

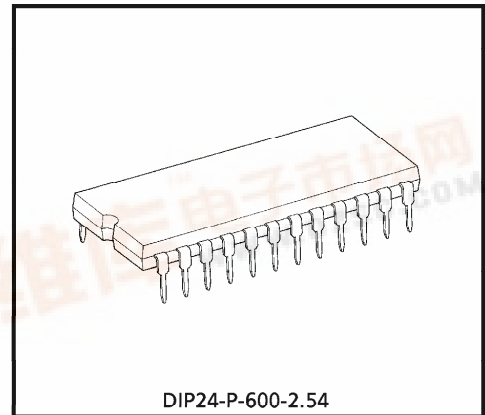
TOSHIBA Bi-CMOS INTEGRATED CIRCUIT SILICON MONOLITHIC

# T B 6 5 2 8 P

## FIVE-PHASE STEPPING MOTOR DRIVE CONTROLLER

The TB6528P universal controller for stepping motor drives is a Bi-CMOS monolithic-type IC for controlling five-phase stepping motors.

This IC enables five-phase stepping motor drive units to be configured simply by preparing a pulse oscillator, a switching element and a direct current power source. This IC was developed in order to simplify the use of stepping motors.



Weight : 3.38g (Typ.)

### FEATURES

- Universal controller : The excitation mode switching terminal enables the selection of the following eight modes.
  - Uni-polar type : 2 excitation, 2-3 excitation, 3 excitation
  - Bi-polar type : 2-3 excitation, 3 excitation, 4 excitation, 4-5 excitation, 5 excitation
- Operating supply voltage range :  $V_{CC} = 4 \sim 16V$
- High-output current : 20mA min (source)
- High noise margin : All input pin are equipped with a Schmidt circuit.
- Two types of pulse input : 2 input pin method (CW and CCW input modes).  
 1 input / 1 switching pin method (CK and U/D input modes).  
 } Either of these can be selected.
- Power down function : All output is at the "L" level

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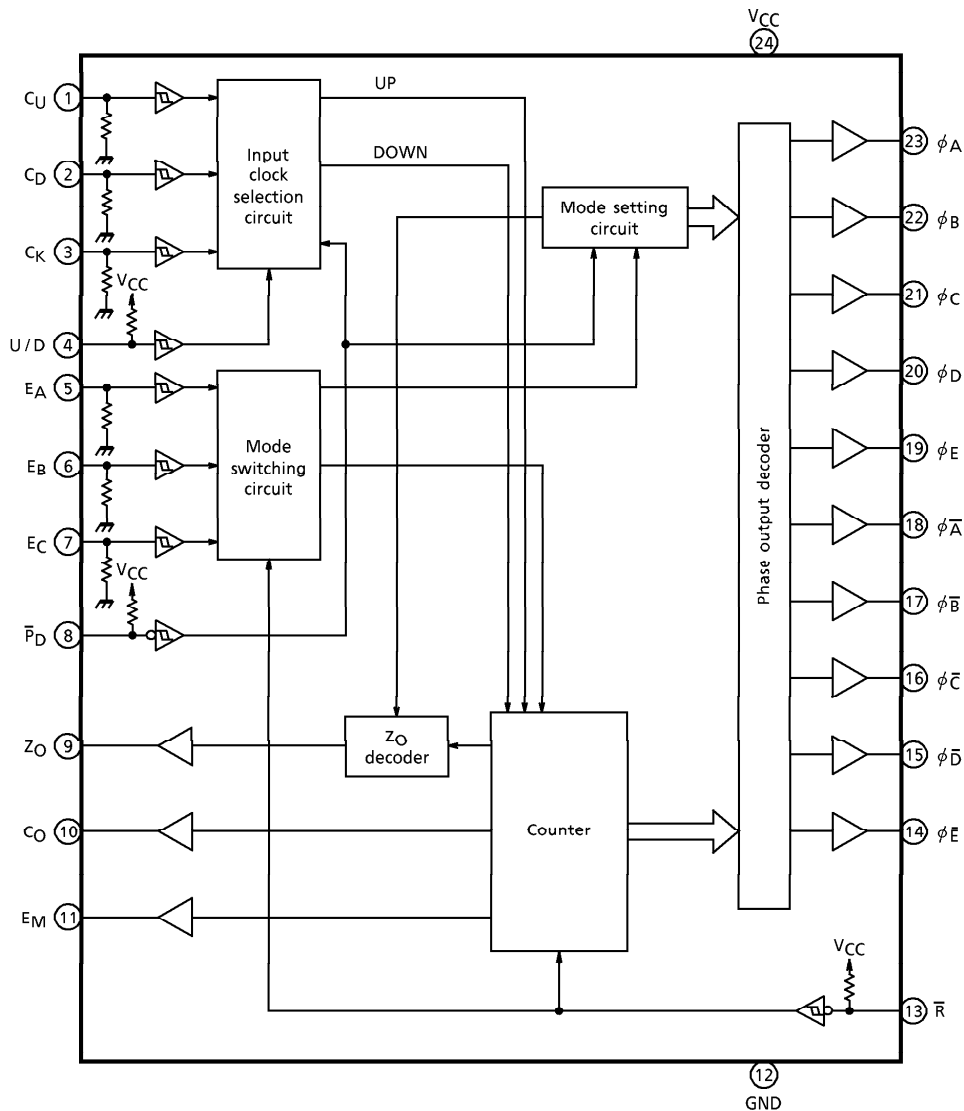
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- Excitation mode protection function : No fluctuations in output even when switching excitation modes such as 2Ex↔2-3Ex↔3Ex, 4Ex↔4-5Ex↔5Ex.
- Reset function : Moves the phase home position across to the excitation status.
- Phase home position monitor : "H" level is output when at the phase home position (output in the reset mode).
- Excitation status identification monitor : The controller's operating status is output as a monitor signal.
- Input pulse monitor : The input is output as a monitor signal.

**BLOCK DIAGRAM**

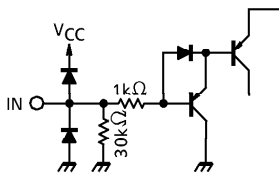


PIN FUNCTION

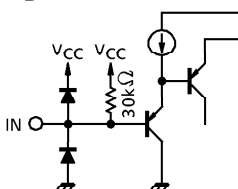
PIN No.	PIN SYMBOL	PIN FUNCTION	
1	C <sub>U</sub>	Input pulse UP clock	Truth table A
2	C <sub>D</sub>	Input pulse DOWN clock	
3	C <sub>K</sub>	Input pulse clock	
4	U/D	Converts rotation directions "0" is DOWN, "1" is UP	Truth table B
5	E <sub>A</sub>	Excitation mode switching input	
6	E <sub>B</sub>		
7	E <sub>C</sub>		
8	P <sub>D</sub>	All output becomes "L" when power down is "L"	
9	Z <sub>O</sub>	Phase home position monitor	
10	C <sub>O</sub>	Input pulse monitor	
11	E <sub>M</sub>	Excitation monitor	
12	GND	GND	
13	$\bar{R}$	Reset when the reset input is "L"	
14	$\phi_E$	$\phi_E$ Output	
15	$\phi_D$	$\phi_D$ Output	
16	$\phi_C$	$\phi_C$ Output	
17	$\phi_B$	$\phi_B$ Output	
18	$\phi_A$	$\phi_A$ Output	
19	$\phi_E$	$\phi_E$ Output	
20	$\phi_D$	$\phi_D$ Output	
21	$\phi_C$	$\phi_C$ Output	
22	$\phi_B$	$\phi_B$ Output	
23	$\phi_A$	$\phi_A$ Output	
24	V <sub>CC</sub>	V <sub>CC</sub>	

EQUIVALENT I/O CIRCUIT

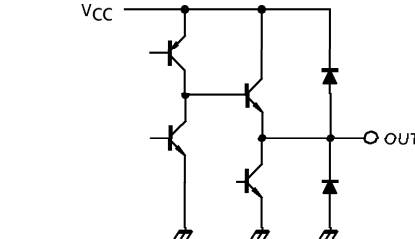
C<sub>U</sub>, C<sub>D</sub>, C<sub>K</sub>



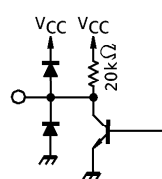
U/D, P<sub>D</sub>,  $\bar{R}$







$\phi_A \sim \phi_E$  and  $\phi_{\bar{A}} \sim \phi_{\bar{E}}$



Z<sub>O</sub>, C<sub>O</sub>, E<sub>M</sub>



**TRUTH TABLE A**

C <sub>U</sub>	C <sub>D</sub>	C <sub>K</sub>	U/D	FUNCTION
	L	L	*	CW
L		L	*	CCW
L	L		H	CW
L	L		L	CCW

- (Note 1) \* means Don't Care
- (Note 2) The C<sub>U</sub> pin is an input pin when counting up, and the C<sub>D</sub> pin is an input pin when counting down.
- (Note 3) The C<sub>K</sub> pin is the count pulse input pin, and count-up and count-down is determined by the U/D pin.

**TRUTH TABLE B**

E <sub>A</sub>	E <sub>B</sub>	E <sub>C</sub>	$\bar{R}$	$\bar{P}_D$	FUNCTION	EXCITATION TYPE
L	H	H	H	H	2 Excitation	Uni-polar type
L	L	H	H	H	2-3 Excitation	
H	L	H	H	H	3 Excitation	
H	H	L	H	H	2-3 Excitation	Bi-polar type
H	H	H	H	H	3 Excitation	
L	H	L	H	H	4 Excitation	
L	L	L	H	H	4-5 Excitation	
H	L	L	H	H	5 Excitation	

- (Note 4) The output enters the initial status when  $\bar{R}$  is set at the LOW level, and the Z<sub>O</sub> output indicates the High level.
- (Note 5) The input clock signal is prohibited and the phase output terminals ( $\phi_A \sim \phi_E$  and  $\phi_{\bar{A}} \sim \phi_{\bar{E}}$ ) enter the LOW level when  $\bar{P}_D$  is set at the LOW level. Z<sub>O</sub>, C<sub>O</sub> and E<sub>M</sub> output is not prohibited.

**FUNCTION 1 (Uni-polar type)**  
**2 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5
$\phi A$	H	L	L	L	H	H
$\phi B$	H	H	L	L	L	H
$\phi C$	L	H	H	L	L	L
$\phi D$	L	L	H	H	L	L
$\phi E$	L	L	L	H	H	L
$\phi \bar{A}$	L	L	L	L	L	L
$\phi \bar{B}$	L	L	L	L	L	L
$\phi \bar{C}$	L	L	L	L	L	L
$\phi \bar{D}$	L	L	L	L	L	L
$\phi \bar{E}$	L	L	L	L	L	L
ZO	H	L	L	L	L	H
EM	L	L	L	L	L	L
UP	→					
DOWN	←					

**2-3 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10
$\phi A$	H	H	L	L	L	L	L	H	H	H	H
$\phi B$	H	H	H	H	L	L	L	L	L	H	H
$\phi C$	L	H	H	H	H	H	L	L	L	L	L
$\phi D$	L	L	L	H	H	H	H	H	L	L	L
$\phi E$	L	L	L	L	L	H	H	H	H	H	L
$\phi \bar{A}$	L	L	L	L	L	L	L	L	L	L	L
$\phi \bar{B}$	L	L	L	L	L	L	L	L	L	L	L
$\phi \bar{C}$	L	L	L	L	L	L	L	L	L	L	L
$\phi \bar{D}$	L	L	L	L	L	L	L	L	L	L	L
$\phi \bar{E}$	L	L	L	L	L	L	L	L	L	L	L
ZO	H	L	L	L	L	L	L	L	L	L	H
EM	L	H	L	H	L	H	L	H	L	H	L
UP	→										
DOWN	←										

**3 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5
$\phi_A$	H	H	L	L	H	H
$\phi_B$	H	H	H	L	L	H
$\phi_C$	L	H	H	H	L	L
$\phi_D$	L	L	H	H	H	L
$\phi_E$	H	L	L	H	H	H
$\phi_{\bar{A}}$	L	L	L	L	L	L
$\phi_{\bar{B}}$	L	L	L	L	L	L
$\phi_{\bar{C}}$	L	L	L	L	L	L
$\phi_{\bar{D}}$	L	L	L	L	L	L
$\phi_{\bar{E}}$	L	L	L	L	L	L
ZO	H	L	L	L	L	H
EM	H	H	H	H	H	H
UP	→					
DOWN	←					

**FUNCTION 2 (Bi-polar type)**  
**2-3 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
$\phi_{A'}$	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	L	L	L	L	L
$\phi_{B'}$	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H
$\phi_{C'}$	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L
$\phi_{D'}$	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L
$\phi_{E'}$	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L
$\phi_{\bar{A}'}$	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
$\phi_{\bar{B}'}$	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L
$\phi_{\bar{C}'}$	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	L	L	L
$\phi_{\bar{D}'}$	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H
$\phi_{\bar{E}'}$	L	L	L	L	L	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L
ZO	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H
EM	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L
UP	→																				
DOWN	←																				

**3 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10
$\phi A'$	L	L	L	L	L	L	H	H	H	L	L
$\phi B'$	H	H	L	L	L	L	L	L	L	H	H
$\phi C'$	L	L	H	H	H	L	L	L	L	L	L
$\phi D'$	L	L	L	L	L	H	H	H	L	L	L
$\phi E'$	H	L	L	L	L	L	L	L	H	H	H
$\phi \bar{A}'$	L	H	H	H	L	L	L	L	L	L	L
$\phi \bar{B}'$	L	L	L	L	H	H	H	L	L	L	L
$\phi \bar{C}'$	L	L	L	L	L	L	L	H	H	H	L
$\phi \bar{D}'$	H	H	H	L	L	L	L	L	L	L	H
$\phi \bar{E}'$	L	L	L	H	H	H	L	L	L	L	L
Z <sub>O</sub>	H	L	L	L	L	L	L	L	L	L	H
EM	H	H	H	H	H	H	H	H	H	H	H
UP	→										
DOWN	←										

**4 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10
$\phi A$	H	L	L	L	L	L	L	H	H	H	H
$\phi B$	H	H	L	L	L	L	L	L	H	H	H
$\phi C$	H	H	H	L	L	L	L	L	L	H	H
$\phi D$	H	H	H	H	L	L	L	L	L	L	H
$\phi E$	L	H	H	H	H	L	L	L	L	L	L
$\phi \bar{A}$	L	L	H	H	H	H	L	L	L	L	L
$\phi \bar{B}$	L	L	L	H	H	H	H	L	L	L	L
$\phi \bar{C}$	L	L	L	L	H	H	H	H	L	L	L
$\phi \bar{D}$	L	L	L	L	L	H	H	H	H	L	L
$\phi \bar{E}$	L	L	L	L	L	L	H	H	H	H	L
Z <sub>O</sub>	H	L	L	L	L	L	L	L	L	L	H
EM	L	L	L	L	L	L	L	L	L	L	L
UP	→										
DOWN	←										

**4-5 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
$\phi_A$	H	H	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H
$\phi_B$	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H
$\phi_C$	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H
$\phi_D$	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	H	H	H
$\phi_E$	L	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L
$\phi_{\bar{A}}$	L	L	L	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L
$\phi_{\bar{B}}$	L	L	L	L	L	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L
$\phi_{\bar{C}}$	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L
$\phi_{\bar{D}}$	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	H	L	L	L
$\phi_{\bar{E}}$	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	H	L
ZO	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H
EM	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
UP	→																					
DOWN	←																					

**5 EXCITATION**

PHASE \ PULSE	0 (RESET)	1	2	3	4	5	6	7	8	9	10
$\phi_A$	H	H	L	L	L	L	L	H	H	H	H
$\phi_B$	H	H	H	L	L	L	L	L	H	H	H
$\phi_C$	H	H	H	H	L	L	L	L	L	H	H
$\phi_D$	H	H	H	H	H	L	L	L	L	L	H
$\phi_E$	L	H	H	H	H	H	L	L	L	L	L
$\phi_{\bar{A}}$	L	L	H	H	H	H	H	L	L	L	L
$\phi_{\bar{B}}$	L	L	L	H	H	H	H	H	L	L	L
$\phi_{\bar{C}}$	L	L	L	L	H	H	H	H	H	L	L
$\phi_{\bar{D}}$	L	L	L	L	L	H	H	H	H	H	L
$\phi_{\bar{E}}$	H	L	L	L	L	L	H	H	H	H	H
ZO	H	L	L	L	L	L	L	L	L	L	H
EM	H	H	H	H	H	H	H	H	H	H	H
UP	→										
DOWN	←										



**MAXIMUM RATINGS (Ta = 25°C)**

CHARACTERISTIC	SYMBOL	RATING	UNIT
Power Suplly Voltage	V <sub>CC</sub>	- 0.5~20	V
Output Current φn	"H" level I <sub>OH</sub> φ	- 30	mA
	"L" level I <sub>OL</sub> φ	2	
Output Current (C <sub>O</sub> , E <sub>M</sub> , Z <sub>O</sub> )	"H" level I <sub>OH</sub>	- 50	μA
	"L" level I <sub>OL</sub>	2	mA
Input Voltage	V <sub>IN</sub>	- 0.5~V <sub>CC</sub>	V
Input Current	I <sub>IN</sub>	± 1	mA
Power Dissipation	P <sub>D</sub>	1000	mW
Operating Temperature	T <sub>opr</sub>	- 20~85	°C
Storage Temperature	T <sub>stg</sub>	- 55~150	°C

**RECOMMENDED OPERATING CONDITIONS (Ta = - 30~85°C)**

CHARACTERISTIC	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Power Suplly Voltage	V <sub>CC</sub>	—	4	—	13	V
Output Current φn	"H" level I <sub>OH</sub> φ	—	—	—	- 10	mA
	"L" level I <sub>OL</sub> φ	—	—	—	1.6	
Output Current (C <sub>O</sub> , E <sub>M</sub> , Z <sub>O</sub> )	"H" level I <sub>OH</sub>	—	—	—	- 40	μA
	"L" level I <sub>OL</sub>	—	—	—	1.6	mA
Input Voltage	V <sub>IN</sub>	—	0	—	V <sub>CC</sub>	V
Clock Frequency	—	—	0	—	250	kHz

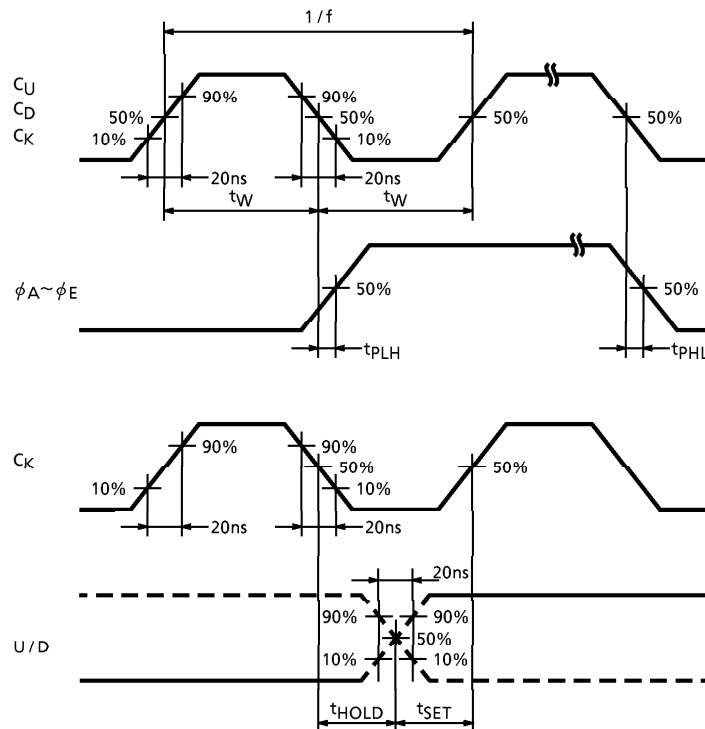
**ELECTRICAL CHARACTERISTICS (Ta = 25°C)**

CHARACTERISTIC		SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Current $\phi A \sim \phi \bar{E}$	"H" level	I <sub>OH</sub>	—	V <sub>CC</sub> = 5V, V <sub>O</sub> = V <sub>CC</sub> - 2.0	-20	—	—	mA
			—	V <sub>CC</sub> = 10V, V <sub>O</sub> = V <sub>CC</sub> - 2.0	-20	—	—	
	"L" level	I <sub>OL</sub>	—	V <sub>CC</sub> = 5V, V <sub>O</sub> = 0.3V	1.6	—	—	mA
			—	V <sub>CC</sub> = 10V, V <sub>O</sub> = 0.3V	1.6	—	—	
Output Current C <sub>O</sub> , E <sub>M</sub> , Z <sub>O</sub>	"H" level	V <sub>OH</sub>	—	V <sub>CC</sub> = 5V, I <sub>O</sub> = -40μA	3.6	—	—	V
			—	V <sub>CC</sub> = 10V, I <sub>O</sub> = -40μA	8.6	—	—	
	"L" level	V <sub>OL</sub>	—	V <sub>CC</sub> = 5V, I <sub>O</sub> = 1.6mA	—	—	0.4	V
			—	V <sub>CC</sub> = 10V, I <sub>O</sub> = 1.6mA	—	—	0.6	
Input Voltage	"H" level	V <sub>IH</sub>	—	V <sub>CC</sub> = 5V	3.0	2.5	—	V
			—	V <sub>CC</sub> = 10V	6.0	5.0	—	
	"L" level	V <sub>IL</sub>	—	V <sub>CC</sub> = 5V	—	2.0	1.5	V
			—	V <sub>CC</sub> = 10V	—	4.0	3.0	
Input Current C <sub>U</sub> , C <sub>D</sub> , C <sub>K</sub> E <sub>A</sub> , E <sub>B</sub> , E <sub>C</sub>	"H" level	I <sub>IH</sub>	—	V <sub>CC</sub> = 5V, V <sub>IN</sub> = V <sub>CC</sub> - 0.5V	—	—	0.4	mA
			—	V <sub>CC</sub> = 10V, V <sub>IN</sub> = V <sub>CC</sub> - 0.5V	—	—	0.7	
	"L" level	I <sub>IL</sub>	—	V <sub>CC</sub> = 5V, V <sub>IN</sub> = 0V	—	—	± 10	μA
			—	V <sub>CC</sub> = 10V, V <sub>IN</sub> = 0V	—	—	± 10	
Input Current U/D, P <sub>D</sub> , R̄	"H" level	I <sub>IH</sub>	—	V <sub>CC</sub> = 5V, V <sub>IN</sub> = V <sub>CC</sub> - 0.5V	—	—	-100	μA
			—	V <sub>CC</sub> = 10V, V <sub>IN</sub> = V <sub>CC</sub> - 0.5V	—	—	-100	
	"L" level	I <sub>IL</sub>	—	V <sub>CC</sub> = 5V, V <sub>IN</sub> = 0V	—	—	-0.4	mA
			—	V <sub>CC</sub> = 10V, V <sub>IN</sub> = 0V	—	—	-0.7	
Static Current Consumption		I <sub>CC</sub>	—	V <sub>CC</sub> = 5V, all pins open	—	—	25	mA
			—	V <sub>CC</sub> = 10V, all pins open	—	—	35	

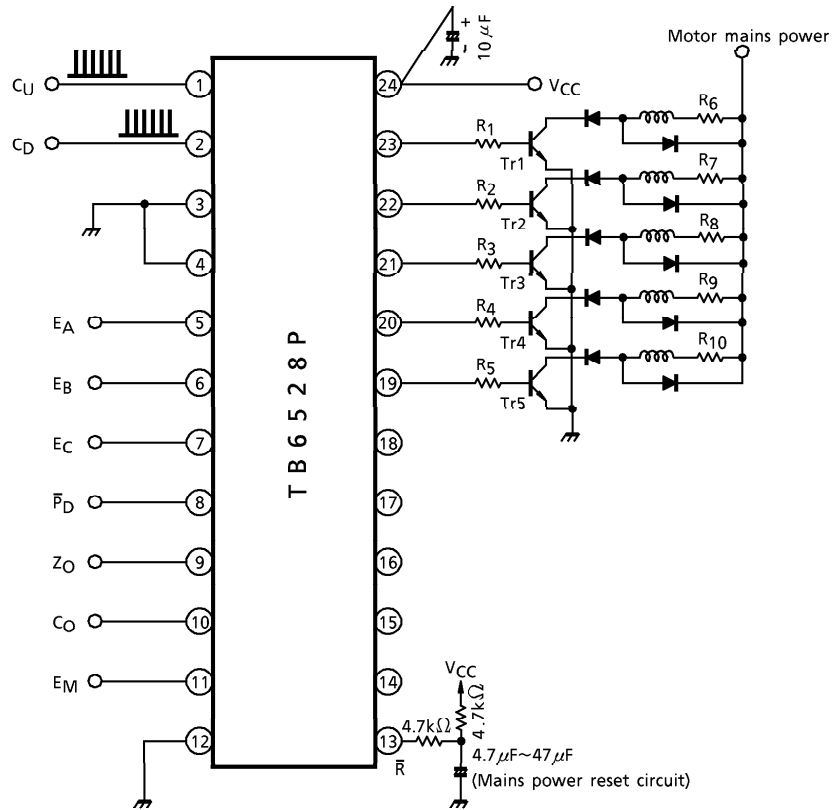
**SWITCHING CHARACTERISTICS (Ta = 25°C)**

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Clock Frequency	f <sub>MAX</sub>	—	V <sub>CC</sub> = 5V	250	300	—	kHz
			V <sub>CC</sub> = 10V	270	350	—	
Minimum Clock Pulse Width	t <sub>W</sub>	—	V <sub>CC</sub> = 5V	—	300	500	ns
			V <sub>CC</sub> = 10V	—	300	500	
Minimum Reset Pulse Width	t <sub>WR</sub>	—	V <sub>CC</sub> = 5V	—	200	500	ns
			V <sub>CC</sub> = 10V	—	200	500	
Delay Time (φ output from clock input)	t <sub>PLH</sub>	—	V <sub>CC</sub> = 5V	—	2500	3500	ns
	t <sub>PHL</sub>		V <sub>CC</sub> = 10V	—	2500	3500	
Delay Time (each monitor from clock input)	t <sub>PLH</sub>	—	V <sub>CC</sub> = 5V	—	3000	4000	ns
	t <sub>PHL</sub>		V <sub>CC</sub> = 10V	—	3000	4000	
Setting Time	t <sub>SET</sub>	—	V <sub>CC</sub> = 5V	4000	3000	—	ns
			V <sub>CC</sub> = 10V	4000	3000	—	
Storage Time	t <sub>HOLD</sub>	—	V <sub>CC</sub> = 5V	500	0	—	ns
			V <sub>CC</sub> = 10V	500	0	—	

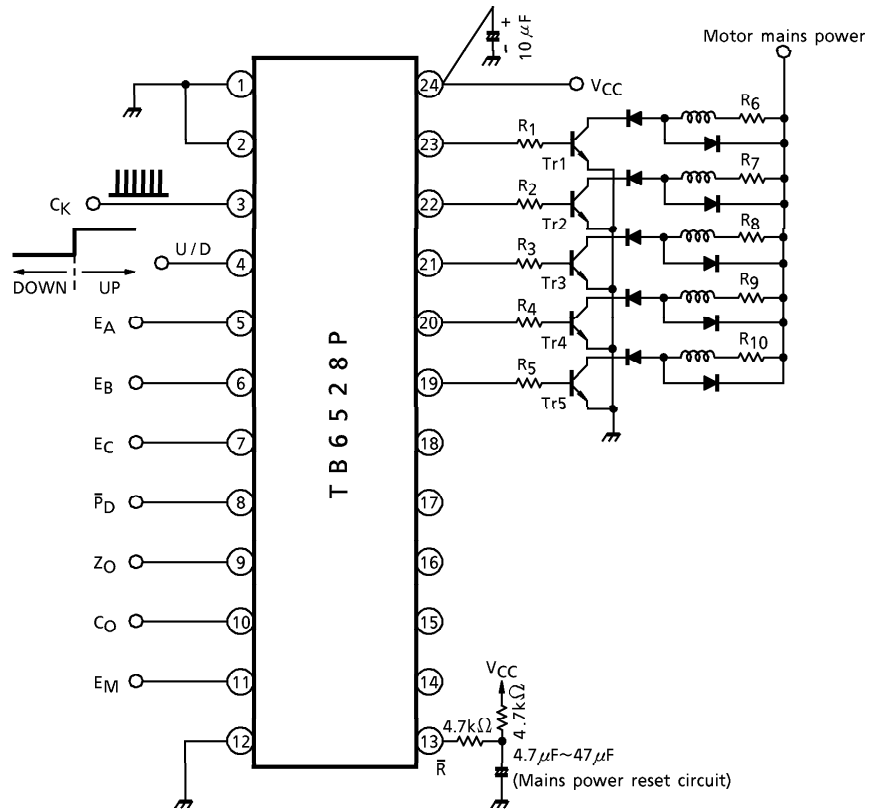
**MEASURED WAVE-FORM FOR SWITCHING TIME**



APPLICATION CIRCUIT 1  
2 input pin method

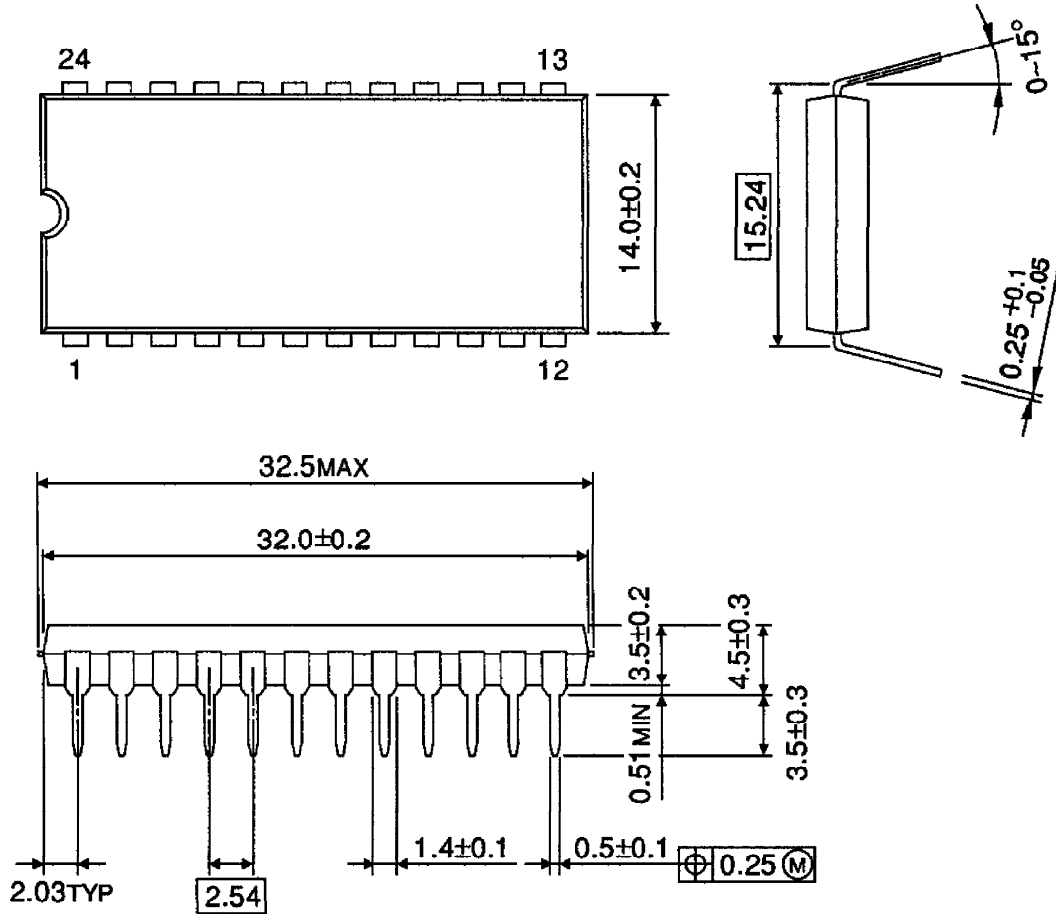


APPLICATION CIRCUIT 2  
1 input/switching pin method



OUTLINE DRAWING  
DIP24-P-600-2.54

Unit : mm



Weight : 3.38g (Typ.)