BRUSH DC MOTOR CONTROL MODULE

BDCMCM 1105; BDCMCM 1110

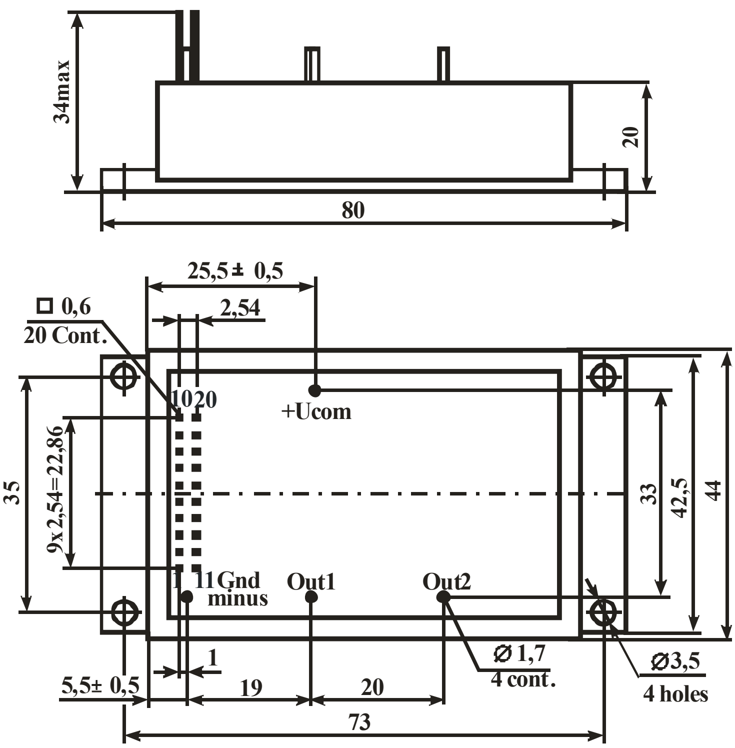
USER'S MANUAL

1 Function

1.1 Semiconductor module is intended for controlling, regulating and stabilizing of rotation velocity of brush DC motor of low power.

2 Module technology and operation

2.1 The module is hybrid assembly of air-tight structure in metal-plastic housing (Figure 1). There are vertical outputs on the top surface for bonding wire connection. The lower metal surface is heat-generating. To provide error-free performance you should install the module housing to a heat sink (radiator or structural component).



1 – GND;
2 – Rc-;
3 - Tc+;
4 – ERROR;
7 – PWM;
8 – U_{cont};
9 – BRAKING;
10 – Fwd/Back;
11 –GND;
12 – Rc+;
13 – Tc-;
17 – U_{ref};
18 – $-U_{cont}$;
19 – OSC;
20 – Enable;

Contacts 5, 6, 14, 15, 16 are not used.

Figure 1 – Overall drawing and output function

2.2 The module is high-integrated air-tight circuit that includes monolithic control circuit, built-in power supply, output switch circuit of the driver; power output switches of field transistor that are connected by H-bridge circuit.

2.3 The module enables to control the DC brush motor and provides: regulation of velocity rotation; motor braking; measurement and limitation of current level that is consumed by motor armature winding from external source, "Error" signal delivery in critical conditions.

2.4 Structure circuit is shown at Figure 2. Output function is shown in Table 1.

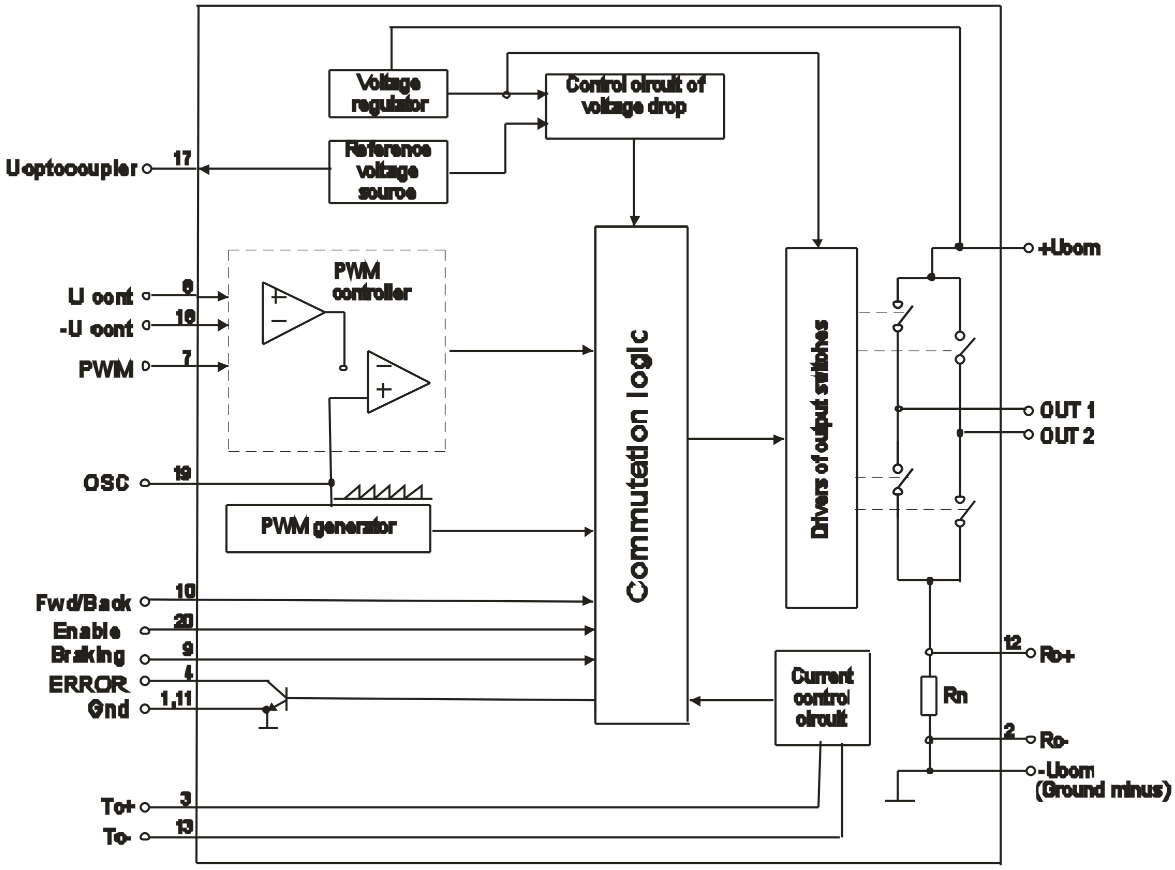


Figure 2 – Structure circuit

Table 1 – Output function

Title	Function
+Ucom	Operating voltage
-Ucom	Ground minus
Out1, Out2	Armature winding connection output
Uref	Reference voltage source for charge current generation of timing capacitance Cg and U_{cont} organization.
U_{cont}	Input of velocity control signal, non-inverse input of PWM amplifier
- U_{cont}	Differential input of error signal, inverse input of PWM amplifier
PWM	Differential input of error signal, inverse input of PWM amplifier
CS	Timing element Cg, Rg connection, they define PWM generator frequency
Fwd/Back	Control input of rotor rotation direction
ENABLE	Enable of motor operation/shutdown
BRAKING	Dynamic braking signal
ERROR	Output signal on basis of OC circuit, it has active low level when one of the controlled parameters is impaired: low level (0) on input «Enable»; current consumption increase by more than controlled limit; supply voltage decrease by lower than the controlled level
Tc+; Tc-	Sensor input of current control circuit
Rc+; Rc-	Outputs (potential) of current-measuring shunt

Module contains the following functional blocks:

- Voltage regulator for elements and device units supply;
- Reference voltage source with high temperature stability enables to organize the velocity control signal for FB systems;
- Control circuit of voltage levels for non-failure operation;
- PWM-controller realize regulation of rotor rotation velocity;
- Saw-tooth signal generator for velocity PWM-regulation;
- Commutation logic that is controlled by means of three logic signal, it receives the signals of functional blocks, give control signals of output switches and “Error” signal in critical conditions;
- Gate control driver of output field transistors that provide big switching speed of field transistors;
- Circuit of current control/limitation consumed by motor winding;

- Current test circuit consumed by motor winding;
- H-bridge of field transistor that enables to measure current leakage direction through motor winding and value of voltage effective value.

2.6 Module state variants when DC brush motor drive only in case of maximum velocity demand is shown in Table 2.

Table 2 – Module state variants when DC brush motor drive

<table>
<tr><td colspan="3">Inputs</td><td>Current sensor</td><td colspan="3">outputs</td><td>Note</td></tr>
<tr><td>Fwd/Back</td><td>Enable</td><td>Braking</td><td></td><td>Out 1</td><td>Out 2</td><td>ERROR</td><td></td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>p.1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>p.1</td></tr>
<tr><td>X</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>p.2</td></tr>
<tr><td>X</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>p.3</td></tr>
<tr><td>X</td><td>0</td><td>0</td><td>0</td><td>-</td><td>-</td><td>0</td><td>p.4</td></tr>
<tr><td>X</td><td>1</td><td>0</td><td>1</td><td>-</td><td>-</td><td>0</td><td>p.5</td></tr>
<tr><td>p.1</td><td colspan="7">Binary inputs «Fwd/Back», «ENABLE», «BRAKING» have TTL-compatible levels. X – any state. High level (1) on «Out1», «Out2» means connection to «+U_{com}», low level (0) – connection to «- U_{com}» (ground minus).</td></tr>
<tr><td>p.2</td><td colspan="7">In case of high level (1) of «ENABLE» and «BRAKING» – «Out1» and «Out2» is connected to «-U_{com}» (ground minus), outputs of motor winding are closed between, this provides retarding electromagnetic retarding force (dynamic brake)</td></tr>
<tr><td>p.3</td><td colspan="7">In case of low level (0) of «Enable» output and high level (1) of «Brake» output, the outputs «Out1», «Out2» are in dynamic braking mode; «ERROR» output built by circuit with open collector has active low level (0).</td></tr>
<tr><td>p.4</td><td colspan="7">In case of low level (0) on «ENABLE» and «Brake» outputs, the outputs «Out1», «Out2» are disconnected; low level (0) on «ERROR» output.</td></tr>
<tr><td>p.5</td><td colspan="7">If current level (consumed from external source) is higher than the prescribed limit then «Out1», «Out2» are disconnected; low level (0) on «ERROR» output. Current sensor signal is in-circuit, level operating threshold 100 mV on current-measuring shunt. Logic zero (0) is generated when level is < 85 mV, level logic-1 (1) - > 115 mV.</td></tr>
</table>

3 Basic specifications and characteristics

3.1 Basic electric characteristics are shown in Table 3.
3.2 Maximum permissible service regimes are shown in Table 4.

Table 3 – Basic electric characteristics

<table>
<tr><td rowspan="2">Parameter</td><td rowspan="2">Symbol</td><td rowspan="2">Unit</td><td colspan="2">Rate</td><td rowspan="2">Note</td></tr>
<tr><td>BDCMCM 1105</td><td>BDCMCM 1110</td></tr>
<tr><td>1 Max pulse supply voltage</td><td>$U_{s.\ max}$</td><td>V</td><td colspan="2">45</td><td>t_p=5 ms</td></tr>
<tr><td>2 Max closed transistor voltage of control channel of motor winding</td><td>$U_{tr.max}$</td><td>V</td><td colspan="2">100</td><td></td></tr>
<tr><td>3 Control input voltage (outputs 9, 10, 20)</td><td>$U_{in.max}$</td><td>V</td><td colspan="2">U_{ref}</td><td></td></tr>
<tr><td>4 Input PWM-generator current (source/drain current) (output 19)</td><td>I_{ocs}</td><td>mA</td><td colspan="2">30</td><td></td></tr>
<tr><td>5 Input voltage range of PWM amplifier (outputs 8, 18)</td><td>$U_{in.ampl}$, max</td><td>V</td><td colspan="2">-0.3÷U_{ref}</td><td></td></tr>
</table>

Continuation of Table 3

Parameter	Symbol	Unit	Rate BDCMCM 1105	Rate BDCMCM 1110	Note
6 Output PWM amplifier current (source or drain current) (output 7)	$I_{out.ampl}$	mA	10		-0.3<Uin.ampl< U_{ref}.
7 Input voltage range of current control circuit (output 3, 13)	$U_{cs\ in.max}$	V	-0.3÷5.0		
8 Output voltage «ERROR» (output 4)	$U_{ce(/er)max}$	V	20		
9 «ERROR» Source current (output 4)	$I_{ce(/er)max}$	mA	20		
10 Output pulse current	$I_{p\ мах}$	A	15		t_p<30 µs Q=100
11 Max limitation current	$I_{lim.\ max}$	A	7.5	15	at di/dt=0.4A/µs
12 Isolation voltage (output - housing)	U_{isol}	V	500		DC,1 minute
13 Max junction temperature	$T_{j.max}$	°C	+150		
14 Thermal junction-housing resistance	$R_{th.\ j\text{-}h}$	°C/W	2		

Table 4 – Maximum service modes

Parameter	Symbol	Unit	Rate BDCMCM 1105		Rate BDCMCM 1110		Note
			min	max	min	max	
1 Operation temperature range	T_{oper}	°C	-40	+85	-40	+85	
2 Storage temperature	T_{stor}	°C	-60	+100	-60	+100	
Input and reference voltage parameter							
1 Supply voltage	Us	V	15	29.7	15	29.7	
2 Current consumption	Ic	mA	40	60	40	60	U_{com}=27V±10%
3 Reference voltage (output 17)	U_{ref}	V	5.82	6.57	5.82	6.57	T= (-40÷85) °C I_{ref}=1 mA
4 Reference voltage change	ΔU_{ref}	mV	30				I_{ref} = (1÷20) mA
5 Output source current of reference voltage	I_{ref}	mA	40	70	40	70	
6 Threshold off voltage of reference voltage source	$U_{ref.off}$	V	4	5	4	5	
7 Shutdown voltage when line voltage decrease	U_{off}	V	9.5	11.3	9.5	11.3	
PWM-controller parameter							
1 Input voltage of amplifier offset	U_a	mV	0.4	10	0.4	10	
2 Difference of input amplifier currents	I_{isol}	nA	80	500	80	500	
3 Input bias current	I_{bi}	nA	-46	-1000	-46	-1000	
4 Input common-mode voltage range	U_{ICR}	V	0÷U_{ref}				
5 Coefficient of amplification without FB	A_{VOL}	dB	70	80	70	80	Uin=3 V, R_L=15 kΩ
6 Reduction factor of common-mode signal	CMMR	dB	55		55		

Continuation of Table 4

Parameter	Symbol	Unit	Rate BDCMCM 1105 min	Rate BDCMCM 1105 max	Rate BDCMCM 1110 min	Rate BDCMCM 1110 max	Note
7 Output voltage of comparator switching:		V					R_L=15kΩ, connection to GND,
High level	$U_{in\ h}$		4.6		4.6		R_L=15 kΩ connection to U_{ref}
Low level	$U_{in\ l}$			1.0		1.0	
PWM generator parameter (output 19)							
1 Generator frequency	F_{ocs}	kHz	22	28	22	28	
2 Max peak saw-tooth voltage	$U_{ocs.}(h)$	V		4.6		4.6	
3 Min peak saw-tooth voltage	$U_{ocs.}(l)$	V	1.0		1.0		
Control signal parameter							
1 Input threshold voltage (outputs 9,10,20)							
High level	$U_{in\ h}$	V	3.0				
Low level	$U_{in\ l}$	V		0.8			
2 Input current (outputs 9,10)							
High level	$I_{in\ h}$	μA	-190	-100	-190	-100	U in h=5 V
Low level	$I_{in\ l}$	μA	-800	-500	-800	-500	U in l=0 V
3 Input current (outputs 20) High and low level	I_h	μA	-60	-10	-60	-10	U in h=5 V; U in l=0 V
Parameter of control circuit and current limitation							
1 Threshold voltage	U_{thresh}	mV	85	115	85	115	
2 Input bias current	I_{bi}	μA		-5.0		-5.0	
3 Input common-mode voltage range (outputs 3 , 13)	U_{ICR}	V	3				
4 Voltage of current measuring resistor outputs (outputs 2 , 12)	U_{RC}	mV	95	105	95	105	$I_m = I_{lim}$
5 Limitation current	I_{lim}	A	4.5	5.5	9.0	10.5	
Output signal parameter							
1 On-state resistance of power transistor	$R_{ds.on}$	Ω		0.1		0.1	$I_m = I_{lim}$
2 Closed transistor leakage current of control channel of motor winding	$I_{l.tr}$	μA		100		100	U_{ds}=100 V U_{gs}=0 V
3 «ERROR» saturation voltage (output 4)	$U_{ce.r}$	mV		500		500	I_c=16 mA
4 «ERROR» output leakage current (output 4)	$I_{c.l}$	μA		100		100	U_{ce} = 20 V
5 Switching time of top switches							
Rise time	$t_{r.h}$	μs	2.5	5	2.5	5	
Fall time	$t_{f.l}$	μs	5	10	5	10	
6 Switching time of low switches							
Rise time	$t_{r.h}$	μs	1	1.5	1	1.5	
Fall time	$t_{f.l}$	μs	1	1.5	1	1.5	
7 Switching delay when current level exceeding	$t_{off.c}$	μs	10	20	10	20	

4 Application recommendations

4.1 The module enables smooth regulation of rotation frequency of power brush DC motor within wide ranges. The module can be used as well as a composed part of automation control system.

4.2 Rotation frequency is regulated by changing of effective voltage value that is applied to armature winding. Motor connection circuit of parallel excitation is shown at Figure 3.

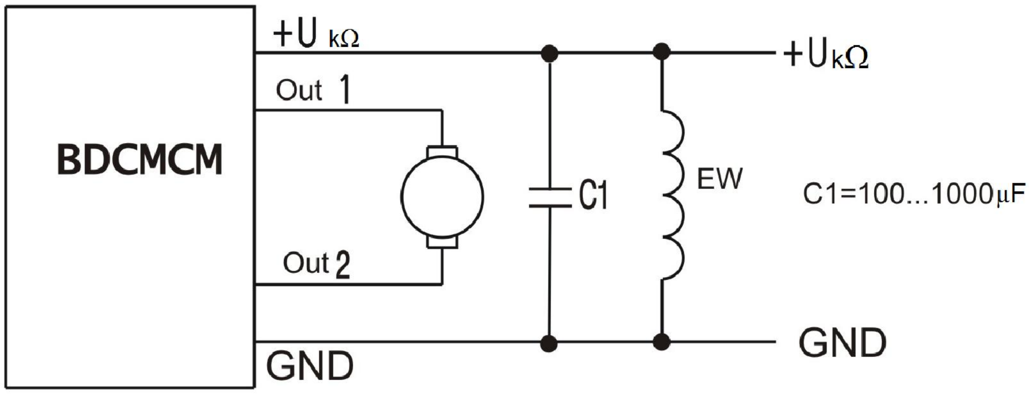


Figure 3

4.3 «ENABLE/SHUTDOWN» signal may be used when switching motor rotation direction as well as for control of dynamic braking mode.

4.3.1 If rotation direction is changed it is necessary to install low level (0) signal on «ENABLE» input, therewith power transistor will be closed. Whereupon you should change rotation direction signals «FWD/BACK».

Timing diagram of recommended signal sequence to «ENABLE» and «FWD/BACK» inputs are shown at Figure 4.

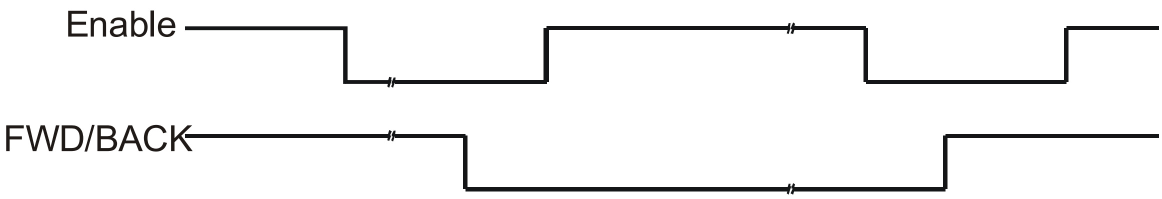


Figure 4

4.3.2. In order to control dynamic braking mode you should install low level signal to «ENABLE» input therewith power transistor will be closed. Whereupon deliver the pulses with the required duty factor to «Brake» input in order to open "low" H-bridge transistor.

When you change "Brake" signal duty factor you can change hardness of dynamic braking mode.

Timing diagram of control signal of PWM-regulation by dynamic braking is shown at Figure 5.

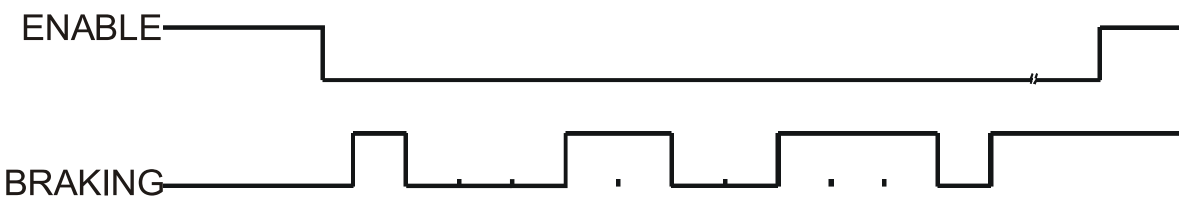


Figure 5

4.4 «BRAKE» input underlies the other control inputs. High level (1) signal delivery provides the transition to dynamic braking mode. "Top" H-bridge transistor connected to «+U_{com}» will be closed. "Low" H-bridge transistor will be open thereby connecting armature winding to «-U_{com}» (ground minus). Thus, the winding is closed that creates braking electromagnetic force.

4.5 PWM generator is adjusted by means of external elements Rg and Cg, connection circuit is shown at Figure 6a.

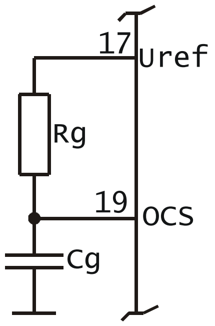


Figure 6a

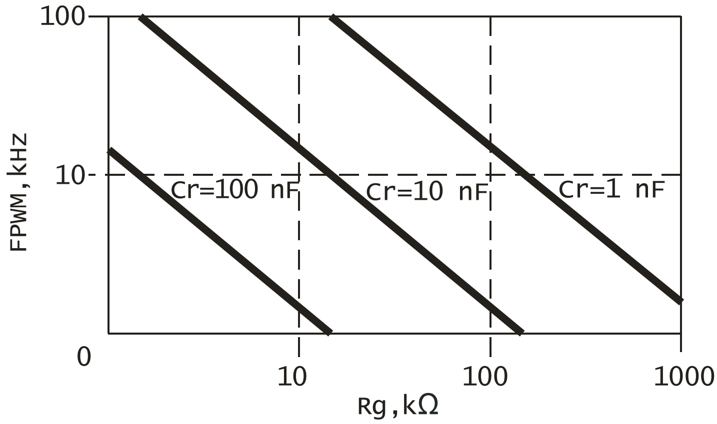


Figure 6b

Capacitor Cg is charged from reference voltage (U_{ref}) source by means of resistor Rg and discharged by means of internal transistor.

To decrease the level of acoustic noise and thereby to create continuous armature current mode (to preserve the tilt of mechanical motor characteristics – hardness support at minimum speed) it will be better to set the PWM-generator frequency in the range of 20…30 kHz. PWM-generator frequency versus value Rg and Cg is shown at nomogram of Figure 6b. For instance, optimal generator frequency 25 kHz is installed Cg=0.01 µF, Rg=4.7 kΩ.

4.6 The module control value of current consumed by the motor from external source on current-measuring shunt. The signal from the potential shunt outputs may be connected directly to current limitation circuit («Tc+» and «Tc-» outputs) or can be used in the circuit of external scheme of current limitation. The virtual connection circuit is shown at Figure 7. Additional elements R1, R2, C1 compose low-pass filter that prevents the drop of pulse noises to comparator input of current limitation circuit.

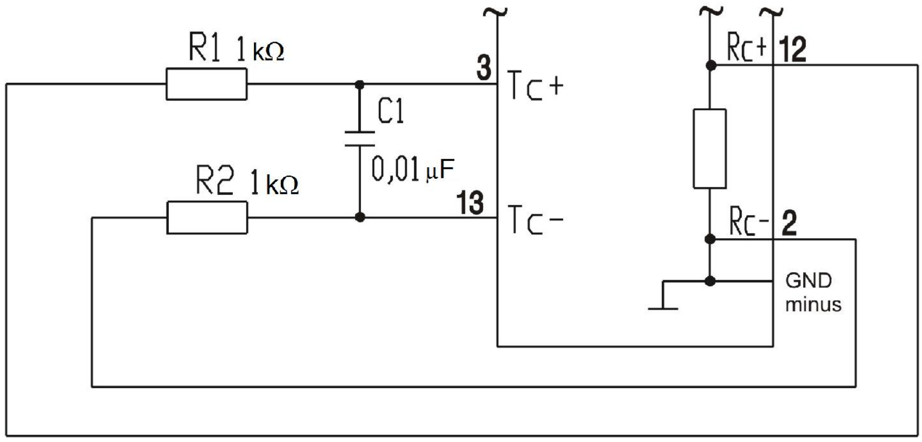


Figure 7

4.7. To control motor rotation speed the multiple PWM method is used in the module, it changes average voltage value, applied to collector motor winding.

Thereby top transistor (that connects armature to «$+U_{com}$») is conducting, regulation is performed by low transistor switching (that connects armature to «$-U_{com}$»). Timing PWM-regulation diagram of motor speed is shown at Figure 8. As soon as the capacitor Cg of WM-generator is discharged the power transistor will be open thereby supplying current to the winding. When the level of accumulative saw-tooth voltage of Cg capacitor is more than the signal level of PWM-amplifier output (PWM input), then the low transistor is closed thereby disconnecting the winding from power supply voltage. If signal level of PWM amplifier output (PWM input) exceeds the peak value of saw-tooth voltage of PWM generator, then PWM-regulation ends, the motor is rotated at maximum speed. If current level that is consumed by winding is more than the limit value («Tc+», «Tc-» outputs - signal U > 100 mV) then transistors will be totally disconnected, «ERROR» output - low level.

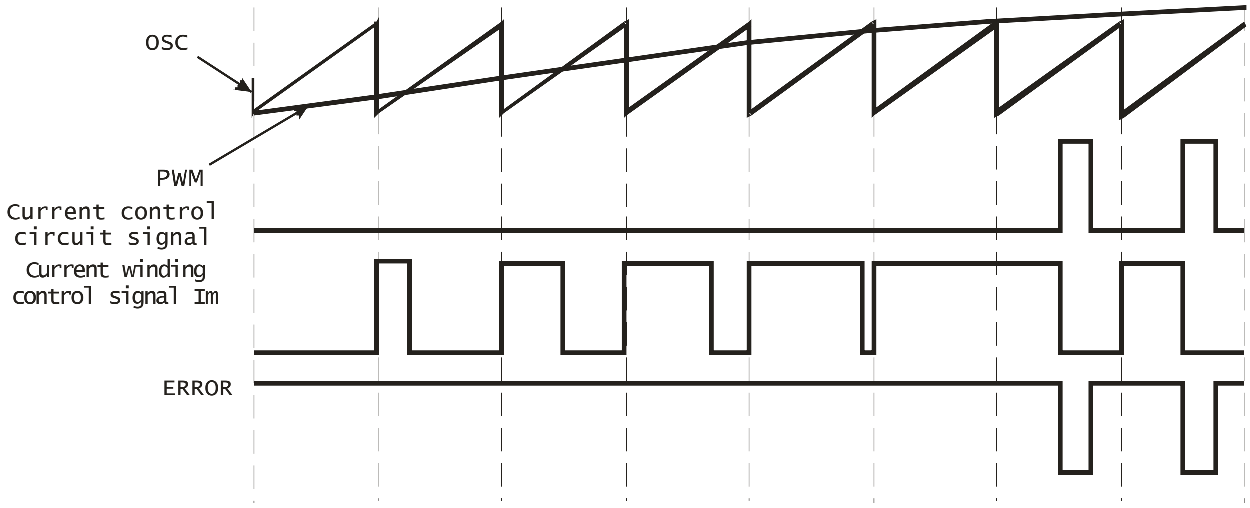


Figure 8

4.8 The module can be used in the modes of open FB loop (when stabilization and speed control problem is resolved by the other devices) and of closed FB loop (when speed control in different functions is carried out by module facilities).

4.9 Speed level control is performed by means of potential signal that is delivered to «U_{cont}» input, the virtual connection circuit shown at Figure 9.

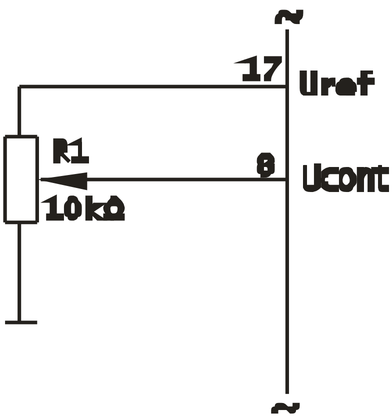


Figure 9

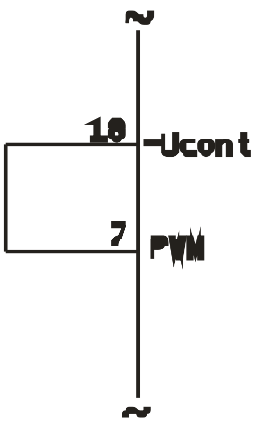
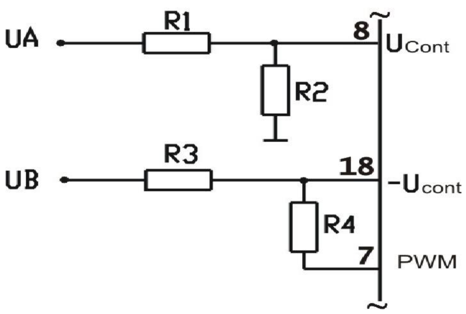


Figure 10

4.10 If the module is used in the mode of open FB loop then PWM amplifier will operate in the mode voltage repeater. Connection example is shown at Figure 10.

The application variant of speed control mode of two differential input is shown at Figure 11.

The time of current control signal of motor winding versus PWM input voltage is shown at Figure 12.



$$U_{PWM} = U_A \times \left(\frac{R3+R4}{R1+R2}\right) \times \frac{R2}{R3} - \left(\frac{R4}{R3} \times U_B\right)$$

Figure 11

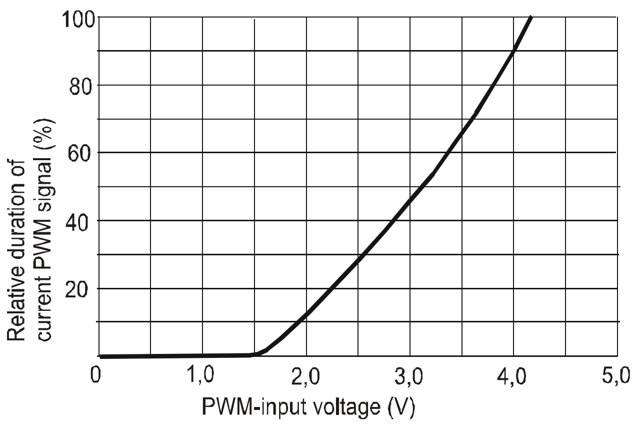


Figure 12

4.11 The module may be utilized in acceleration/deceleration control mode. The virtual turn-on circuit is shown at Figure 13. R1 and C1 determine the constant of acceleration time, and R2 and C1 – deceleration time. Resistance values of R1 and R2 should be many times smaller than resistance value R3.

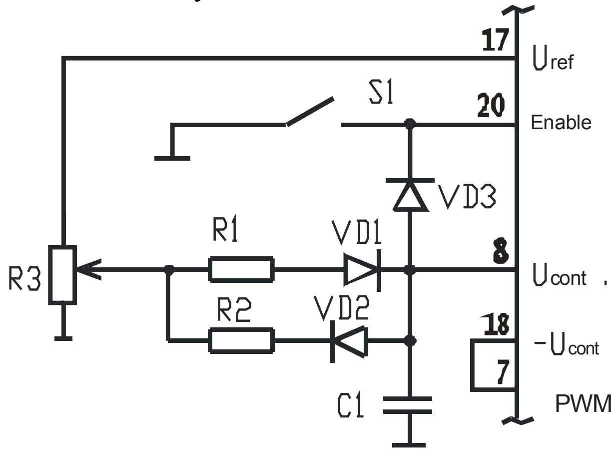
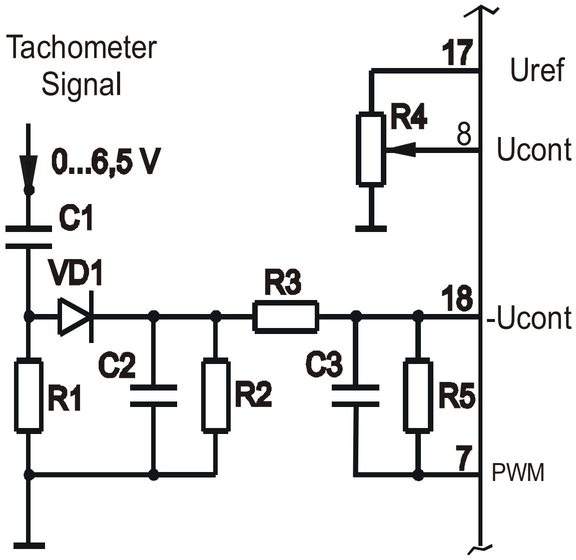


Figure 13

4.12 The module use in the mode of closed FB loop is shown at Figure 14. Pulse signal that is proportional to velocity level (tachometer signal) can be received from any sensor (optical, Hall Sensor, etc.) with signal level 0÷6.5 V.



C1 – 0.01 μF
C2 – 0.1 μF
C3 – 0.22 μF
R1 – 10 kΩ
R2 – 1 MΩ
R3 – 100 kΩ
R4 – 10 кΩ
R5 – 1 MΩ

Figure 14

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