

### MONOLITHIC 3-ASPECT SPINDLE MOTOR DRIVER

#### DESCRIPTION

$\mu$ PD16873/A/B/C is 3 aspect spindle motor driver that composed by CMOS control circuit and MOS bridge output.

The consumption electric power can be substantially reduced to the screwdriver which used a conventional Bipolar transistor by the adoption of 3 aspect all-wave PWM methods and making an output paragraph MOSFET.

#### FEATURES

- Low On resistance. (The summation of the on resistance of the upper and lower MOSFET)  $R_{ON} = 0.6 \Omega$  (TYP.)
- Low consumption power for 3 aspects all-wave PWM drive method.
- Index pulse (FG pulse) output function built in.
- By the PWM-drive form and the IND pulse pattern, 4 kind, line-up

	PWM method	Pattern of IND pulse (at 12 pole motor)
$\mu$ PD16873	normal	3 phase composition output (18 pulses/turn)
$\mu$ PD16873A	normal	1 phase output (6 pulses/turn)
$\mu$ PD16873B	synchronous	1 phase output (6 pulses/turn)
$\mu$ PD16873C	synchronous	3 phase composition output (18 pulses/turn)

- Built in STANDBY terminal and off the inner circuit at the time of the standby.
- Built in START/STOP terminal. Operating short brake works, when ST/SP terminal is off state.
- Supply voltage: 5 V drive
- Low consumption current:  $I_{DD} = 3 \text{ mA}$  (MAX.)
- Thermal shut down circuit (TSD) built in.
- Over current protection circuit built in. (Setting by outside resistance)
- Low voltage malfunction prevention circuit built in.
- Reverse turn prevention circuit built in.
- Hall bias switch built in. (synchronized STB signal.)
- Loading into 30-pin plastic TSSOP (300 mil).

#### ORDERING INFORMATION

Part number	Function	Package
$\mu$ PD16873MC-6A4	normal-PWM/3 phase IND	30-pin plastic TSSOP (7.62 mm (300))
$\mu$ PD16873AMC-6A4	normal-PWM/1 phase IND	
$\mu$ PD16873BMC-6A4	synchronous-PWM/1 phase IND	
$\mu$ PD16873CMC-6A4	synchronous-PWM/3 phase IND	

The information in this document is subject to change without notice. Before using this document, please confirm that this is the latest version.

Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

**ABSOLUTE MAXIMUM RATINGS (T<sub>A</sub> = 25°C)**

When mounted on a glass epoxy board (10 cm × 10cm × 1mm, 15% copper foil)

Parameter	Symbol	Condition	Rating	Unit
Supply voltage	V <sub>DD</sub>	control block	-0.5 to +5.7	V
	V <sub>M</sub>	output block	-0.5 to +5.7	V
Input voltage	V <sub>IN</sub>		-0.5 to V <sub>DD</sub> + 0.5	V
Output pin voltage	V <sub>OUT</sub>		-0.5 to +6.7	V
Output current (DC) <sup>Note 1</sup>	I <sub>D(DC)</sub>	DC	±0.5	A/phase
Output current (pulse) <sup>Note 2</sup>	I <sub>D(pulse)</sub>	PW < 5 ms, Duty < 30 %	±1.3	A/phase
Output current (pulse, reverse brake) <sup>Note 3</sup>	I <sub>DR(pulse)</sub>	PW < 5 ms, Duty < 30 %	±1.9	A/phase
Power consumption	P <sub>T</sub>		1.0	W
Peak junction temperature	T <sub>CH(MAX)</sub>		150	°C
Storage temperature range	T <sub>stg</sub>		-55 to 150	°C

**Notes 1.** DC

2. PW < 5 ms, Duty < 30 % (start-up, locking)
3. PW < 5 ms, Duty < 30 % (reverse brake)

**RECOMMENDED OPERATING CONDITIONS**

When mounted on a glass epoxy board (10 cm × 10cm × 1mm, 15% copper foil)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply voltage	V <sub>DD</sub>	control block	4.5	5.0	5.5	V
	V <sub>M</sub>	output block	4.5	5.0	5.5	V
Input voltage	V <sub>IN</sub>		0		V <sub>DD</sub>	V
Output current (DC) <sup>Note 1</sup>	I <sub>D(DC)</sub>	DC			0.4	A/phase
Output current (pulse) <sup>Note 2</sup>	I <sub>D(pulse)</sub>	PW < 5 ms, Duty < 30 %			1.0	A/phase
Output current (pulse, reverse brake) <sup>Note 3</sup>	I <sub>DR(pulse)</sub>	PW < 5 ms, Duty < 30 %			1.5	A/phase
Hall bias current	I <sub>HB</sub>			10	20	mA
IND terminal output current	I <sub>FG</sub>			±2.5	±5.0	mA
Operating temperature	T <sub>A</sub>		-20		75	°C

**Notes 1.** DC

2. PW < 5 ms, Duty < 30 % (start-up, locking)
3. PW < 5ms, Duty < 30 % (reverse brake)

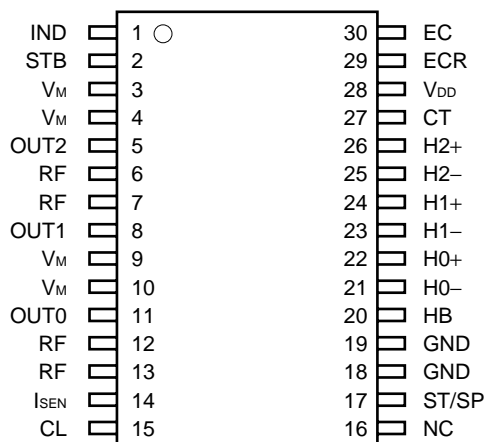
**CHARACTERISTICS (Unless otherwise specified, T<sub>A</sub> = 25°C, V<sub>DD</sub> = V<sub>M</sub> = 5 V)**

Parameter	Symbol	Condition	MIN.	TYP.	MAX	Unit
<all>						
V <sub>DD</sub> pin current (operating)	I <sub>DD</sub>	STB = V <sub>DD</sub>		1.5	3.0	mA
V <sub>DD</sub> pin current (standby)	I <sub>DD(ST)</sub>	STB = GND			1.0	μA
<ST/SP, STB pin>						
High level input voltage	V <sub>IH</sub>		1.8		V <sub>DD</sub>	V
Low level input voltage	V <sub>IL</sub>				0.8	V
Input pull-down resistance	R <sub>IND</sub>			110		kΩ
<Oscillation circuit part>						
Triangle wave oscillation frequency	f <sub>PWM</sub>	C <sub>T</sub> = 330pF		75		kHz
<Hall amplifier part>						
Same aspect input range	V <sub>Hch</sub>		1.5		4.0	V
Hysteresis	V <sub>Hhys</sub>	V <sub>H</sub> = 2.5 V		15	50	mV
Input bias voltage	I <sub>Hbias</sub>				1.0	μA
<Hall bias part>						
Hall bias voltage	V <sub>HB</sub>	I <sub>HB</sub> = 10 mA		0.3	0.5	V
<IND signal output part>						
IND terminal high level voltage	V <sub>FG_H</sub>	I <sub>FG</sub> = -2.5 mA	3.5			V
IND terminal low level voltage	V <sub>FG_L</sub>	I <sub>FG</sub> = +2.5 mA			0.5	V
<Output part>						
Output on resistance (upper + lower MOSFET)	R <sub>ON</sub>	I <sub>D</sub> = 200 mA -20°C < T <sub>A</sub> < 75°C		0.6	0.9	Ω
Off state leakage	I <sub>D(OFF)</sub>	-20°C < T <sub>A</sub> < 75°C			10	μA
Output turn-on time	t <sub>ONH</sub>	R <sub>M</sub> = 5Ω star connection			1.0	μs
Output turn-off time	t <sub>OFFH</sub>				1.0	μs
<Torque order part>						
Control standard input voltage range	ECR		0.3		4.0	V
Control input voltage range	EC		0.3		4.0	V
Input current	I <sub>IN</sub>	EC, ECR = 0.5 to 3.0 V			70	μA
Input voltage difference	ECR-EC	Duty = 100%, ECR = 2 V excluding dead zone		0.75		V
Dead zone (+)	EC_d+	ECR = 2 V	0	65	100	mV
Dead zone (-)	EC_d-	ECR = 2 V	0	-65	-100	mV
<Over current detection part>						
Input offset voltage	V <sub>IO</sub>		-15		15	mV
CL terminal voltage	V <sub>CL</sub>		90	100	110	mV

Thermal shut down circuit (TSD) works in T<sub>CH</sub> > 150°C.

Low voltage malfunction prevention circuit (UVLO) works in 4 V (TYP.).

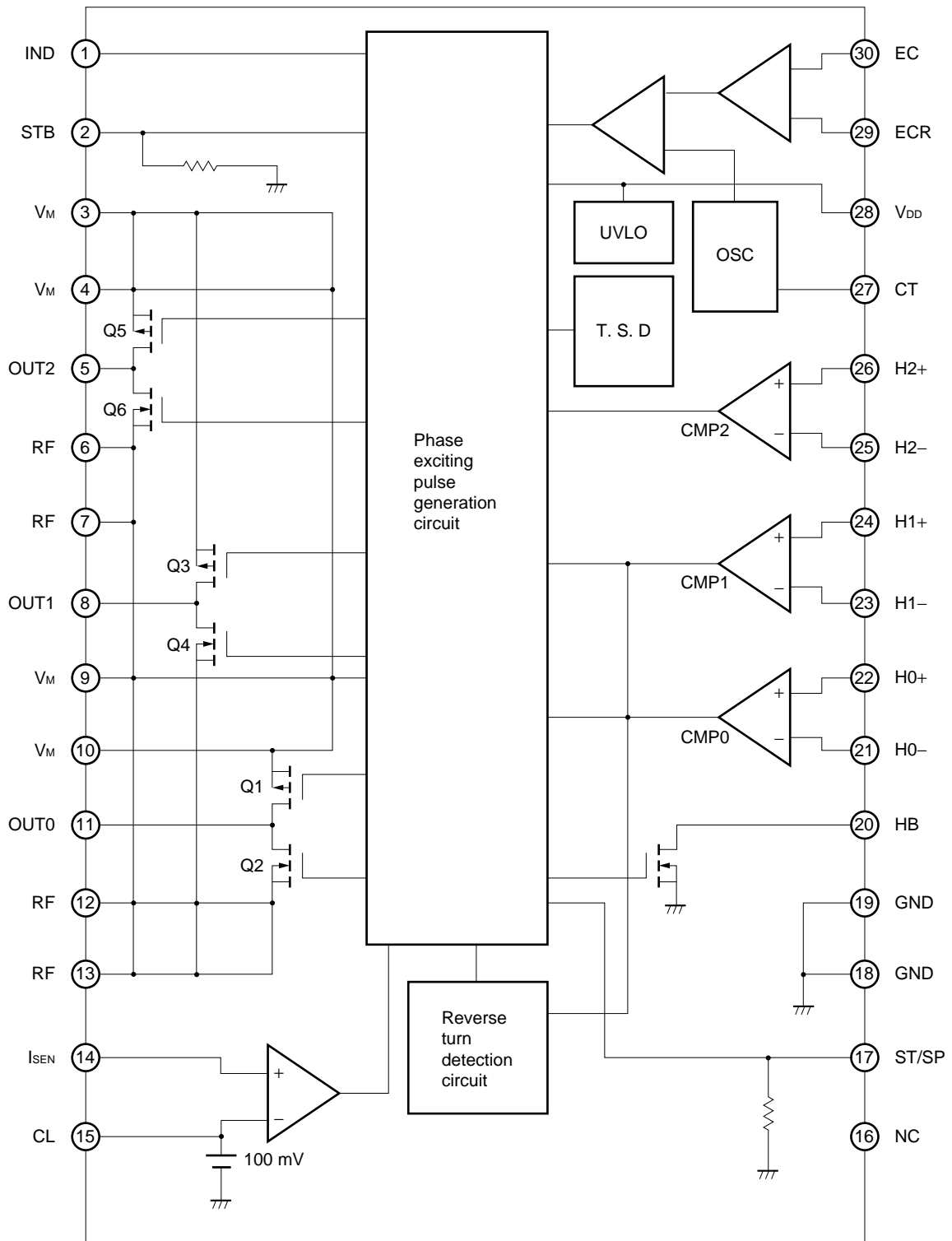
PIN CONNECTION



Pin No.	Pin name	Terminal function
1	IND	Index signal output terminal
2	STB	Standby mode input terminal
3	V <sub>M</sub>	Supply voltage input terminal for motor part
4	V <sub>M</sub>	Supply voltage input terminal for motor part
5	OUT2	Motor connection terminal (W-phase)
6	RF	3 phase bridge common terminal
7	RF	3 phase bridge common terminal
8	OUT1	Motor connection terminal (V-phase)
9	V <sub>M</sub>	Supply voltage input terminal for motor part
10	V <sub>M</sub>	Supply voltage input terminal for motor part
11	OUT0	Motor connection terminal (U-phase)
12	RF	3 phase bridge common terminal
13	RF	3 phase bridge common terminal
14	I <sub>SENSE</sub>	Sense resistance connection terminal
15	CL	Over current detection voltage filter terminal
16	NC	No connection
17	ST/SP	Start/Stop input terminal
18	GND	Ground terminal
19	GND	Ground terminal
20	HB	Hall bias terminal
21	H0-	
22	H0+	
23	H1-	
24	H1+	
25	H2-	
26	H2+	
27	C <sub>T</sub>	Oscillation frequency setting condenser connection terminal
28	V <sub>DD</sub>	Supply voltage input terminal for control part
29	ECR	Control standard voltage input terminal
30	EC	Control voltage input terminal

**Caution** Plural terminal (V<sub>M</sub>, RF, GND) is not only 1 terminal and connect all terminals.

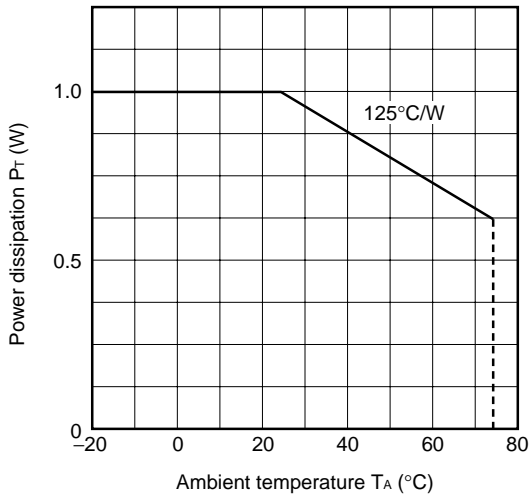
BLOCK DIAGRAM



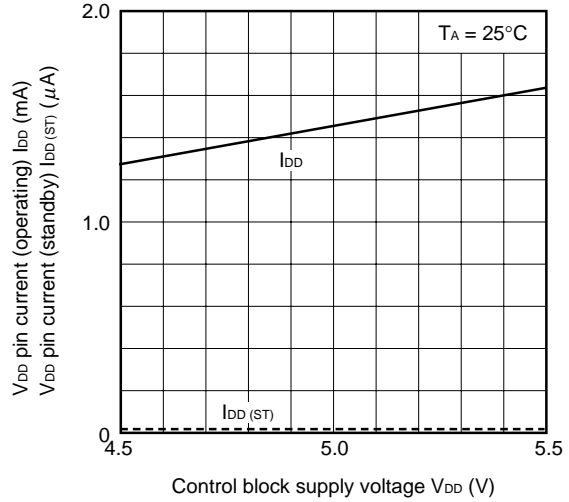
**Caution** Plural terminal (VM, RF, GND) is not only 1 terminal and connect all terminals.

TYPICAL CHARACTERISTICS (T<sub>A</sub> = 25°C)

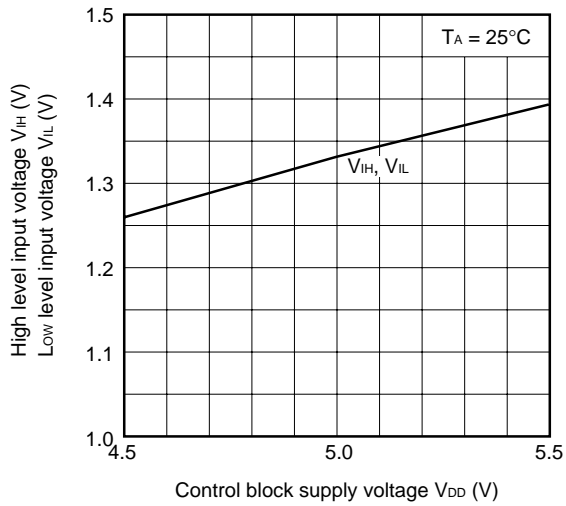
P<sub>T</sub> vs. T<sub>A</sub> characteristics



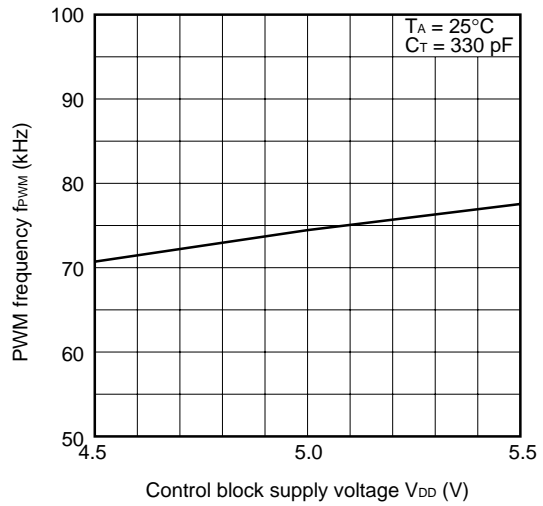
I<sub>DD</sub>, I<sub>DD(ST)</sub> vs. V<sub>DD</sub> characteristics



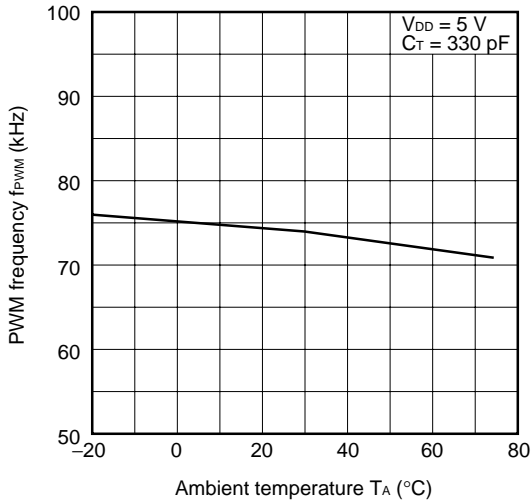
V<sub>IH</sub>, V<sub>IL</sub> vs. V<sub>DD</sub> characteristics (ST/SP, STB)



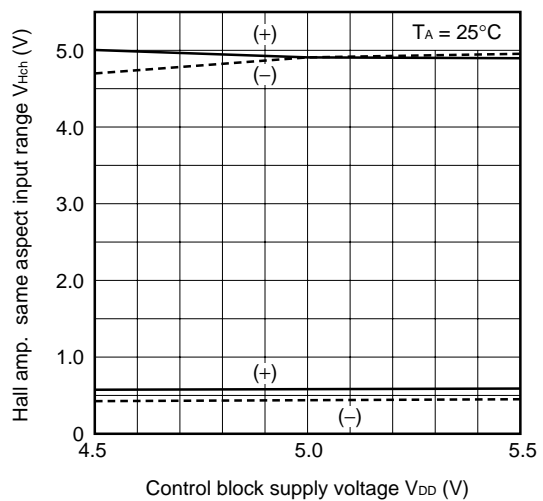
f<sub>PWM</sub> vs. V<sub>DD</sub> characteristics



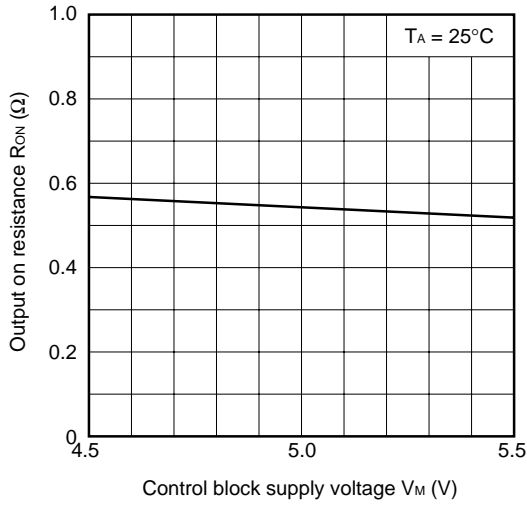
f<sub>PWM</sub> vs. T<sub>A</sub> characteristics



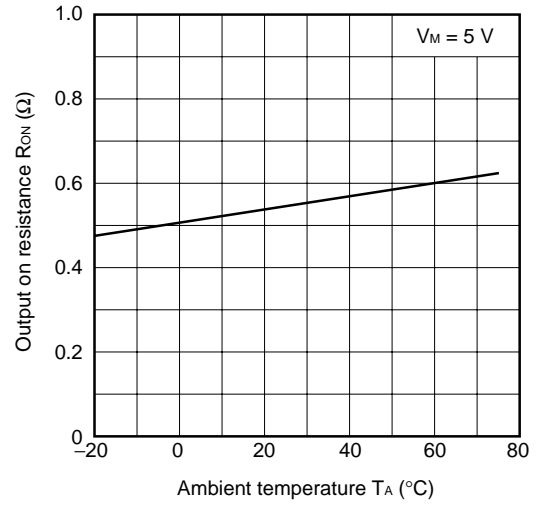
V<sub>Hch</sub> vs. V<sub>DD</sub> characteristics



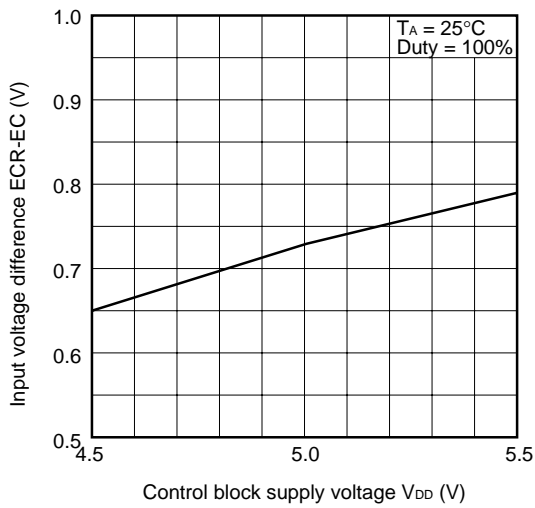
R<sub>ON</sub>, vs. V<sub>M</sub> characteristics



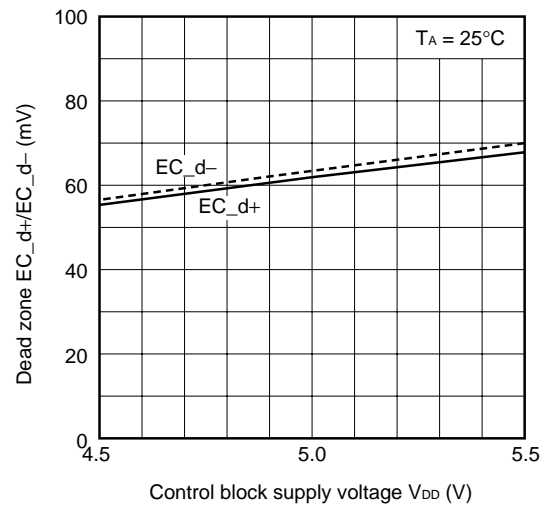
R<sub>ON</sub>, vs. T<sub>A</sub> characteristics



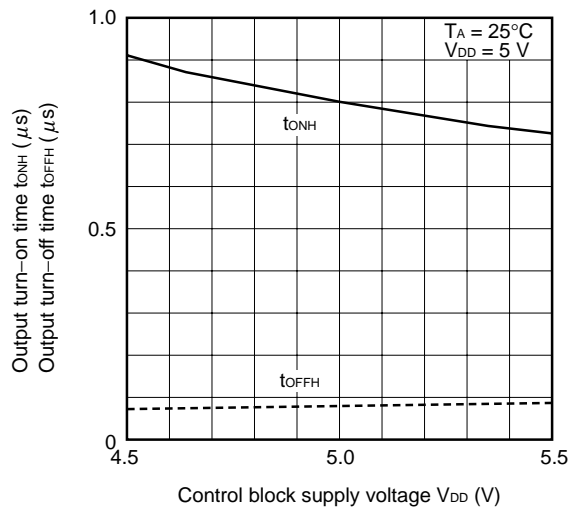
(ECR-EC) vs. V<sub>DD</sub> characteristics



EC<sub>d+</sub>/EC<sub>d-</sub> vs. V<sub>DD</sub> characteristics



t<sub>ONH</sub>, t<sub>OFFH</sub> vs. V<sub>M</sub> characteristics



**FUNCTION OPERATION TABLE**

**(1) ST/SP (start/stop) function**

ON/OFF of the movement can be set up under the condition which makes oscillation circuit work. Setting is done with ST/SP terminal.

When ST/SP terminal is high level, it becomes active (operating) condition. And, when ST/SP terminal is low level, it becomes stop condition. It becomes short brake condition under the stop condition.

• **ST/SP = “H”**

Input signal (Hall amplifier output)				Operation mode	exciting phase
CMP 0	CMP 1	CMP 2	PWM		
H	H	L	H	ON	W → V
H	H	L	L	OFF	
H	L	L	H	ON	W → U
H	L	L	L	OFF	
H	L	H	H	ON	V → U
H	L	H	L	OFF	
L	L	H	H	ON	V → W
L	L	H	L	OFF	
L	H	H	H	ON	U → W
L	H	H	L	OFF	
L	H	L	H	ON	U → V
L	H	L	L	OFF	

In addition, the movement in OFF varies in the product.

Loop is composed through parasitic diode of the high-side MOSFET. (μPD16873/μPD16873A)

Loop is composed through channel of the high-side MOSFET. (μPD16873B/μPD16873C)

• **ST/SP = “L”**

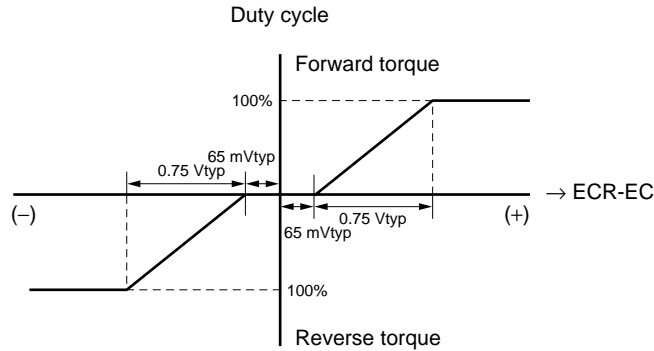
Input signal (Hall amplifier output)				Operation mode
CMP 0	CMP 1	CMP 2	PWM	
-	-	-	-	Stop (short brake)

It becomes short brake condition. (High side switch is “ON” and low side switch is “OFF”)



**(2) Torque order**

The relation between difference (ECR-EC) in control standard voltage (ECR) and control voltage (EC) and the torque is as follows.



Input voltage difference (ECR-EC) and output PWM duty becomes related to the proportion. In addition, it becomes reverse brake when input voltage is ECR < EC. It stops after the reverse rotation of the motor is detected under reverse braking mode. If input voltage difference is zero (ECR = EC), it becomes short brake mode.

Input voltage difference	Output mode
ECR > EC	Forward turn
ECR = EC	Stop (short brake)
ECR < EC	Reverse turn <sup>Note</sup>

**Note** After detecting reverse, it stops.

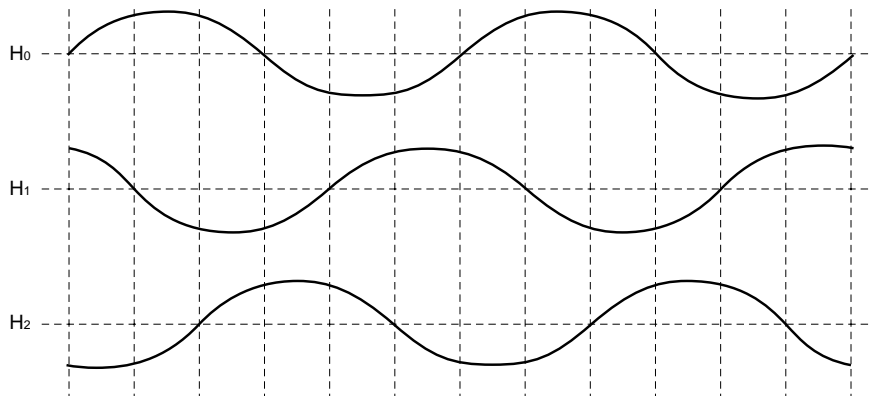
**(3) Standby mode**

By the setting of standby mode, the power supply inside μPD16873 can be made off. Each output terminal at the time of standby mode becomes high impedance. Also, the oscillation block inside, too, stops and it is possible for the circuit current to reduce.

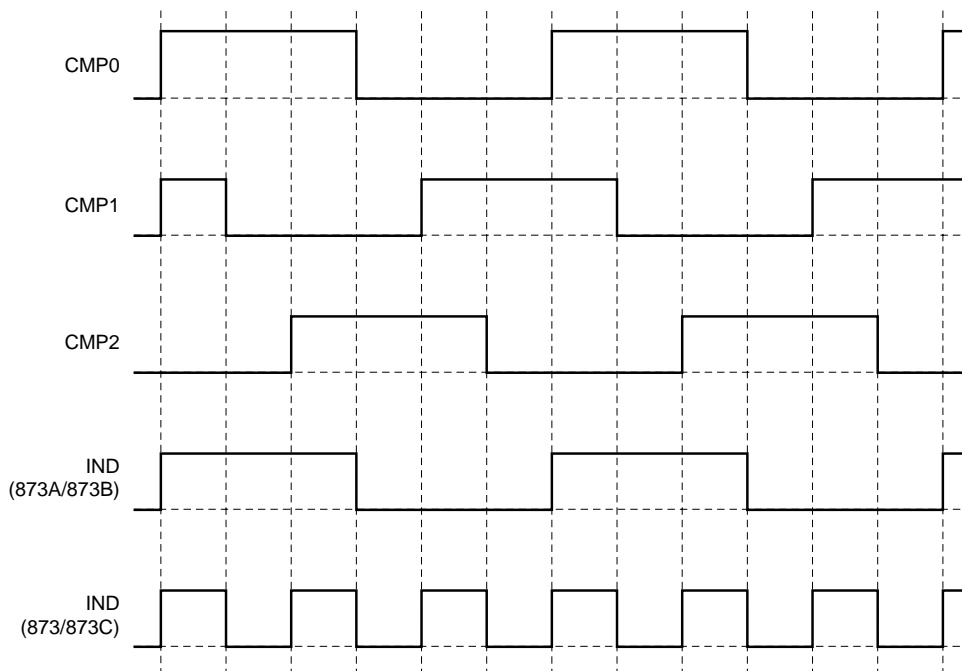
STB terminal	Operation mode
"H" level	Regular mode
"L" level	Standby mode

TIMING CHART

(1) Hall signal input



(2) CMP signal



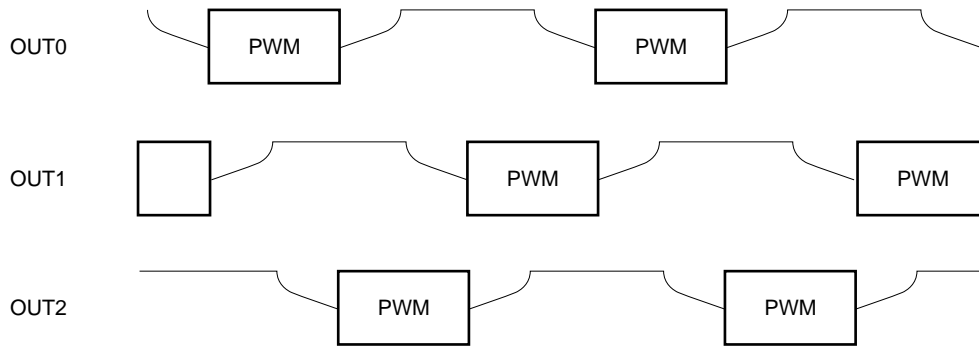
(3) Output MOSFET drive and comparator choice

Q1		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )		ON	ON		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )		ON	ON	
Q2		SW	SW					SW	SW				
Q3	( $\overline{\text{SW}}$ )		ON	ON		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )		ON	ON		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )
Q4	SW					SW	SW					SW	SW
Q5	ON	ON		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )		ON	ON		( $\overline{\text{SW}}$ )	( $\overline{\text{SW}}$ )		ON
Q6				SW	SW					SW	SW		

Remark μPD16873/A are not synchronous switching. (Normal type PWM)

μPD16873B/C are synchronous switching of high-side MOSFET. (Synchronous type PWM)

**(4) Output terminal voltage wave**



**Caution**

**(1) About output current**

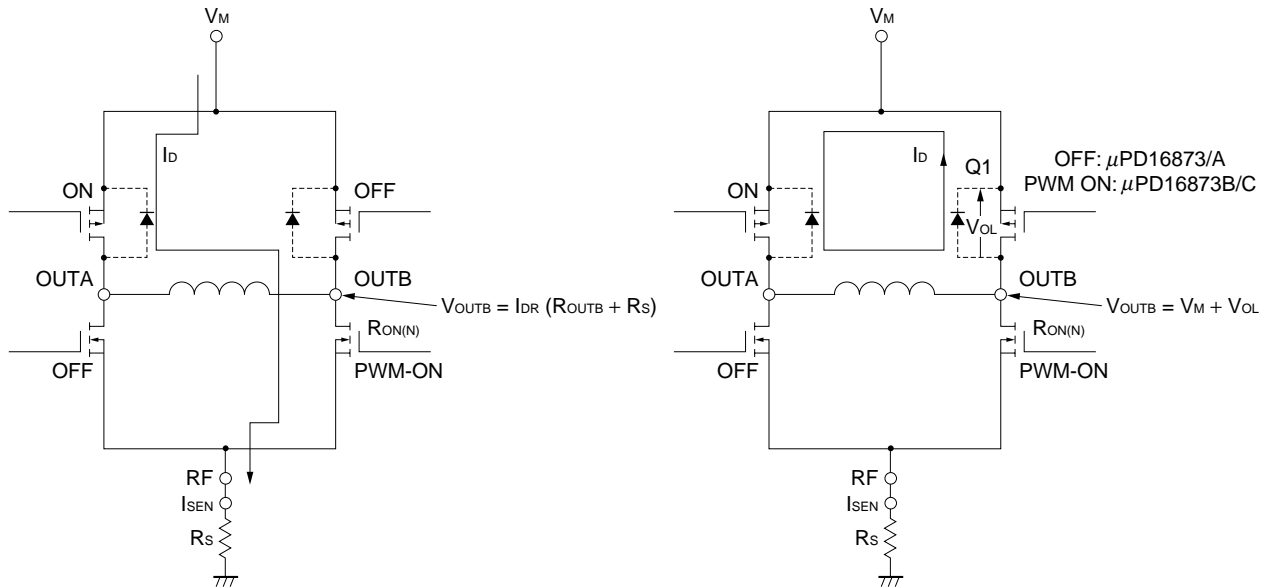
The rated output current differs depending on whether the motor revolves at a constant speed (steady state), is started (steady state), or Reverse brake is applied. The rated DC current when the motor revolves at a constant speed is 0.5 A, and the rated instantaneous current when the is started is 1.3 A. When the motor is stopped by using Reverse brake, the maximum current is 1.9 A.

When use Reverse brake, a current exceeding that when the motor revolves at a constant speed (immediately before a brake is applied) instantaneously flows because of the counter electromotive force due to the motor inductance. Determine the value of over current for steady state, taking the peak current for using Reverse brake to the motor into consideration.

**(2) About output pin voltage**

Output terminal (OUT0, OUT1, OUT2) takes the voltage which exceeds a motor power supply during following counter current.

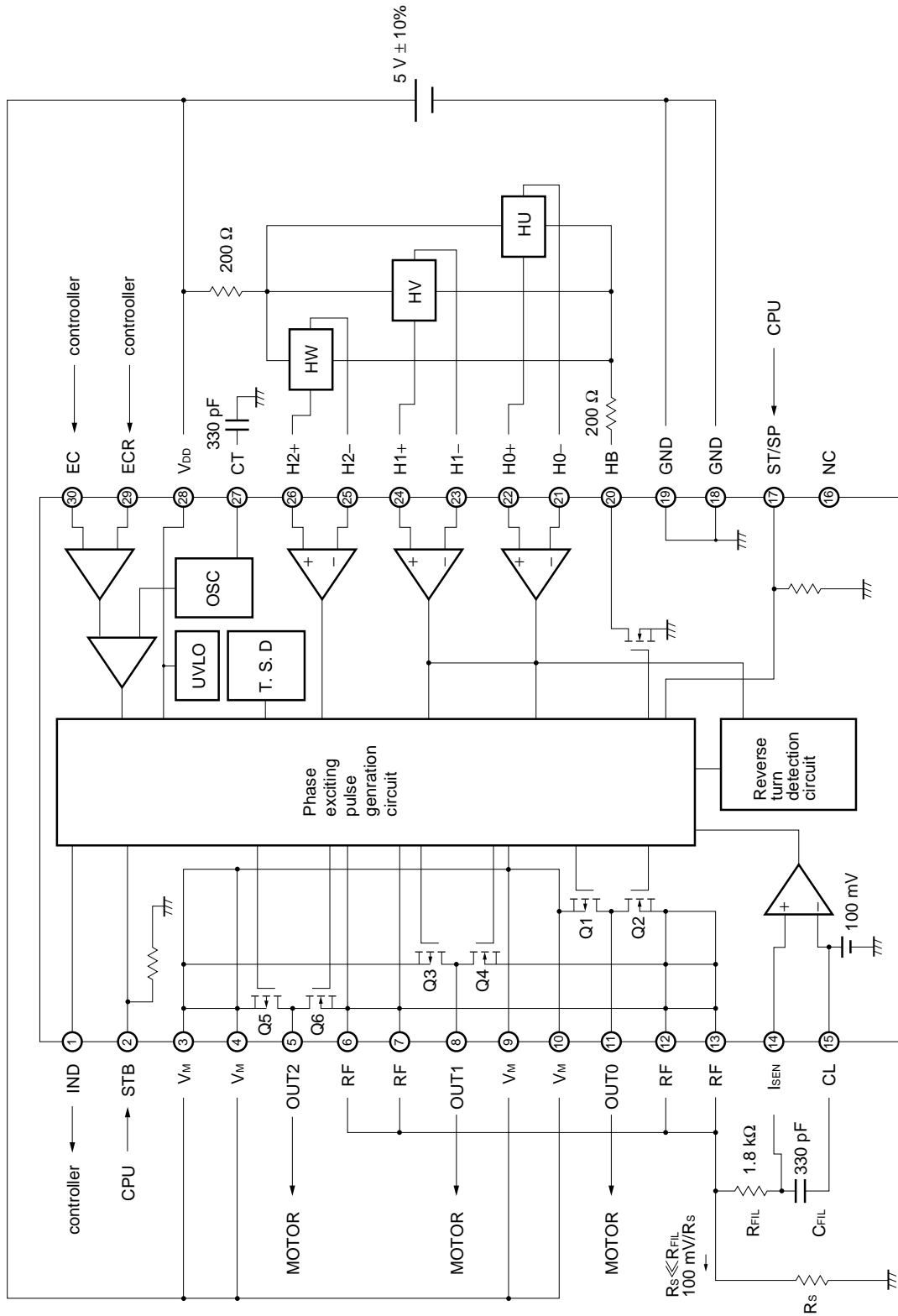
Maximum rate of output pin voltage is 6.7 V. Be careful that an output terminal doesn't take a voltage over 6.7 V.



Lower Nch MOC: PWM-ON time

Lower Nch MOC: PWM-OFF time

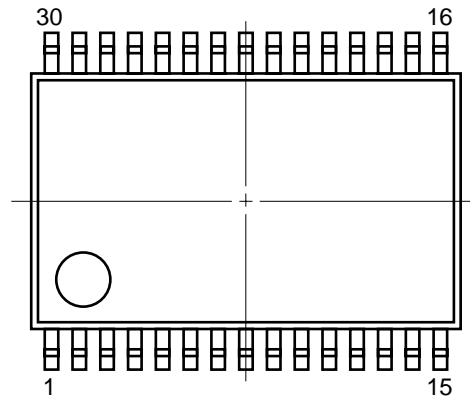
APPLICATION CIRCUIT EXAMPLE



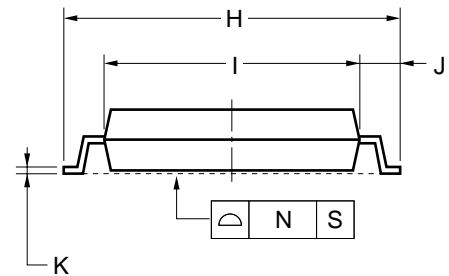
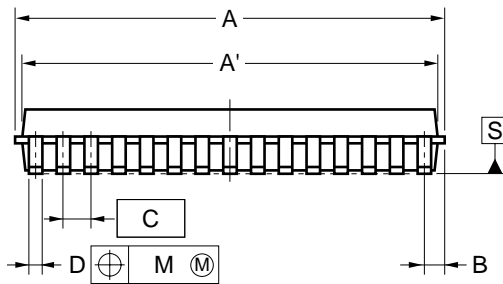
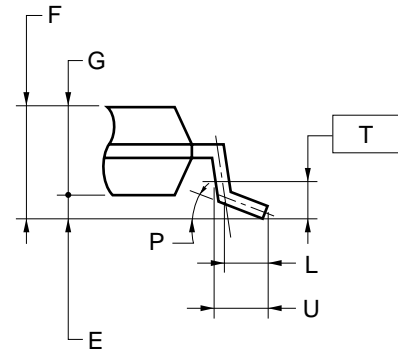
**Caution** If hall elements connected series, please change hall bias resistances, and hall signal include into same aspect input range of hall amplifier.

PACKAGE DIMENSION

30-PIN PLASTIC TSSOP (7.62mm(300))



detail of lead end



NOTE

Each lead centerline is located within 0.10 mm of its true position (T.P.) at maximum material condition.

ITEM	MILLIMETERS
A	9.85±0.10
A'	9.7±0.1
B	0.375
C	0.65 (T.P.)
D	0.24±0.05
E	0.1±0.05
F	1.2 MAX.
G	1.0±0.05
H	8.1±0.1
I	6.1±0.1
J	1.0±0.1
K	0.145±0.025
L	0.5
M	0.10
N	0.10
P	3° <sup>+5°</sup> <sub>-3°</sub>
T	0.25
U	0.6±0.15

S30MC-65-6A4

**RECOMMENDED SOLDERING CONDITIONS**

Solder this product under the following recommended conditions.

For soldering methods and conditions other than those recommended, consult NEC.

For details of the recommended soldering conditions, refer to information document “**Semiconductor Device Mounting Technology Manual**”.

Soldering Method	Soldering Conditions	Recommended Condition Symbol
Infrared reflow	Package peak temperature: 235°C; Time: 30 secs. max. (210°C min.); Number of times: 3 times max.; Number of day: none; Flux: Rosin-based flux with little chlorine content (chlorine: 0.2 Wt% max.) is recommended.	IR35-00-3
VPS	Package peak temperature: 215°C; Time: 40 secs. max.; (200°C min.) Number of times: 3 times max.; Number of day: none; Flux: Rosin-based flux with little chlorine content (chlorine: 0.2 Wt% max.) is recommended.	VP15-00-3
Wave Soldering	Package peak temperature: 260°C; Time: 10 secs. max.; Preheating temperature: 120°C max.; Number of times: once; Flux: Rosin-based flux with little chlorine content (chlorine: 0.2 Wt% max.) is recommended.	WS60-00-1

**Caution Do not use two or more soldering methods in combination.**

## NOTES FOR CMOS DEVICES

**① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS**

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

**② HANDLING OF UNUSED INPUT PINS FOR CMOS**

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to  $V_{DD}$  or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

**③ STATUS BEFORE INITIALIZATION OF MOS DEVICES**

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.

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  - While NEC Corporation has been making continuous effort to enhance the reliability of its semiconductor devices, the possibility of defects cannot be eliminated entirely. To minimize risks of damage or injury to persons or property arising from a defect in an NEC semiconductor device, customers must incorporate sufficient safety measures in its design, such as redundancy, fire-containment, and anti-failure features.
  - NEC devices are classified into the following three quality grades:  
"Standard", "Special", and "Specific". The Specific quality grade applies only to devices developed based on a customer designated "quality assurance program" for a specific application. The recommended applications of a device depend on its quality grade, as indicated below. Customers must check the quality grade of each device before using it in a particular application.
    - Standard: Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots
    - Special: Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support)
    - Specific: Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems or medical equipment for life support, etc.
- The quality grade of NEC devices is "Standard" unless otherwise specified in NEC's Data Sheets or Data Books. If customers intend to use NEC devices for applications other than those specified for Standard quality grade, they should contact an NEC sales representative in advance.