PLESSEY
Semiconductors

T-65-09

ZN411

PHASE CONTROL INTEGRATED CIRCUIT

The ZN411 is a monolithic silicon integrated circuit designed primarily for the purpose of closed loop speed control of Universal Motors for use in power tools, food mixers, vacuum cleaners etc. The IC will also function in open loop and with both resistive or inductive loads in a multiplicity of phase control applications.

FEATURES

- Direct Supply from AC Mains or DC Power Source
- Soft Start Ramp Circuit
- Negative Triac Firing Pulses
- Triac Retrigger Facility
- Current Limit
- Tacho Input Compatible with Hall Effect Switch Devices
- Electronic Interlock and Speed Limit in Reverse Mode

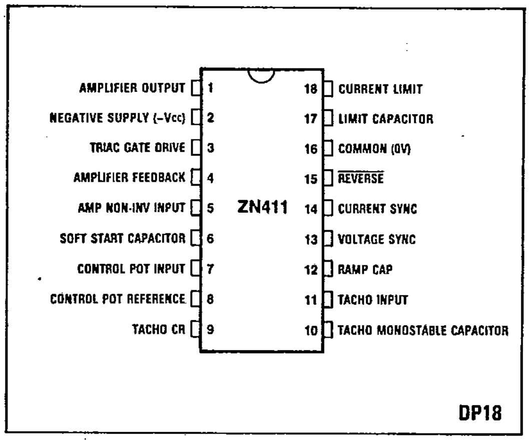

Fig.1 Pin connections

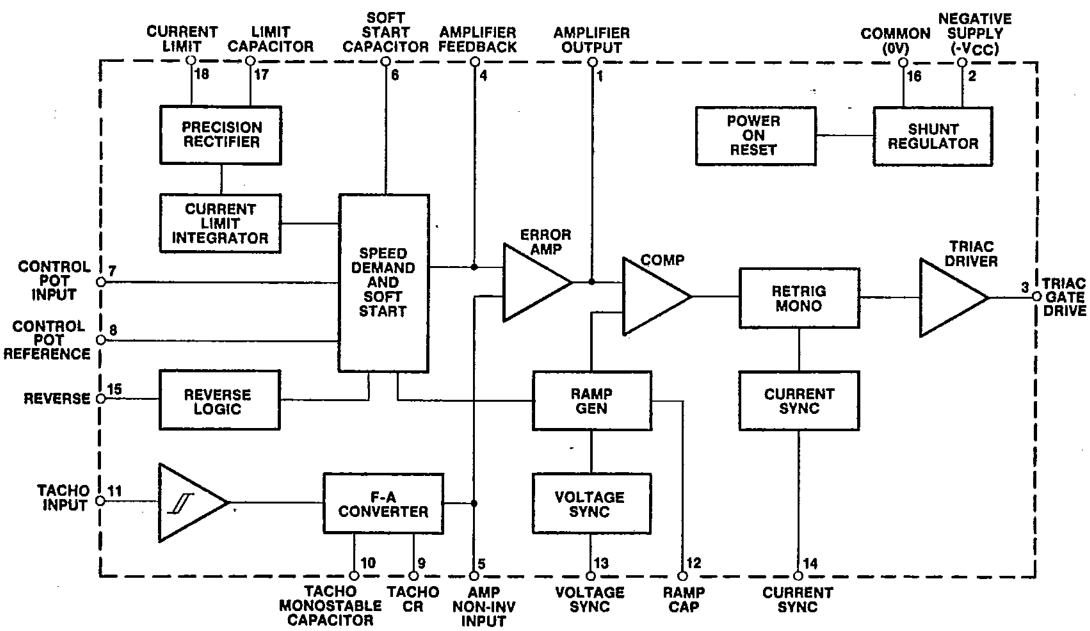

Fig.2 Block diagram of ZN411

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ELECTRICAL CHARACTERISTICS

Test conditions (unless otherwise stated):
T_{amb} = 25°C. All voltages measured w.r.t. 0V Pin 16.

Characteristic	Value			Unit	Conditions
	Min.	Typ.	Max.		
Minimum operating voltage		-4.5		V	
Supply current I_{CC}		-4.0	-8.0	mA	$-V_{CC}$ = 4.5V All other pins O/C
Shunt regulator voltage V_S	-4.75	-5.1	-5.4	V	I_{CC} = 10mA
Shunt regulator slope resistance		4.0	10.0	Ω	I_{CC} = 10mA
Rev input threshold voltage					
Pin 15 V_{TH} High State		2.9	3.4	V	
V_{TL} Low state	1.1	1.3	1.7	V	
(w.r.t. $-V_{CC}$ Pin 2)					
Rev input current Pin 15					
I_{IH} High state		150		µA	V_{IN} = 0V
I_{IL} Low state			-1	µA	V_{IN} = $-V_{CC}$
Tacho input threshold voltage Pin 11					
V_{TH} High state		2.9		V	
V_{TL} Low state		1.3		V	
(w.r.t. $-V_{CC}$ Pin 2)					
Tacho input current Pin 11					
I_{IH} High state		20		µA	V_{IN} = 0V
I_{IL} Low state		-125		µA	V_{IN} = $-V_{CC}$
Control input voltage range Pin 7	V_{p8} (Note 1)		0	V	RV1 = 100k Pin 15 = 0V
Control input voltage range Pin 7 - Reverse mode	0.23V (Note 1)		0	V	RV1 = 100k Pin 15 = $-V_{CC}$
Control input current Pin 7		100		nA	V_{IN} = 0V
Control potentiometer input bias current Pin 8		20		µA	
Soft start capacitor charge current Pin 6		10		µA	
Current limiting input threshold voltage Pin 18		540		mV mean AC	C7 = 470nF
Error amplifier open loop DC voltage gain	29	40	51		
Error amplifier closed loop AC voltage gain	2.9	4.4	5.0		C3 = 220nF R1 = ∞ f = 1kHz
Minimum error amplifier output voltage		-3.4		V	RV1 = 100k
Maximum error amplifier output voltage		0		V	
Voltage sync input, Pin 13					
Positive input threshold current		42		µA	
Negative input threshold current		14		µA	
Clamp voltage (w.r.t. $-V_{CC}$)		+1.4		V	I_{IN} = +1mA
		-100		mV	I_{IN} = -1mA
Current synch. input Pin 14					
Threshold current		±110		µA	
Clamp voltage (w.r.t. $-V_{CC}$)		+1.4		V	I_{IN} = +1mA
		-100		mV	I_{IN} = -1mA
Timing ramp amplitude, Pin 12	1.5	2.0	2.8	V pk-pk	Supply frequency at Pin 13 = 50Hz C5 = 1µF

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ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Value			Unit	Conditions
	Min.	Typ.	Max.		
Timing ramp capacitor charge current Pin 12	15	20	28	μA	
Triac gate pulse output Pin 3 output voltage (V_G)	-3.5			V	R_{LOAD} Pins 3-16 = 68Ω
Output current (On state) (I_G)	80	110	140	mA	V_{OUT} = -3V
Output current (Off state) (I_G)			20	μA	V_{OUT} = 0V
Output pulse width (t_G)	40	80	150	μs	
Minimum tacho input pulse width Pin 11		10		μs	

NOTE
1. V_{p8} = Voltage measured at pin 8 with RV1 = 100kohms. Typically = -2V.

ABSOLUTE MAXIMUM RATINGS

All voltages measured with respect to $-V_{CC}$ Pin 2.

Maximum shunt regulator current	25mA
Input voltage on pins 15 and 18	Maximum 7.5V Minimum -0.5V
Maximum input current on pins 13 and 14	±2mA
Output voltage on pin 3	Maximum 7.5V Minimum -0.5V
Operating temperature range	0°C to 70°C
Storage temperature range	-55°C to +125°C

CIRCUIT DESCRIPTION

The ZN411 basically operates by comparing a voltage set on a potentiometer, proportional to speed demand, with a voltage derived from a frequency to voltage converter, proportional to motor speed. This difference or error voltage is amplified and used to define the conduction angle of a triac connected in series with the motor supply.

The input to the Frequency to Analog (F-A) converter is normally a signal from a tacho generator connected directly to the motor, the output frequency of the tacho being proportional to motor speed. The two voltages representing speed demand and motor speed are subtracted and the results amplified by the Error Amplifier, the output of which is connected to one input of the Ramp Comparator. The other input to the Comparator is driven from the Ramp Generator with a negative going sawtooth waveform which is synchronised to the signal on the Voltage Sync input, normally the 50Hz mains. The ramp is allowed to start shortly after the mains voltage passes through zero volts. When the ramp voltage becomes more negative than the Error Amplifier output then the Comparator output switches low and triggers a Retriggerable Monostable, which via the Output Drive Buffer will fire the Triac with a negative going current pulse. The firing angle of the triac will be dependent on the difference between the speed demand and the actual motor speed. Hence if the speed falls due to increased mechanical load, then the F-A output will go more positive, driving the Error Amplifier output positive also. The Ramp voltage will now charge to a voltage equal to the Amplifier output in a shorter time resulting in the triac gate pulse occurring at an earlier time in the mains half cycle, and consequently more power will be applied to the motor to maintain a constant speed.

When driving inductive loads, with a lagging phase angle, at or near to full conduction angle, it is necessary to ensure that the load current from the previous half cycle has fallen to zero and the triac switched off, before applying the next triac gate pulse. This is accomplished by means of the current crossing sense input which actually monitors the voltage on the live side of the triac. This input is also used to retrigger the Monostable by detecting if, for some reason due to interruptions of the load current (e.g. brush bounce), the triac inadvertently switches off during the conduction phase.

A soft start function is provided at switch-on by ramping the speed demand voltage in a negative direction at a constant rate up to a level dependent on the voltage on the Control input. This ramp is reset whenever the supply to the ZN411 is interrupted. The switch-on reset circuit also inhibits the Output Drive Buffer until the ZN411 supply has reached operating level.

The current limit circuit operates on the average current level flowing in the load. This is achieved by monitoring across a low value resistor connected in series with the load. This signal is rectified by a precision half wave rectifier and the negative cycles fed to an integrator. The output from this integrator feeds one input of a threshold comparator, the other input of which is maintained at a fixed reference level. When the voltage output from the integrator exceeds the reference level the comparator switches and the output is used to reduce the speed demand level until the average load current drops below the set limit. In effect the motor output changes from a constant speed to a constant torque characteristic.

The reverse logic is activated by detecting a change in logic state (i.e. Low to High or vice versa) at the REV input pin. When this occurs the Soft Start Ramp is reset, removing the Triac gate drive until the motor speed, as detected by monitoring the output falls to almost zero. At this point the reset is removed allowing the Soft Start Ramp to commence. With the REV input low the speed demand signal level is clamped to nominally 25% of its full scale range. The purpose of this is to limit the maximum speed of the motor in the reverse direction, primarily to minimise wear on the brush gear and commutator. For normal applications the reverse switch would be one-pole of a three-pole changeover used to reverse the connections to the armature.