

## STEPPER MOTOR DRIVER

ADVANCE DATA

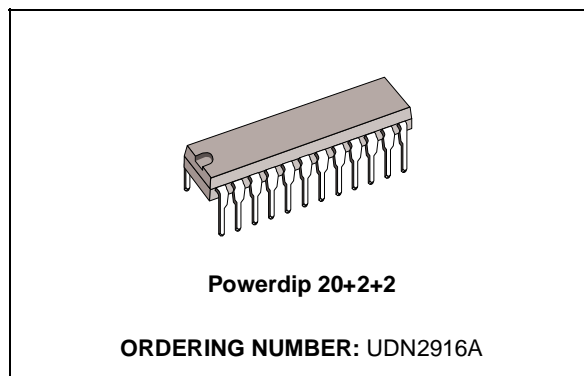
- ABLE TO DRIVE BOTH WINDINGS OF BIPO-LAR STEPPER MOTOR
- OUTPUT CURRENT UP TO 750mA EACH WINDING
- WIDE VOLTAGE RANGE 10V TO 50V
- HALF-STEP, FULL-STEP AND MICROSTEPP-ING MODE
- BUILT-IN PROTECTION DIODES
- INTERNAL PWM CURRENT CONTROL
- LOW OUTPUT SATURATION VOLTAGE
- DESIGNED FOR UNSTABILIZED MOTOR SUPPLY VOLTAGE
- INTERNAL THERMAL SHUTDOWN

### DESCRIPTION

The UDN2916A is a bipolar monolithic integrated circuits intended to control and drive both winding of a bipolar stepper motor or bidirectionally control two DC motors.

The UDN2916A with a few external components form a complete control and drive circuit for LS-TTL or microprocessor controlled stepper motor system.

The power stage is a dual full bridge capable of sustaining 50V and including four diodes for current recirculation.



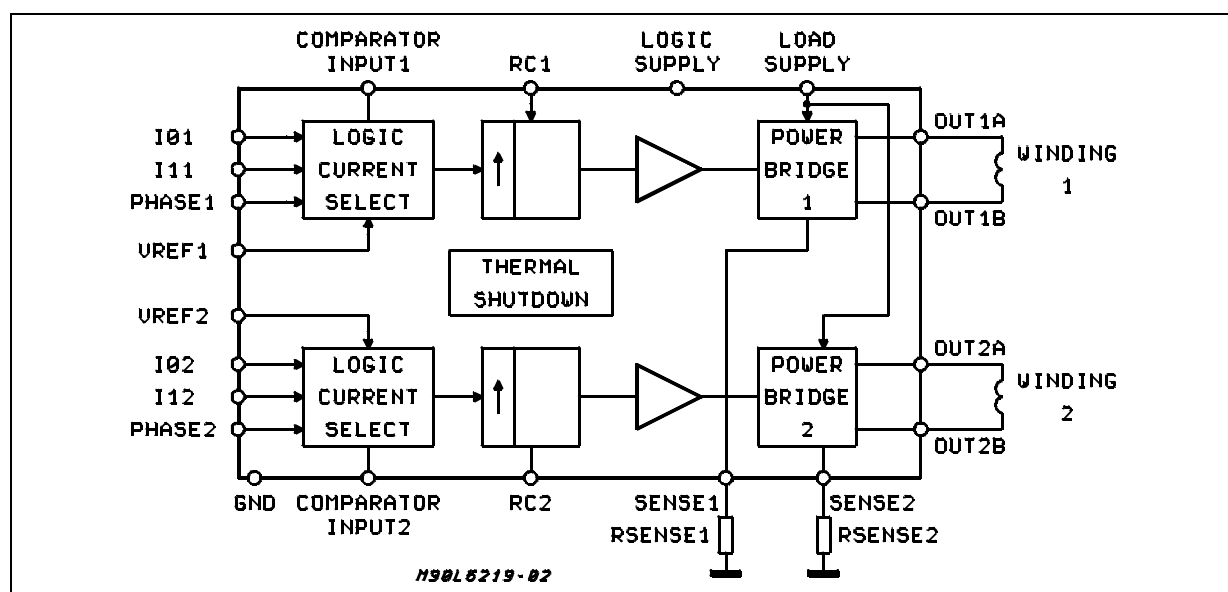
A cross conduction protection is provided to avoid simultaneous cross conduction during switching current direction.

An internal pulse-width-modulation (PWM) controls the output current to 750mA with peak start-up current up to 1A.

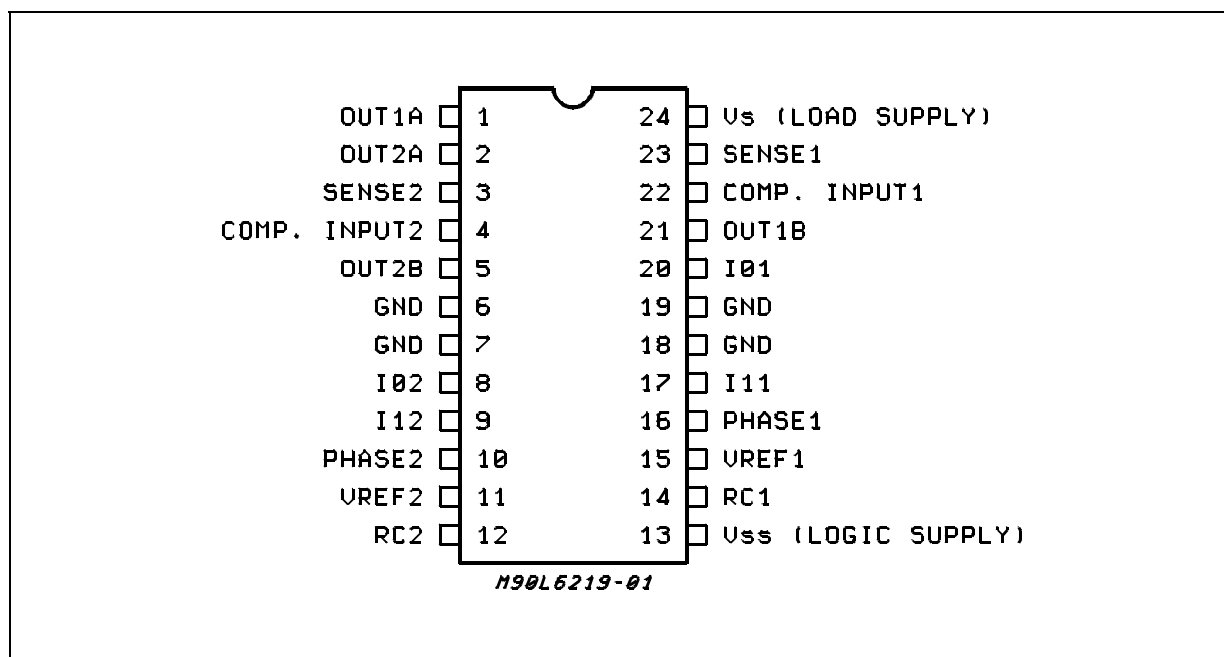
Wide range of current control from 750mA (each bridge) is permitted by means of two logic inputs and an external voltage reference. A phase input to each bridge determines the load current direction.

A thermal protection circuitry disables the outputs if the chip temperature exceeds safe operating limits.

### BLOCK DIAGRAM



## PIN CONNECTION (Top view)



## PIN FUNCTIONS

N°	Name	Function
1;2	OUTPUT A	See pins 5;21
3;23	SENSE RESISTOR	Connection to Lower Emitters of Output Stage for Insertion of Current Sense Resistor
4;22	COMPARATOR INPUT	Input connected to the comparators. The voltage across the sense resistor is feedback to this input through the low pass filter RC CC. The higher power transistors are disabled when the sense voltage exceeds the reference voltage of the selected comparator. When this occurs the current decays for a time set by $R_T C_T$ ( $t_{off} = 1.1 R_T C_T$ ). See fig. 1.
5;21	OUTPUT B	Output Connection. The output stage is a "H" bridge formed by four transistors and four diodes suitable for switching applications.
6;19	GROUND	See pins 7;18
7;18	GROUND	Ground Connection. With pins 6 and 19 also conducts heat from die to printed circuit copper.
8;20	INPUT 0	See INPUT 1 (pins 9;17)
9;17	INPUT 1	These pins and pins 8;20 (INPUT 0) are logic inputs which select the outputs of the comparators to set the current level. Current also depends on the sensing resistor and reference voltage. See Functional Description.
10;16	PHASE	This TTL-compatible logic inputs sets the direction of current flow through the load. A high level causes current to flow from OUTPUT A (source) to OUTPUT B (sink). A schmitt trigger on this input provides good noise immunity and a delay circuit prevents output stage short circuits during switching.
11;15	REFERENCE VOLTAGE	A voltage applied to this pin sets the reference voltage of the comparators, this determining the output current (also thus depending on $R_s$ and the two inputs INPUT 0 and INPUT 1).
12;14	RC	A parallel RC network connected to this pin sets the OFF time of the higher power transistors. The pulse generator is a monostable triggered by the output of the comparators ( $t_{off} = 1.1 R_T C_T$ ).
13	V <sub>SS</sub> - LOGIC SUPPLY	Supply Voltage Input for Logic Circuitry
24	V <sub>S</sub> - LOAD SUPPLY	Supply Voltage Input for the Output Stages.

**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Value	Unit
$V_S$	Supply Voltage	50	V
$I_o$	Output Current (peak)	$\pm 1$	A
$I_o$	Output Current (continuous)	$\pm 0.75$	A
$V_{SS}$	Logic Supply Voltage	7	V
$V_{IN}$	Logic Input Voltage Range	-0.3 to +7	V
$V_{sense}$	Sense Output Voltage	1.5	V
$T_J$	Junction Temperature	+150	°C
$T_{op}$	Operating Temperature Range	0 to 70	°C
$T_{stg}$	Storage Temperature Range	-55 to +150	°C

**THERMAL DATA**

Symbol	Description	Value	Unit
$R_{thj-case}$	Thermal Resistance Junction-case	Max	14 °C/W
$R_{thj-ambient}$	Thermal Resistance Junction-ambient	Max	60 °C/W

**ELECTRICAL CHARACTERISTICS** ( $T_{amb} = 25^\circ\text{C}$ ,  $T_{tab} \leq 70^\circ\text{C}$ ,  $V_S = 50\text{V}$ ,  $V_{SS} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $V_{REF} = 5\text{V}$ ; unless otherwise specified) See fig. 3.

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
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**OUTPUT DRIVERS (OUT<sub>A</sub> or OUT<sub>B</sub>)**

$V_S$	Motor Supply Range		10		50	V
$I_{CEX}$	Output Leakage Current	$V_{OUT} = V_S$ $V_{OUT} = 0$	- -	<1 <-1	50 -50	$\mu\text{A}$ $\mu\text{A}$
$V_{CE(sat)}$	Output Saturation Voltage	Sink Driver, $I_{OUT} = +500\text{mA}$ Sink Driver, $I_{OUT} = +750\text{mA}$ Source Driver, $I_{OUT} = -500\text{mA}$ Source Driver, $I_{OUT} = -750\text{mA}$	- - - -	0.3 0.7 1.1 1.3	0.6 1 1.4 1.6	V V V V
$I_R$	Clamp Diode Leakage Current	$V_R = 50\text{V}$	-	<1	50	$\mu\text{A}$
$V_F$	Clamp Diode Forward Voltage	Sink Diode Source Diode $I_F = 750\text{mA}$		1 1	1.5 1.5	V V
$I_{S(on)}$	Driver Supply Current	Both Bridges ON, No Load	-	8	15	mA
$I_{S(off)}$	Driver Supply Current	Both Bridges OFF	-	6	10	mA

**CONTROL LOGIC**

$V_{IN(H)}$	Input Voltage	All Inputs	2.4	-	-	V
$V_{IN(L)}$	Input Voltage	All Inputs	-	-	0.8	V
$I_{IN(H)}$	Input Current	$V_{IN} = 2.4\text{V}$	-	<1	20	$\mu\text{A}$
$I_{IN(L)}$	Input Current	$V_{IN} = 0.84\text{V}$	-	-3	-200	$\mu\text{A}$
$V_{REF}$	Reference Voltage	Operating	1.5	-	7.5	V
$I_{SS(ON)}$	Total Logic Supply Current	$I_o = I_1 = 0.8\text{V}$ , No Load	-	54	64	mA
$I_{SS(OFF)}$	Total Logic Supply Current	$I_o = I_1 = 2.4\text{V}$ , No Load	-	10	14	mA

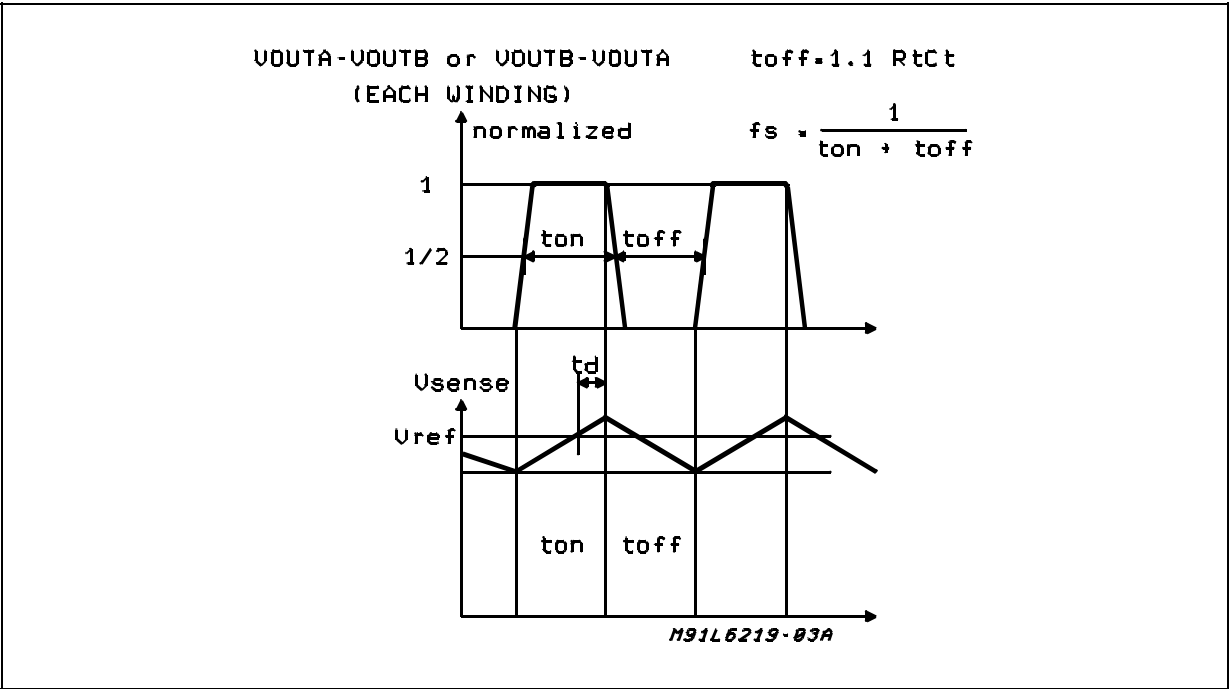
**COMPARATORS**

$V_{REF} / V_{sense}$	Current Limit Threshold (at trip point)	$I_o = I_1 = 0.8\text{V}$ $I_o = 2.4\text{V}$ , $I_1 = 0.8\text{V}$ $I_o = 0.8\text{V}$ , $I_1 = 2.4\text{V}$	9.5 13.5 25.5	10 15 30	10.5 16.5 34.5	- - -
$t_{off}$	Cutoff Time	$R_t = 56\text{K}\Omega$ $C_t = 820\text{pF}$	-	50		$\mu\text{s}$
$t_d$	Turn Off Delay	Fig. 1	-	1		$\mu\text{s}$

ELECTRICAL CHARACTERISTICS (Continued)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
PROTECTION						
T <sub>J</sub>	Thermal Shutdown Temperature		-	170	-	°C

Figure 1



FUNCTIONAL DESCRIPTION

The circuit is intended to drive both windings of a bipolar stepper motor. The peak current control is generated through switch mode regulation. There is a choice of three different current levels with the two logic inputs I<sub>01</sub> - I<sub>11</sub> for winding 1 and I<sub>02</sub> - I<sub>12</sub> for winding 2. The current can also be switched off completely

Input Logic (I<sub>0</sub> and I<sub>1</sub>)

The current level in the motor winding is selected with these inputs. (See fig. 2) If any of the logic inputs is left open, the circuit will treat it has a high level input.

I <sub>0</sub>	I <sub>1</sub>	Current Level
H	H	No Current
L	H	Low Current 1/3 I <sub>0</sub> max
H	L	Medium Current 2/3 I <sub>0</sub> max
L	L	Maximum Current I <sub>0</sub> max

Phase

This input determines the direction of current flow

in the windings, depending on the motor connections. The signal is fed through a Schmidt-trigger for noise immunity, and through a time delay in order to guarantee that no short-circuit occurs in the output stage during phase-shift. High level on the PHASE input causes the motor current flow from Out A through the winding to Out B

Current Sensor

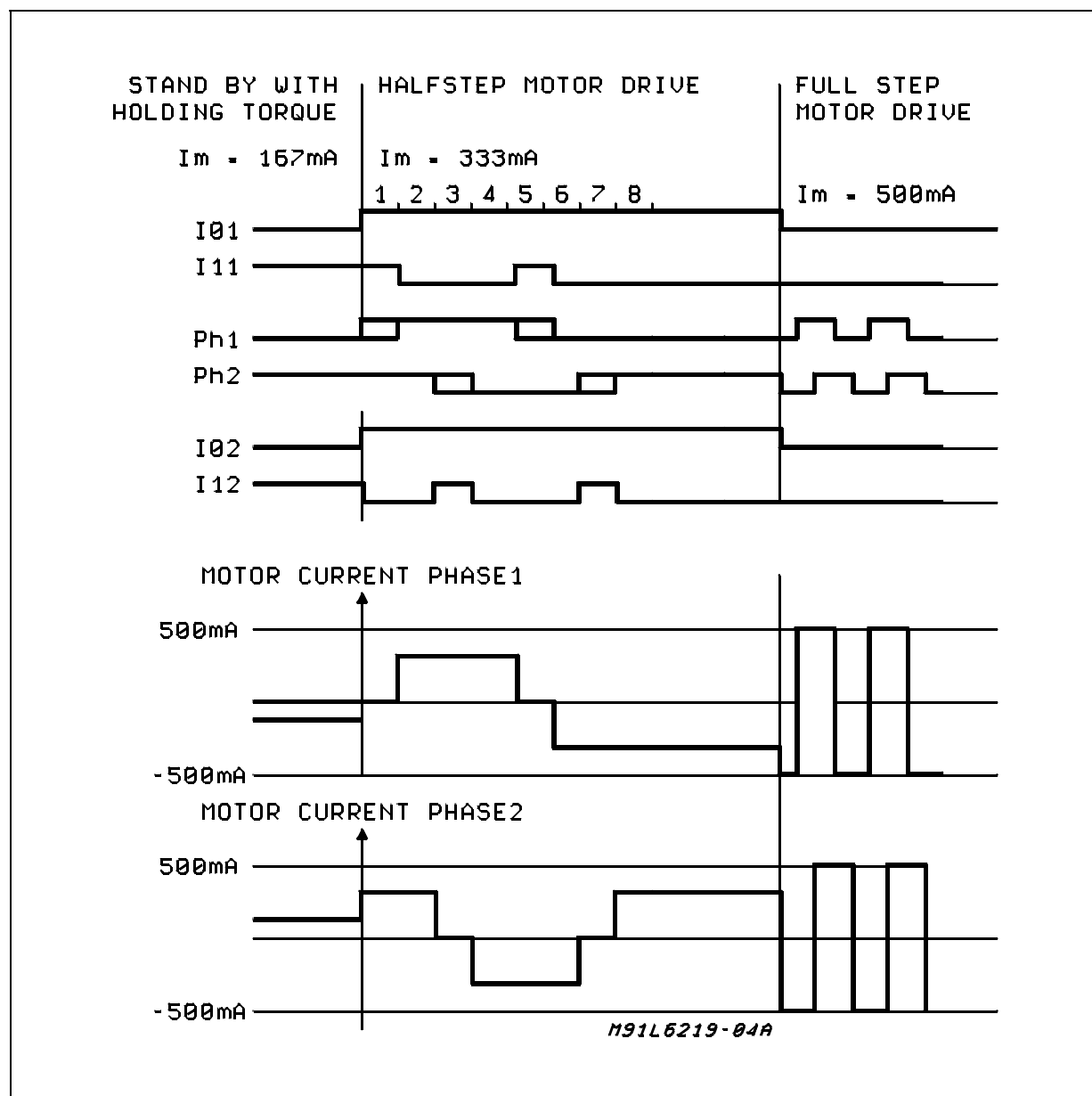
This part contains a current sensing resistor (R<sub>S</sub>), a low pass filter (R<sub>C</sub>, C<sub>C</sub>) and three comparators. Only one comparator is active at a time. It is activated by the input logic according to the current level chosen with signals I<sub>0</sub> and I<sub>1</sub>. The motor current flows through the sensing resistor R<sub>S</sub>. When the current has increased so that the voltage across R<sub>S</sub> becomes higher than the reference voltage on the other comparator input, the comparator goes high, which triggers the pulse generator.

The max peak current I<sub>max</sub> can be defined by:

$$I_{max} = \frac{V_{ref}}{10 R_S}$$

Single-pulse Generator

### Figure 2: Principle Operating Sequence



The pulse generator is a monostable triggered on the positive going edge of the comparator output. The monostable output is high during the pulse time,  $t_{off}$ , which is determined by the time components  $R_t$  and  $C_t$ .

$$t_{\text{off}} = 1.1 \cdot R_t C_t$$

The single pulse switches off the power feed to the motor winding, causing the winding current to decrease during  $t_{\text{off}}$ .  
If a new trigger signal should occur during  $t_{\text{off}}$ , it is ignored.

The output stage contains four Darlington transistors (source drivers) four saturated transistors (sink drivers) and eight diodes, connected in two H bridge.

The source transistors are used to switch the power supplied to the motor winding, thus driving a constant current through the winding.

It should be noted however, that is not permitted to short circuit the outputs.

Internal circuitry is added in order to increase the accuracy of the motor current particularly with low current levels.

## Output Stage

 $V_S, V_{SS}, V_{Ref}$

## UDN2916A

The circuit will stand any order of turn-on or turn-off the supply voltages  $V_S$  and  $V_{SS}$ . Normal  $dV/dt$  values are then assumed.

Preferably,  $V_{Ref}$  should be tracking  $V_{SS}$  during power-on and power-off if  $V_S$  is established.

### APPLICATION INFORMATION (Note 1)

Some stepper motors are not designed for continuous operation at maximum current. As the circuit drives a constant current through the motor, its temperature might increase exceedingly both at low and high speed operation.

Also, some stepper motors have such high core losses that they are not suited for switch mode current regulation.

Unused inputs should be connected to proper voltage levels in order to get the highest noise im-

munity.

As the circuit operates with switch mode current regulation, interference generation problems might arise in some applications. A good measure might then be to decouple the circuit with a 100nF capacitor, located near the package between power line and ground.

The ground lead between  $R_S$  and circuit GND should be kept as short as possible.

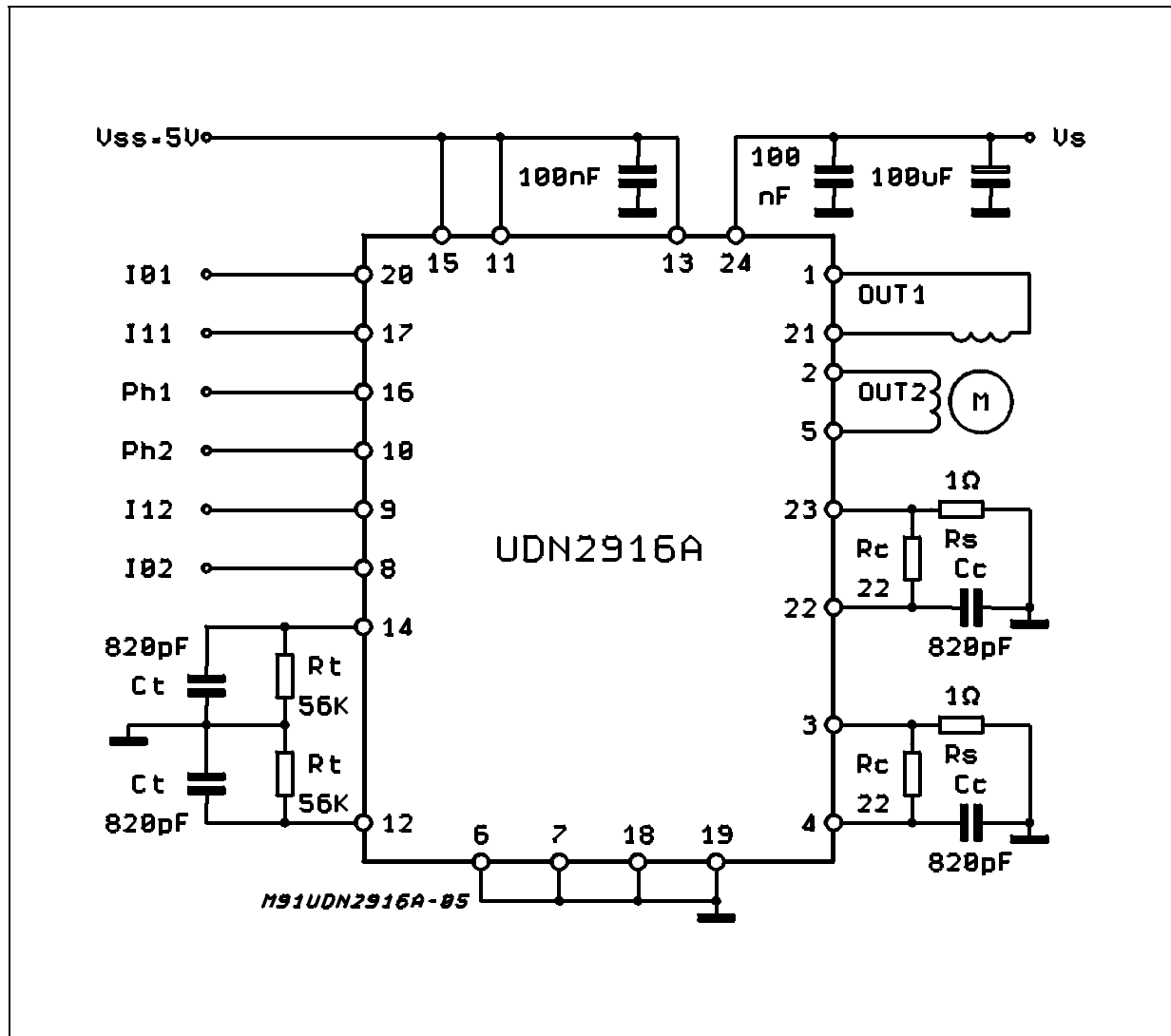
A typical Application Circuit is shown in Fig. 3.

Note that  $C_t$  must be NPO type or similar else.

To sense the winding current, paralleled metal film resistors are recommended ( $R_S$ )

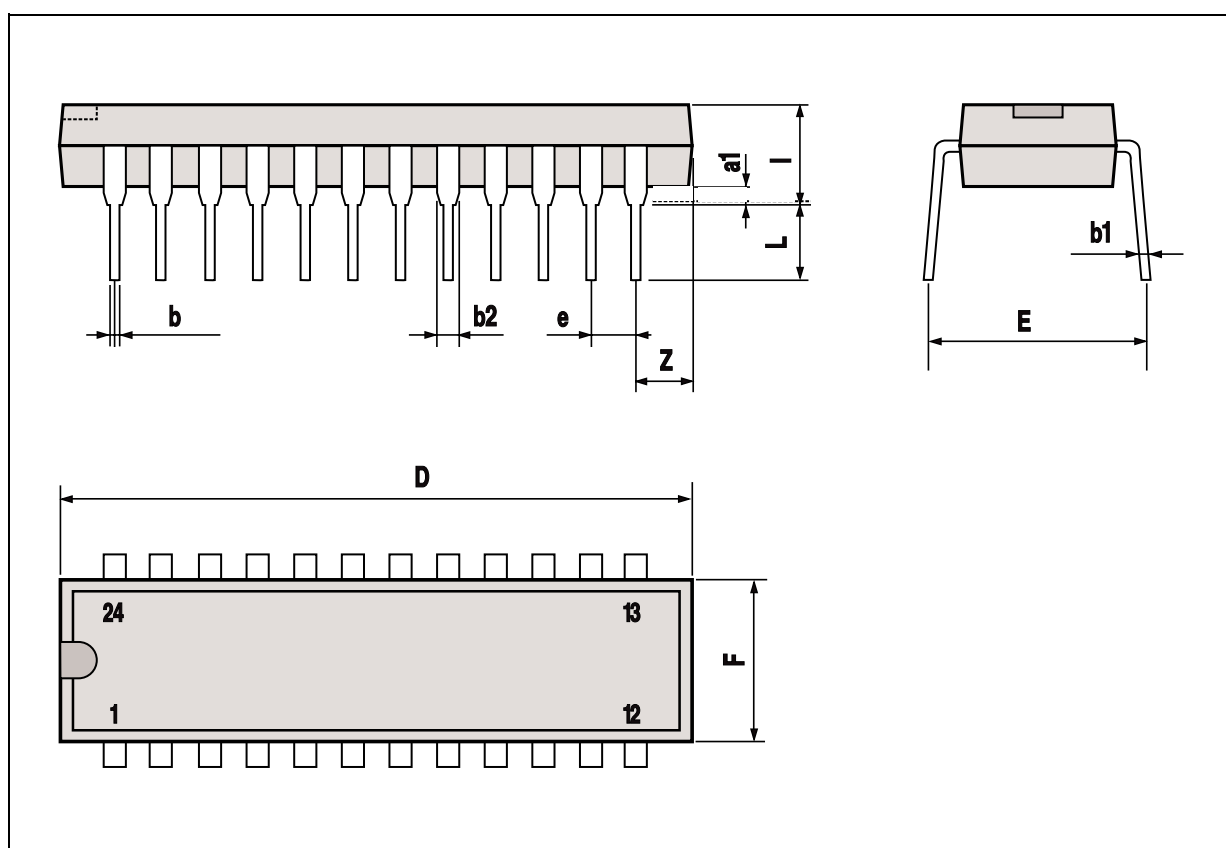
**Note 1** - Other information is available as "Smart Power Development System": HWPC2916A.

**Figure 3:** Typical Application Circuit.



## DIP24 (20+2+2) MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.38			0.015		
b	0.41		0.51	0.016		0.020
b1	0.20	0.25	0.30	0.008	0.010	0.012
b2	1.40	1.52	1.65	0.055	0.060	0.065
D			30.23			1.19
E		7.62			0.300	
e		2.54			0.100	
F			6.86			0.270
I			4.32			0.170
L	3.18			0.125		



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