M57161L-01

Hybrid IC for driving IGBT modules

DESCRIPTION

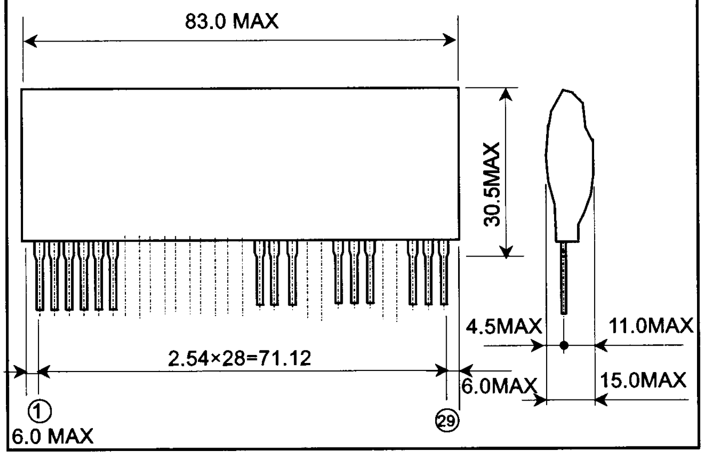
M57161L−01 is a hybrid IC designed to drive trench-gate IGBT modules with built-in RTC. This device can operate only by a power supply that has an output of +15V, because of both electrical isolation between the input and output by an opto coupler and a built-in DC-DC converter.

With built-in protection circuits, this device can maintain a reverse bias for a predetermined time after the detection of overcurrent or short circuit. Therefore, the protective system operates with a margin of time.

The overcurrent detection system functions only by the direct connection between the gate terminal of IGBT and the detection terminal of M57161L-01 without high-voltage proof /high-speed diodes and protective Zener diodes for the system to monitor the collector voltage of IGBT, because of the built-in RTC circuits to detect a drop in gate voltage.

Recommended module: IGBT module with built-in RTC circuit (Mitsubishi F series)

OUTLINE DRAWING Dimensions: mm



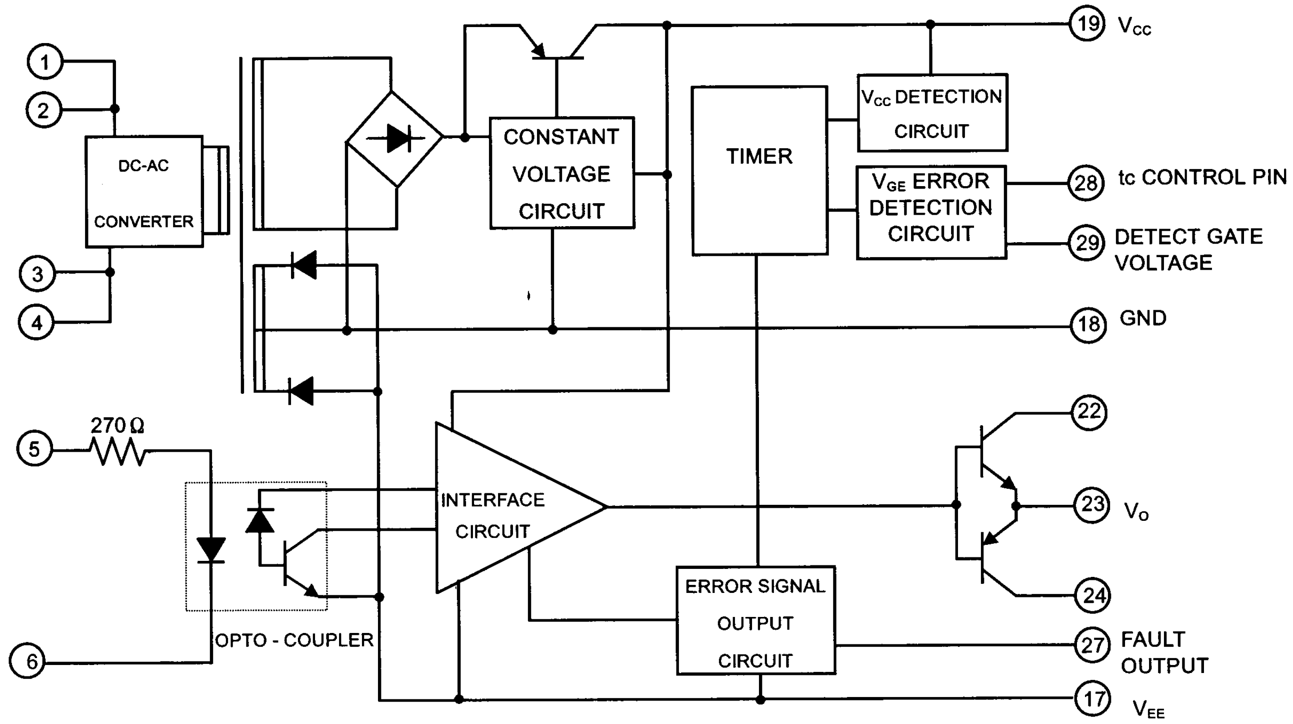
FEATURES

- Insulated type DC-DC converter built-in for a gate drive.
- High CMR opto-coupler built-in.
- Over current (short-circuit) protector built-in (with timer-operated circuit and reset circuit)
- Capability of adjusting time to control over current (short-circuit) detection
- Input-output isolation voltage: 2500Vrms for 1 min

APPLICATIONS

To drive IGBT modules for UPS, inverters, AC servo systems, PCs and so on.

BLOCK DIAGRAM



MAXIMUM RATINGS (unless otherwise noted, Ta=25°C)

Symbol	Parameter	Conditions	Ratings	Unit
V_D	Supply voltage	—	16	V
V_I	Input voltage	Between pins 5 and 6	-1 ~ +7	V
I_{OHP}	Output current	Pulse width 1μs, f ≦ 20kHz	-7	A
I_{OLP}			7	A
Viso	Isolation voltage	Sine wave voltage 60Hz, for 1ms,RH ≦ 50%	2500	Vrms
Tc 1	Case temperature 1	Surface temperature(opto-coupler mounting part)	85	°C
Tc 2	Case temperature 2	Surface temperature(excepting opto-coupler mounting part)	95	°C
Topr	Operating temperature	—	-20 ~ +60	°C
Tstg	Storage temperature	—	-25 ~ +100	°C
I_{FO}	Fault output current	Inflow current at 27 pin	25	mA
V_R	Input voltage at 29pin	—	V_{CC}	V

ELECTRICAL CHARACTERISTICS

(Unless otherwise noted, Ta=25°C, V_D=15V, V_{IN} = 5.0V, f = 20kHz, R_G = 2.2Ω, Load: CM600HU-24F)

Symbol	Parameter	Conditions	Limits			Unit
			Min	Typ	Max	
V_D	Supply voltage	Recommended range	14.3	15.0	15.7	V
V_{IN}	Pull-up voltage on primary side	Recommended range	4.5	5.0	5.5	V
I_{IH}	"H" input current	Recommended range	11.0	13.5	16.0	mA
f	Switching frequency	Recommended range (*)	—	—	20	kHz
R_G	Gate resistance	Recommended range	2.2	—	—	Ω
I_{IH}	"H" input current	V_{IN} = 5V	—	13.5	—	mA
V_{CC}	Gate supply voltage (+)	V_{IN} = 0V, f = 0Hz	17.0	17.4	17.8	V
V_{EE}	Gate supply voltage (-)	V_{IN} = 0V, f = 0Hz	-5.5	-6.5	-7.5	V
V_{OH}	"H" output voltage	—	14.0	15.5	16.5	V
V_{OL}	"L" output voltage	—	-4.0	-5.0	-6.0	V
t_{PLH}	"L-H" propagation time	I_{IH} = 13.5mA, Tc = 25°C	—	0.5	1.0	μs
t_r	"L-H" rise time	I_{IH} = 13.5mA, Tc = 25°C	—	0.4	1.0	μs
t_{PHL}	"H-L" propagation time	I_{IH} = 13.5mA, Tc = 25°C	—	0.9	2.0	μs
t_f	"H-L" fall time	I_{IH} = 13.5mA, Tc = 25°C	—	0.4	1.0	μs
t_{timer}	Timer	From protection operation to release (Input signal is "L")	1.2	—	2.5	ms
I_{FO}	Fault output current	Inflow current at 27pin, R = 470Ω	–	12	–	mA
t_d	Short-circuit protect delay time	When the output raises, 29pin: 11V, 28pin:open	–	–	6.0	μs
V_{CL}	Protection start voltage (When V_{CC} falls)	Min value of gate supply voltage required to set V_O to H.	14.2	–	16.2	V
V_{SC}	Over current detection voltage	Voltage at 29pin	11	–	13	V

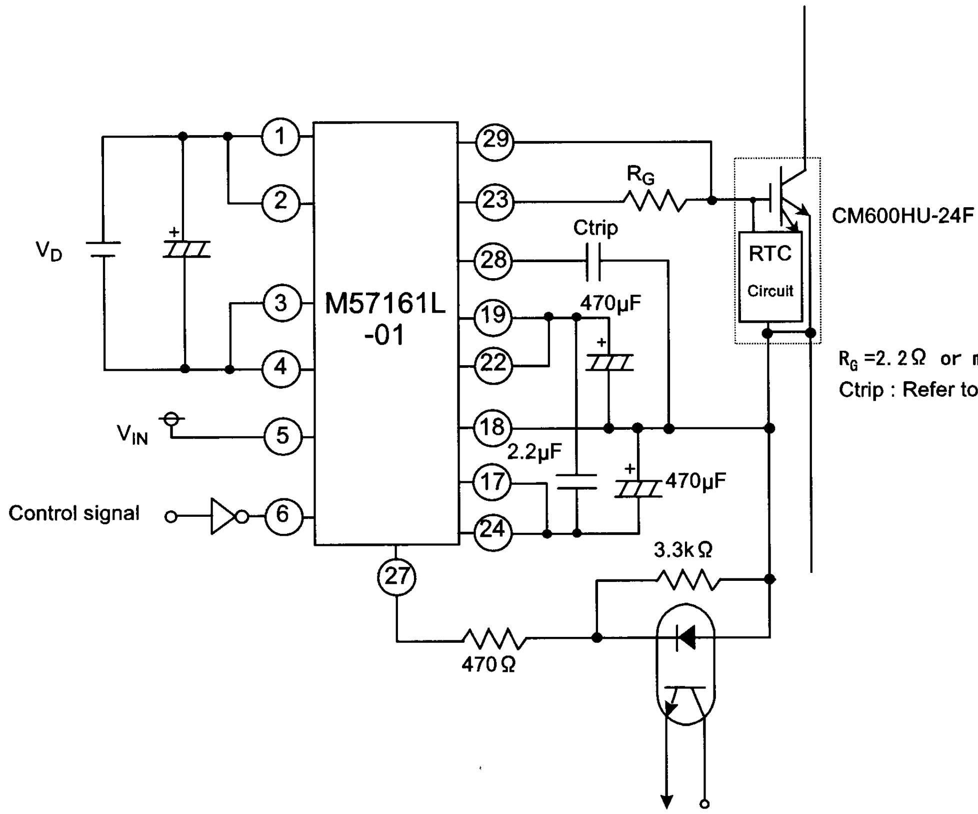
(*) If IGBT modules are directly driven, there is a possibility that switching frequency becomes below 20kHz.

APPRICATION CIRCUIT

1. Direct driving

V_D = 15V±5%

V_{IN} = 5V±5%

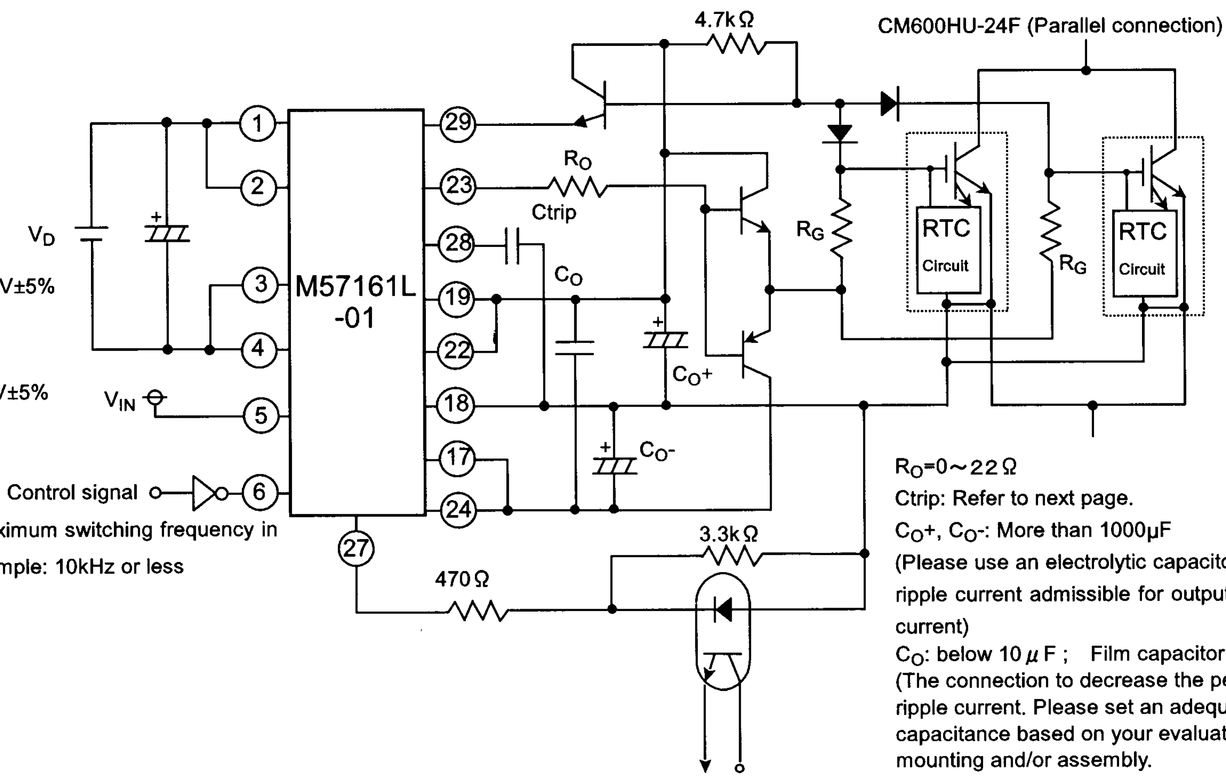


R_G =2.2Ω or more
Ctrip : Refer to next page.

2. Additional transistor for output current

V_D = 15V±5%

V_{IN} = 5V±5%



The maximum switching frequency in this example: 10kHz or less

R_O=0~22Ω
Ctrip: Refer to next page.
C_O+, C_O-: More than 1000μF
(Please use an electrolytic capacitor with ripple current admissible for output peak current)
C_O: below 10μF ; Film capacitor
(The connection to decrease the peak of ripple current. Please set an adequate capacitance based on your evaluation of mounting and/or assembly.

OVER-CURRENT PROTECTION CIRCUIT

1. The VGE error detect circuit operates when an input signal is in the state of "H".
2. An error judgment is made when VGE becomes below VSC(=11V:Min.).
3. The VGE error detect circuit does not function until the time when the gate voltage reaches VSC(=13V).The tc(=2.2 μ s) of controlled time detect short circuit is set in order to ensure the turn-on of IGBT modules.
4. If a rise time of gate voltage is longer than 2.2 μ s, the tc need to be adjusted by connecting a capacitor (Ctrip) between pins 28 and 18.Please refer to " tc, td -Ctrip characteristics " on this page.
5. The td is a delay time due to signal transmission of each protection circuit.
6. If short-circuit current flows at turn-on, the controlled time detect short circuit (tc)is included to the td of short-circuit protect delay time. The td can be changed through Ctrip. As a gate shutdown of IGBT modules within 10 μ s is recommended, Ctrip should be below 220 pF in order to set the maximum of td below 10 μ s. In addition, td changes with circumference temperature. Since td gose up for about 1.0 μ s when the ambient temperature of driver rises to 60°C, It recommends adjusting Ctrip to 220 pF or less.

ADJUSTIMENT METHOD WHEN USING Ctrip

t_c can be calculable by the following formula.

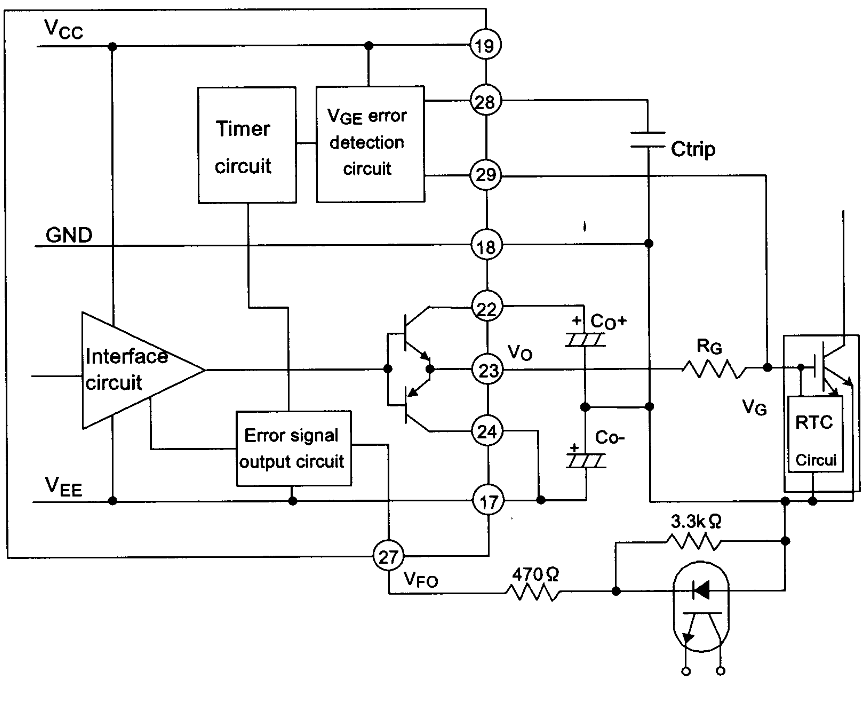
t_c = 14.4 (Ctrip + 15)/1000 + 2.1 (μs) The unit of Ctrip is "pF".

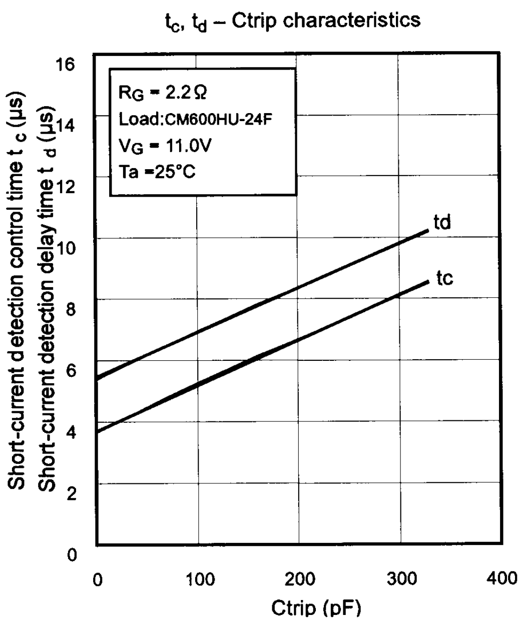
It is necessary to make a gate detection pin (pin 29) opening and to observe V_{GE} of IGBT module at the time of turn-on, and the output (pin 23) of this Hybrid IC. Measure time (ton: μs) after the output of this Hybrid IC becomes 11V until V_{GE} becomes 12V, and if that time is larger than t_c, lengthen t_c.

When time which added the margin for 1.5μs from ton is set to t_c, the minimum of Ctrip (Ctrip/min) is calculable by the following formula.

Ctrip/min = 1000 (ton - 0.6) / 14.4 – 15 (pF)

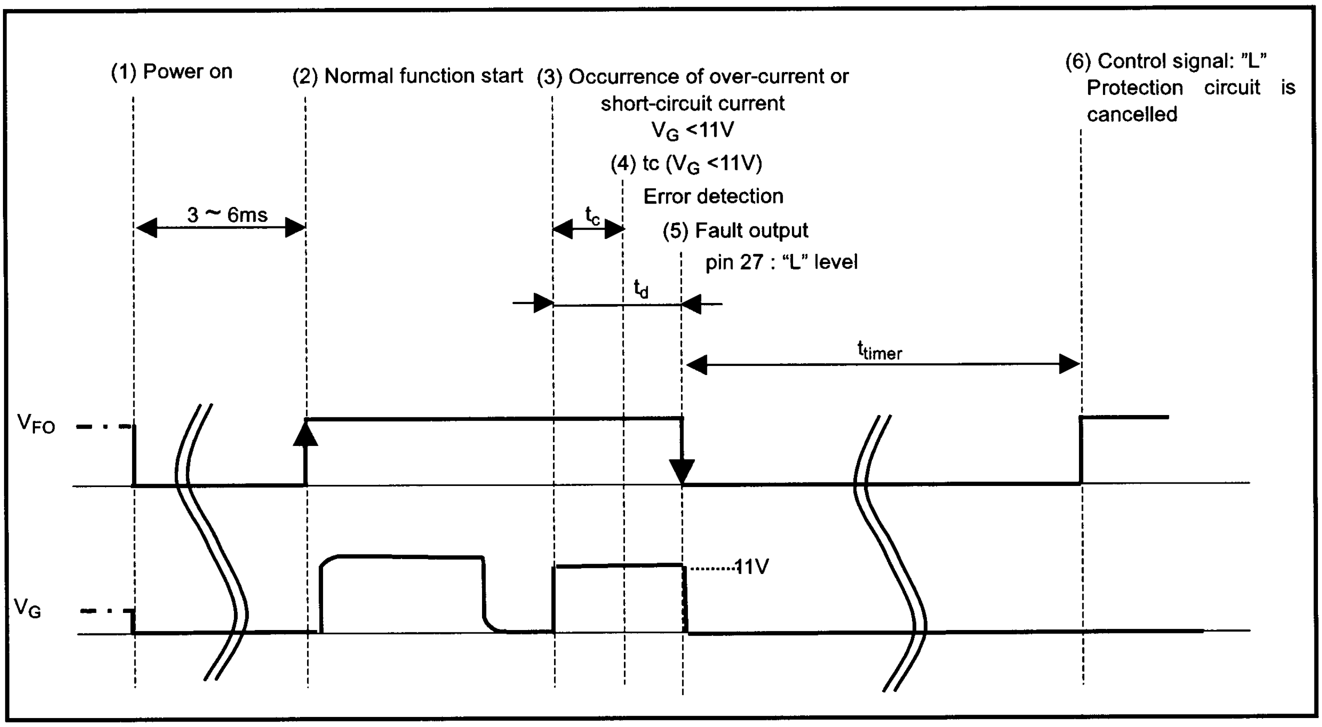
In addition, the minimum of Ctrip can also be calculated from the t_c, t_d - Ctrip characteristic graph of the following figure.





CONTROL OF IGBT MODULE DRIVER

The timing chart for control of IGBT module drivers with electrical isolation between the input and output is as follows:



Timing figure of the protection operation. (Occurrence of over-current or short-circuit)

Supplementary explanation of a timing figure

(1) When Vcc is within 10 to 15 voltages, short-circuit detect output (V_{FO}) is in the low state. The output voltage remains in the low state for 3 to 6 ms. If the power supply is applied in the high state of input signal, the output (Vo) remains in the low state. But VFO becomes in the low state for 3 to 6 ms. After normal function starts, if Vcc is below the start voltage of protection circuit (typ. 15.2V), VFO is low and Vo is low voltage for the same period.

(2) After VFO returns to high level, control signal should be applied.

(3) If over-current or short-circuit current flows between the collector and emitter of IGBT modules, the internal RTC circuit pulls the gate voltage down below 11V.

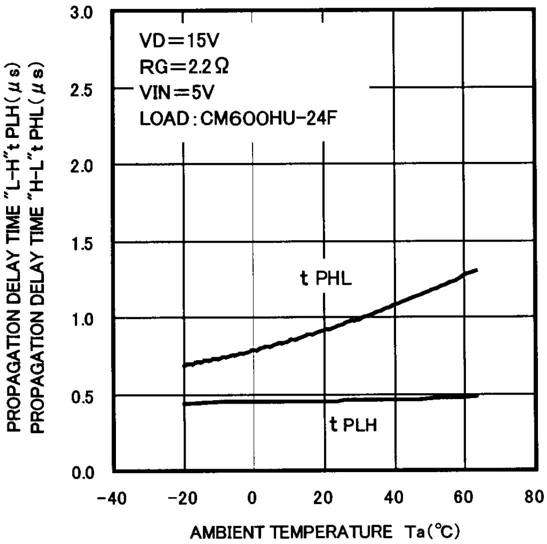
(4) When the turn-on of IGBT coincides with over-current or short-circuit current, the timer circuit functions after tc.

(5) After td from the short-circuit or over-current, the output voltage of Vo is low and VFO is low voltage at the same time.
The output remains low during the operating time of timer circuit regardless of input signals.

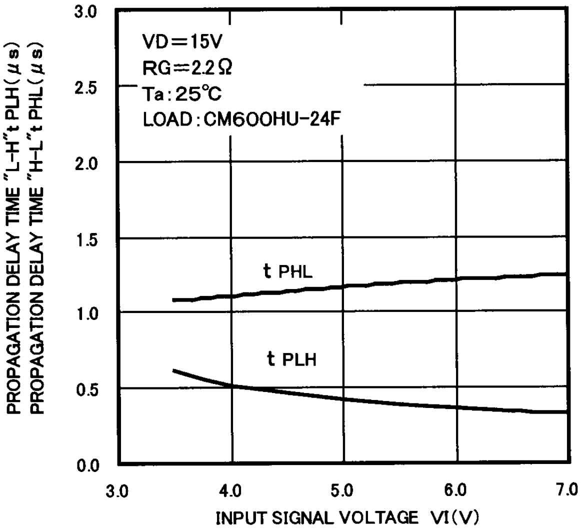
(6) After ttimer VFO returns to high voltage, if the input signal is low level (more than 5 μ s), then the protection function is cancelled.

TYPICAL CHARACTERISTICS

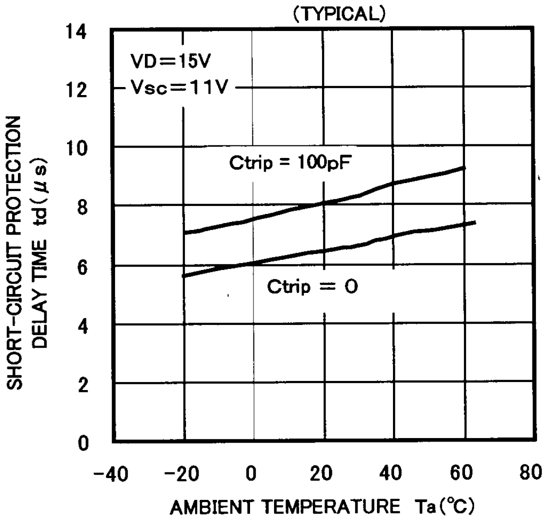
t PLH、t PHL vs. Ta CHARACTERISTICS
(TYPICAL)



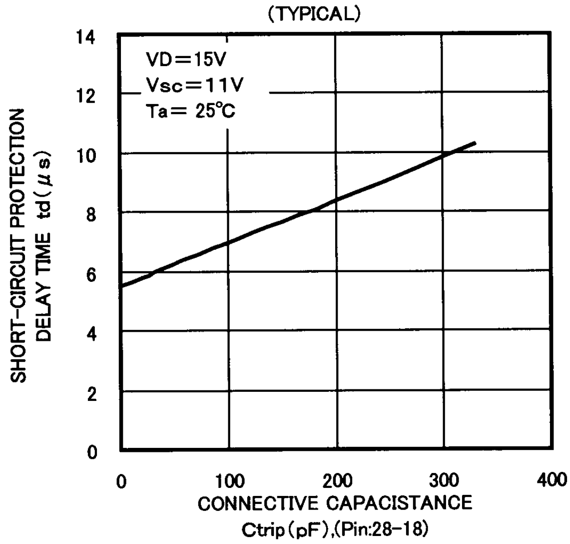
tPLH、tPHL vs. VI CHARACTERISTICS
(TYPICAL)



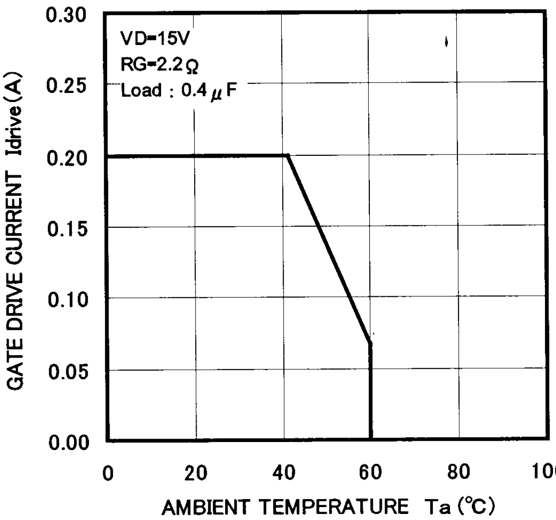
td Vs. Ta CHARACTERISTICS
(TYPICAL)



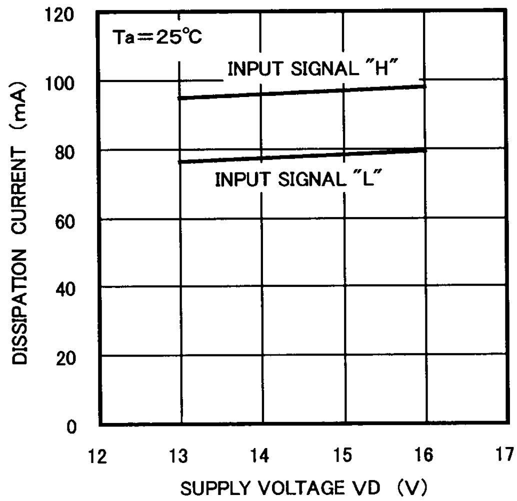
td vs. Ctrip CHARACTERISTICS
(TYPICAL)



Idrive − Ta CHARACTERISTICS
(MAXIMUM RATING)



DISSIPATION CURRENT vs. SUPPLY VOLTAGE
(TYPICAL)



Practicable setting method of "Ctrip"

Please refer to the following steps in adjustment "Ctrip"

1. Notes concerning RTC circuit

Rising time of the gate voltage becomes twice or more compared with since it pulses the 1st pulse that drives the gate and the 2nd.

Figure 1 Show in the equivalent circuit of the RTC circuit, the RTC circuit has a stray capacity: "Cf" those capacitance is larger than the gate input capacitor, the charging current flows to "Cf" by the first pulse that drives the gate voltage, and rising time of the gate voltage becomes long. However, the charging current to "Cf" can be disregarded since it pulses the second because the internal leakage resistance is 100MΩ or more and up to several G„ . The rising time of the gate voltage doesn't depend at the temperature.

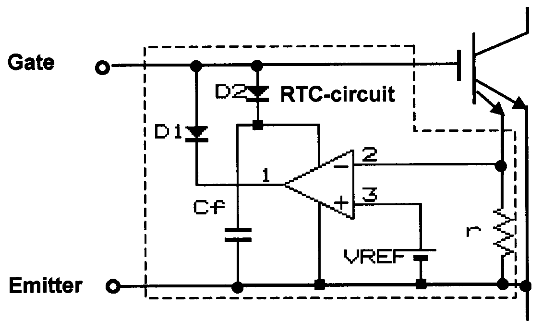


Figure 1 Equivalent circuit of RTC circuit

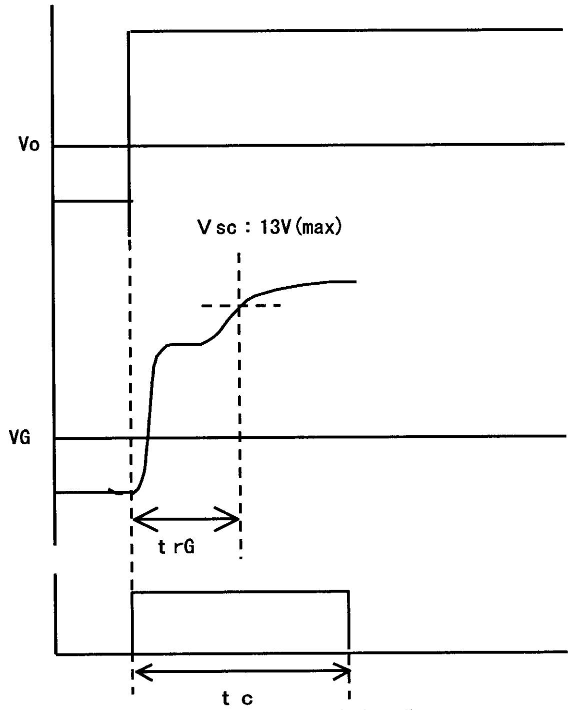


Figure 2 tc setting timing diagram

2. Observation of rising time of gate voltage: trG

"trG" of the first pulse in operation beginning in the following conditions is observed with all gates. Please refer to Figure 2 for the definition of "trG". Moreover, please install the dormant period of five minutes or more in the measurement of each trG.

Test conditions

(1) The power supply of a main circuit leaves cutting.

(2) The gate resistance is set to the maximum value of the allowance.

3. Maximum value evaluation of "trG"

Minimum value trG(min) is calculated from the observation value in clause 2. Moreover, the standard deviation „ is calculated. The expectation value "trGM" of the maximum value of "trG" is calculated as follows. trGM =1.5 ･ [trG(min) - 3„]

4. Setting of minimum value of controlled time detect short circuit: tc(min)

The necessary condition is tc(min) > trGM. "tc(min)" is set like the next expression in consideration of a decrease of tc due to the ambient temperature decrease. tc(min) = trGM+1.0 (us).

5. Constant setting of "Ctrip"

The relation between tc(min) and Ctrip becomes the next expression. tc(min) = 0.0144 ･ [Ctrip(min) + 14] + 1.7(μs)

Minimum value of Ctrip(min) at the controlled time detect short-circuit becomes the next expression through the equation in this expression and the preceding clause. Ctrip(min) = 69.4 ･ [trGM - 0.7] - 14 (pF)

When a ceramic capacitor of the allowance 5% is applied, the capacity value that satisfies the following expression is selected. : Ctrip > 73.1 ･ [trG(max) - 0.7] - 15(pF) and Ctrip < 231/1.05=220 (pF)

Here, the maximum limit of Ctrip assumes the upper bound at the short-circuit interception time of the IGBT module to be 10μs and assumes the ambient temperature to be 50℃.

When the result that calculates the minimum limit of Ctrip from trGM becomes more than the maximum limit, it is necessary to take the following measures. Please refer to next page.

6. Correspondence example to RTC circuit

To initial charge with the stray capacity of the RTC circuit, the rising time of the gate voltage becomes twice or more. This phenomenon lengthens the short-circuit protection delay time on the Ctrip setting. Moreover, if the gate resistance is set to improving, the case that cannot be used is caused by the maximum limit of Ctrip. To evade this, a preliminary pulse to charge each gate with the stray capacity of the RTC circuit before IGBT is really operated is given. Even if each IGBT before it begins to operate really is turned on to the concrete example of a preliminary pulse, the gate control pulse of 2„ s to { tc(min) - 1.0 } „ s is sequentially input to each driver at intervals of 20„ s or more in the state of a main circuit so as not to influence, and it is 2„ s to tc(min) „ s "H" giving the output voltage, and it is at ..each IGBT1 element.. gate in order the method of charging with Cf of the RTC circuit.

Because the input signal is assumed to be "L" to impress the gate pulse of tc or less to the driver before the protection operation starts even if the rise time at the gate is large, it never shifts to the protection operation.

Because tc can be set with trG at the switching, an increase in the protection delay time can be reduced usually. The examination that lowers the gate resistance until becoming Ctrip=220pF is necessary when becoming Ctrip>220pF after measures of a preliminary pulse.

FOR SAFETY USING

Great detail and careful attention are given to the production activity of Hics, such as the development, the quality of production, and in it's reliability. However the reliability of Hics depends not only on their own factors but also in their condition of usage. When handling Hics, please note the following cautions.

CAUTIONS	
Packing	The materials used in packing Hics can only withstand normal external conditions. When exposed to outside shocks, rain and certain environmental contaminators, the packing materials will deteriorates. Please take care in handling.
Carrying	1) Don't stack boxes too high. Avoid placing heavy materials on boxes. 2) Boxes must be positioned correctly during transportation to avoid breakage. 3) Don't throw or drop boxes. 4) Keep boxes dry. Avoid rain or snow. 5) Minimal vibration and shock during transportation is desirable.
Storage	When storing Hics, please observe the following notices or possible deterioration of their electrical characteristics, risk of solderability, and external damage may occur. 1) Devices must be stored where fluctuation of temperature and humidity is minimal, and must not be exposed to direct sunlight. Store at the normal temperature of 5 to 30 degrees Celsius with humidity at 40 to 60%. 2) Avoid locations where corrosive gasses are generated or where much dust accumulates. 3) Storage cases must be static proof. 4) Avoid putting weight on boxes.
Extended storage	When extended storage is necessary, Hics must be kept non-processed. When using Hics which have been stored for more than one year or under severe conditions, be sure to check that the exterior is free from flaw and other damages.
Maximum ratings	To prevent any electrical damages, use Hics within the maximum ratings. The temperaqture, current, voltage, etc. must not exceed these conditions.
Polarity	To protect Hics from destruction and deterioration due to wrong insertion, make sure of polarity in inserting leads into the board holes, conforming to the external view for the terminal arrangement.

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