/torque characteristic, or it provides a trip function which removes power to the load by inhibiting the Triac Gate output. The inhibit is held on until the Power-On Reset circuit is activated by interrupting the IC supply.