ภาคผนวก ก.

รายละเอียดอุปกรณ์ที่ใช้ในวงจร

DATA SHEET

RENESAS

THYRISTORS

5P4M,5P6M

5 A (8 Ar.m.s.) THYRISTOR

The 5P4M and 5P6M are a P gate all diffused mold type Thyristor granted 5 A On-state Average Current (Tc = 103°C).

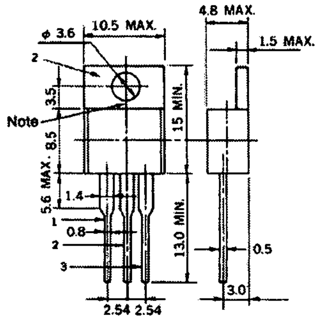
FEATURES

- Easy installation by TO-220AB package.
- 80 A surge current.
- <R> High Voltage.
  : V_{DRM}, V_{RRM} = 400 V (5P4M)
  : V_{DRM}, V_{RRM} = 600 V (5P6M)

APPLICATIONS

- Motor speed control for household appliance.
- Temperature control for heater and constant temperature box.
- Constant voltage power source and battery charger.
- Automotive application such as regulator.
- Various solid state relay etc.

<R> **PACKAGE DRAWING (Unit: mm)**



Pin Connection
1. Cathode
2. Anode
3. Gate

Standard weight: 2 g

Note Tc test point

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Date Published July 2006 NS CP(K)
Printed in Japan

The mark <R> shows major revised points.
The revised points can be easily searched by copying an "<R>" in the PDF file and specifying it in the "Find what:" field.

<R> MAXIMUM RATINGS

CHARACTERISTICS	SYMBOL	5P4M	5P6M	UNIT	REMARK
Non-repetitive Peak Reverse Voltage	V_{RSM}	500	700	V	–
Non-repetitive Peak Off-state Voltage	V_{DSM}	500	700	V	–
Repetitive Peak Reverse Voltage	V_{RRM}	400	600	V	–
Repetitive Peak Off-state Voltage	V_{DRM}	400	600	V	–
Average On-state Current	$I_{T(AV)}$	5 (T_C = 103°C, θ = 180°, Single phase half wave)		A	See Fig. 5
Effective On-state Current	$I_{T(RMS)}$	8		A	
Surge On-state Current	I_{TSM}	80 (f = 50 Hz, sine half wave, 1 cycle) 88 (f = 60 Hz, sine half wave, 1 cycle)		A	See Fig. 2
Fusing Current	$\int i_T^2 dt$	28 (1 ms ≤ t ≤ 10 ms)		A^2s	–
Critical Rate Rise of On-state Current	dI_T/dt	50		A/μs	–
Peak Gate Power Dissipation	P_{GM}	5 (f ≥ 50 Hz, Duty ≤ 10%)		W	See Fig. 3
Average Gate Power Dissipation	$P_{G(AV)}$	0.5		W	
Peak Gate Forward Current	I_{FGM}	2 (f ≥ 50 Hz, Duty ≤ 10%)		A	–
Peak Gate Reverse Voltage	V_{RGM}	10		V	–
Junction Temperature	T_j	–40 to +125		°C	–
Storage Temperature	T_{stg}	–55 to +150		°C	–

<R> ELECTRICAL CHARACTERISTICS (T_j = 25°C)

CHARACTERISTICS	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT	REMARK
Repetitive Peak Reverse Current	I_{RRM}	V_{RM} = V_{RRM}	T_j = 25°C	–	–	100	μA	–
			T_j = 125°C	–	–	2	mA	–
Repetitive Peak Off-state Current	I_{DRM}	V_{DM} = V_{DRM}	T_j = 25°C	–	–	100	μA	–
			T_j = 125°C	–	–	2	mA	–
Critical Rate Rise of Off-state Voltage	dV_D/dt	V_{DM} = 2/3 V_{DRM}, T_j = 125°C		–	40	–	V/μs	–
On-state Voltage	V_{TM}	I_{TM} = 10 A		–	–	1.4	V	See Fig. 1
Gate-trigger Current	I_{GT}	V_{DM} = 6 V, R_L = 100 Ω		–	–	10	mA	See Fig. 3
Gate-trigger Voltage	V_{GT}	V_{DM} = 6 V, R_L = 100 Ω		–	–	1.5	V	
Gate Non-trigger Voltage	V_{GD}	V_{DM} = 1/2 V_{DRM}, T_j = 125°C		0.2	–	–	V	
Holding Current	I_H	V_{DM} = 24 V, I_{TM} = 10 A		–	6	–	mA	–
Circuit Commuted Turn-off Time	t_q	I_{TM} = 5 A, V_R ≥ 25 V V_{DM} = 2/3 V_{DRM}, diR/dt = 15 A/μs dV_D/dt = 10 V/μs, T_j = 125°C		–	50	–	μs	–
Thermal Resistance	$R_{th(j-c)}$	Junction to case DC		–	–	3	°C/W	See Fig. 7
	$R_{th(j-a)}$	Junction to ambient DC		–	–	65	°C/W	

TYPICAL CHARACTERISTICS (T_A = 25°C)

Fig. 1 $i_T - v_T$ CHARACTERISTIC

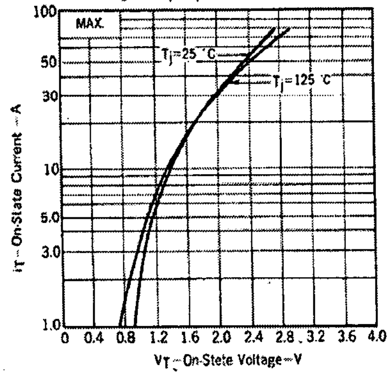


Fig. 2 I_{TSM} RATING

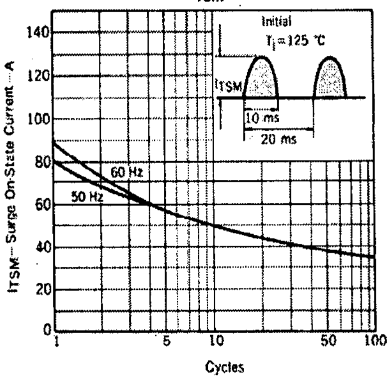


Fig. 3 GATE CHARACTERISTIC

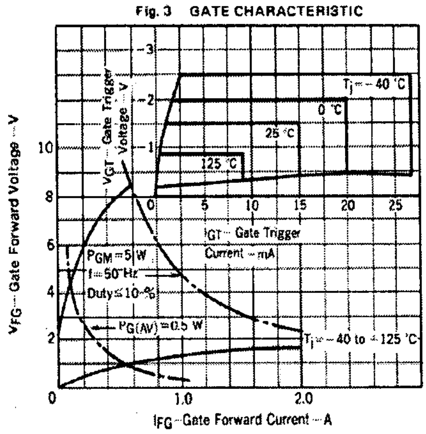


Fig. 4 $P_{T(AV)} - I_{T(AV)}$ CHARACTERISTIC

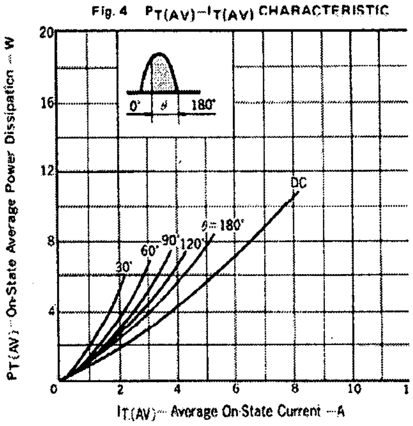


Fig. 5 $T_c - I_{T(AV)}$ RATING

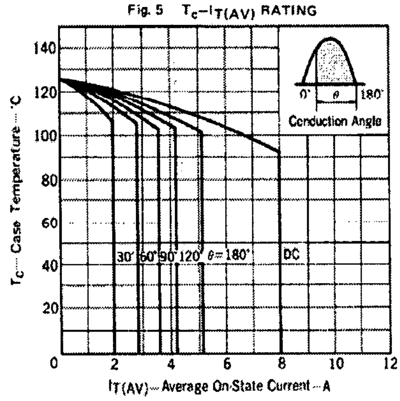
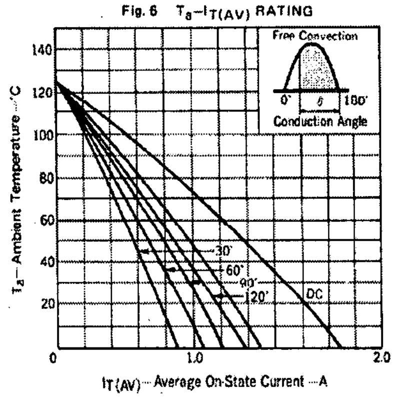
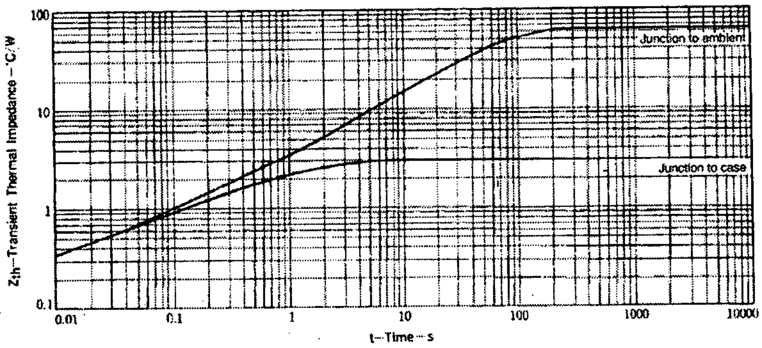


Fig. 6 $T_a - I_{T(AV)}$ RATING



<R>

Fig. 7 Z_{th} CHARACTERISTIC

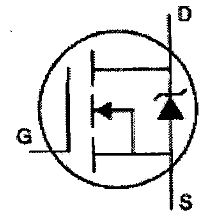


International IOR Rectifier

IRFP460

HEXFET® Power MOSFET

- Dynamic dv/dt Rating
- Repetitive Avalanche Rated
- Isolated Central Mounting Hole
- Fast Switching
- Ease of Paralleling
- Simple Drive Requirements



V_{DSS} = 500V

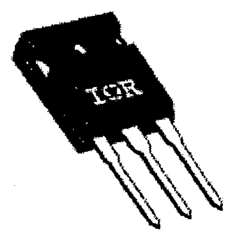
$R_{DS(on)}$ = 0.27Ω

I_D = 20A

Description

Third Generation HEXFETs from International Rectifier provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-247 package is preferred for commercial–industrial applications where higher power levels preclude the use of TO-220 devices. The TO-247 is similar but superior to the earlier TO-218 package because of its isolated mounting hole. It also provides greater creepage distance between pins to meet the requirements of most safety specifications.



TO-247AC

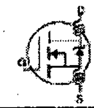
Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ 10 V	20	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ 10 V	13	
I_{DM}	Pulsed Drain Current ①	80	
P_D @ T_C = 25°C	Power Dissipation	280	W
	Linear Derating Factor	2.2	W/°C
V_{GS}	Gate-to-Source Voltage	±20	V
E_{AS}	Single Pulse Avalanche Energy ②	960	mJ
I_{AR}	Avalanche Current ①	20	A
E_{AR}	Repetitive Avalanche Energy ①	28	mJ
dv/dt	Peak Diode Recovery dv/dt ③	3.5	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting Torque, 6-32 or M3 screw	10 lbf•in (1.1 N•m)	

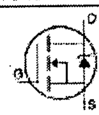
Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{θJC}$	Junction-to-Case	—	—	0.45	°C/W
$R_{θCS}$	Case-to-Sink, Flat, Greased Surface	—	0.24	—	
$R_{θJA}$	Junction-to-Ambient	—	—	40	

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	500	—	—	V	V_{GS}=0V, I_D= 250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	0.63	—	V/°C	Reference to 25°C, I_D= 1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.27	Ω	V_{GS}=10V, I_D=12A ④
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	V_{DS}=V_{GS}, I_D= 250μA
g_{fs}	Forward Transconductance	13	—	—	S	V_{DS}=50V, I_D=12A ④
I_{DSS}	Drain-to-Source Leakage Current	—	—	25	μA	V_{DS}=500V, V_{GS}=0V
		—	—	250		V_{DS}=400V, V_{GS}=0V, T_J=125°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS}=20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS}=-20V
Q_g	Total Gate Charge	—	—	210	nC	I_D=20A
Q_{gs}	Gate-to-Source Charge	—	—	29		V_{DS}=400V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	110		V_{GS}=10V See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	18	—	ns	V_{DD}=250V
t_r	Rise Time	—	59	—		I_D=20A
$t_{d(off)}$	Turn-Off Delay Time	—	110	—		R_G=4.3Ω
t_f	Fall Time	—	58	—		R_D=13Ω See Figure 10 ④
L_D	Internal Drain Inductance	—	5.0	—	nH	Between lead, 6 mm (0.25in.) from package and center of die contact 
L_S	Internal Source Inductance	—	13	—		
C_{iss}	Input Capacitance	—	4200	—	pF	V_{GS}=0V
C_{oss}	Output Capacitance	—	870	—		V_{DS}= 25V
C_{rss}	Reverse Transfer Capacitance	—	350	—		f=1.0MHz See Figure 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I_S	Continuous Source Current (Body Diode)	—	—	20	A	MOSFET symbol showing the integral reverse p-n junction diode. 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	80		
V_{SD}	Diode Forward Voltage	—	—	1.8	V	T_J=25°C, I_S=20A, V_{GS}=0V ④
t_{rr}	Reverse Recovery Time	—	570	860	ns	T_J=25°C, I_F=20A
Q_{rr}	Reverse Recovery Charge	—	5.7	8.6	μC	di/dt=100A/μs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is neglegible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature (See Figure 11)

② V_{DD}=50V, starting T_J=25°C, L=4.3mH R_G=25Ω, I_{AS}=20A (See Figure 12)

③ I_{SD}≤20A, di/dt≤160A/μs, V_{DD}≤$V_{(BR)DSS}$, T_J≤150°C

④ Pulse width ≤ 300 μs; duty cycle ≤2%.

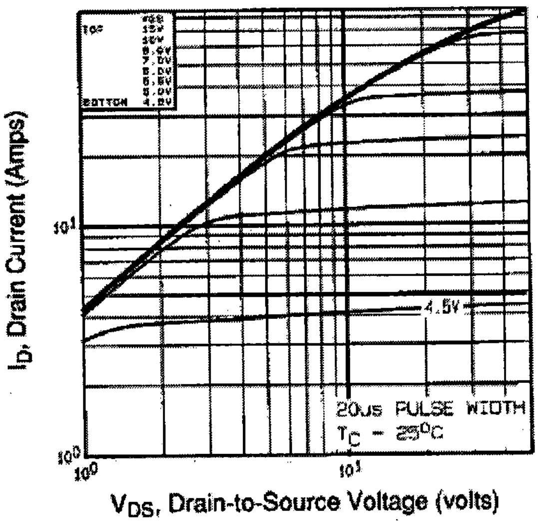


Fig 1. Typical Output Characteristics, T_C=25°C

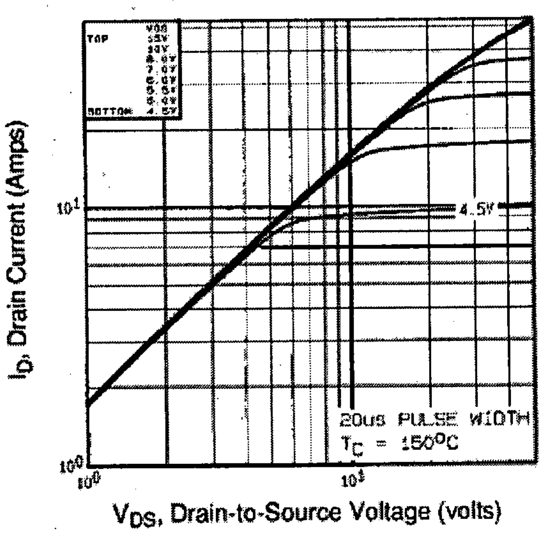


Fig 2. Typical Output Characteristics, T_C=150°C

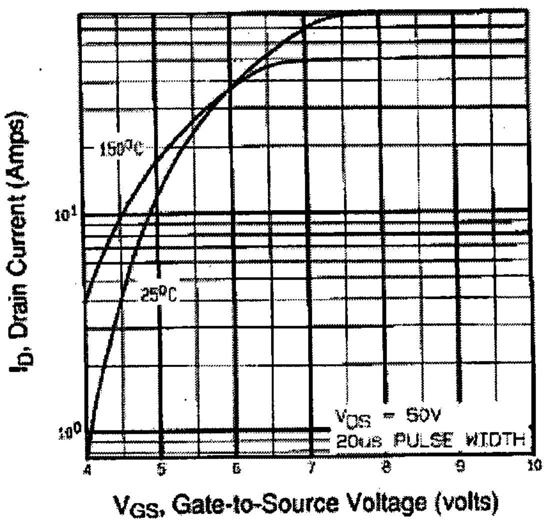


Fig 3. Typical Transfer Characteristics

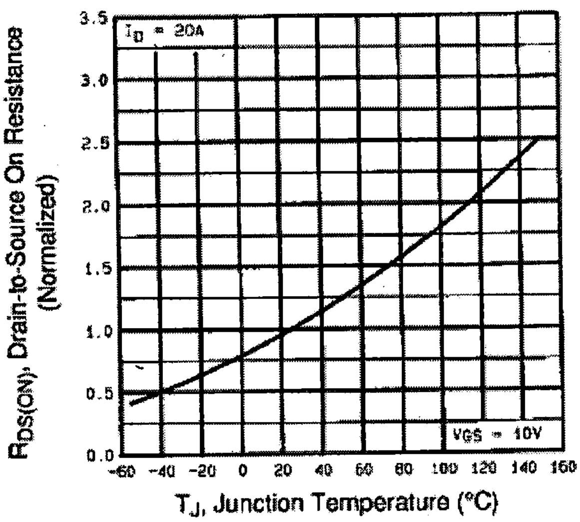


Fig 4. Normalized On-Resistance Vs. Temperature

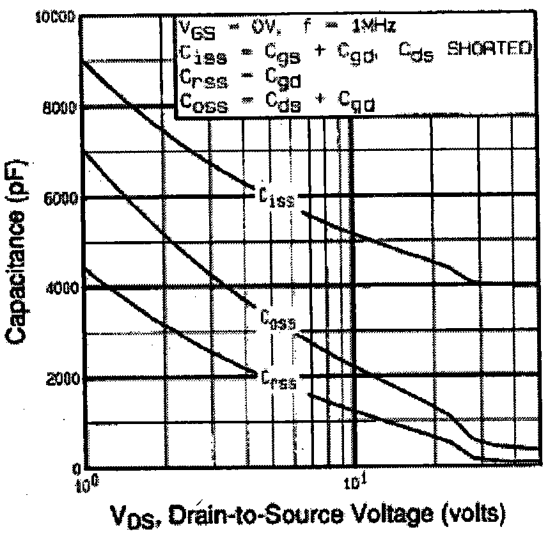


Fig 5. Typical Capacitance Vs. Drain-to-Source Voltage

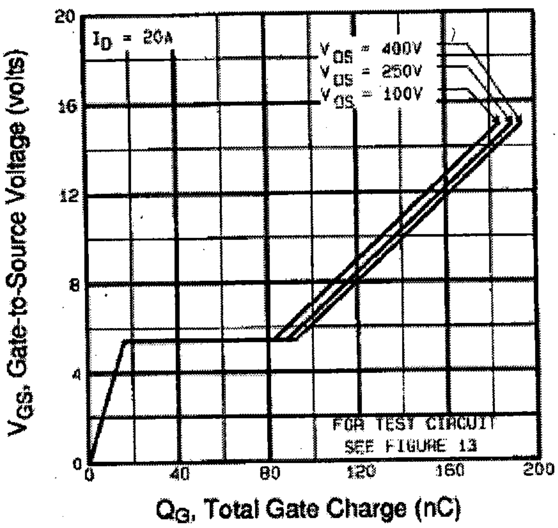


Fig 6. Typical Gate Charge Vs. Gate-to-Source Voltage

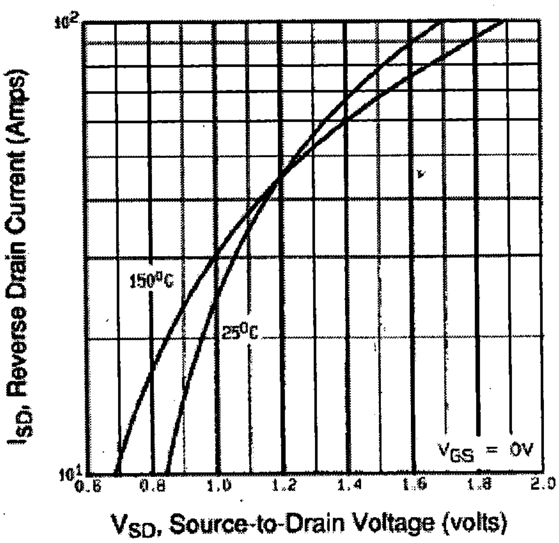


Fig 7. Typical Source-Drain Diode Forward Voltage

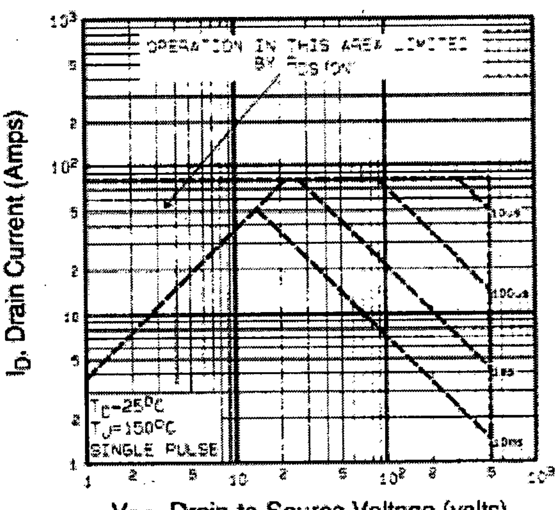


Fig 8. Maximum Safe Operating Area

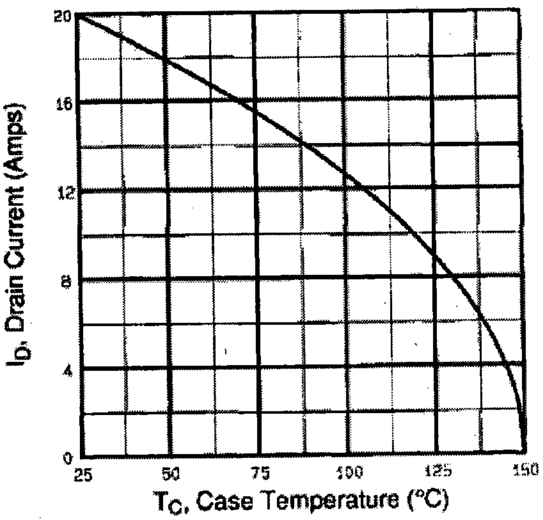


Fig 9. Maximum Drain Current Vs. Case Temperature

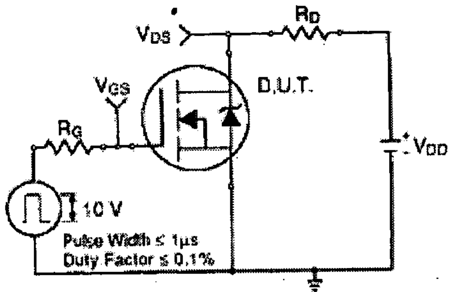


Fig 10a. Switching Time Test Circuit

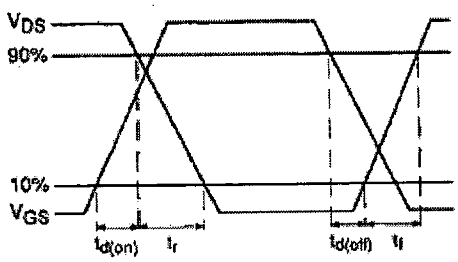


Fig 10b. Switching Time Waveforms

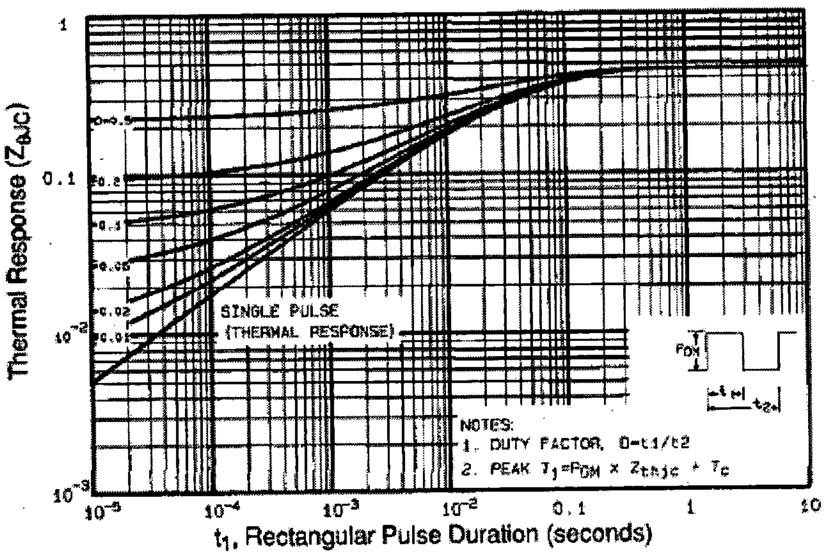


Fig 11. Maximum Effective Transient Thermal Impedance, Junction-to-Case

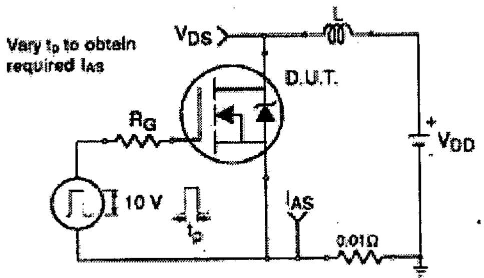


Fig 12a. Unclamped Inductive Test Circuit

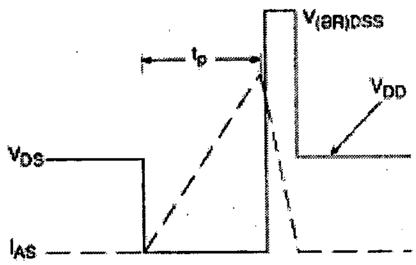


Fig 12b. Unclamped Inductive Waveforms

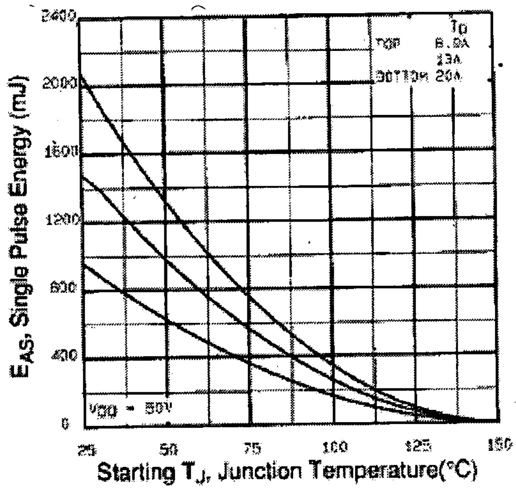


Fig 12c. Maximum Avalanche Energy Vs. Drain Current

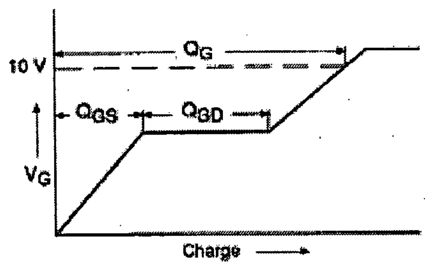


Fig 13a. Basic Gate Charge Waveform

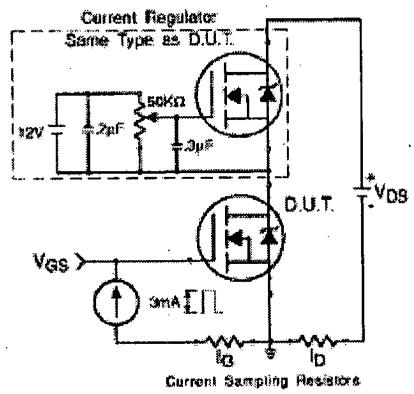


Fig 13b. Gate Charge Test Circuit

Appendix A: Figure 14, Peak Diode Recovery dv/dt Test Circuit – See page 1505
Appendix B: Package Outline Mechanical Drawing – See page 1511
Appendix C: Part Marking Information – See page 1517

International
IOR Rectifier

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Order this document
by MUR420/D

SWITCHMODE™ Power Rectifiers

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state–of–the–art devices have the following features:

- Ultrafast 25, 50 and 75 Nanosecond Recovery Times
- 175°C Operating Junction Temperature
- Low Forward Voltage
- Low Leakage Current
- High Temperature Glass Passivated Junction
- Reverse Voltage to 600 Volts

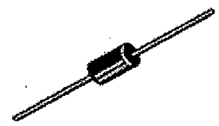
Mechanical Characteristics:

- Case: Epoxy, Molded
- Weight: 1.1 gram (approximately)
- Finish: All External Surfaces Corrosion Resistant and Terminal Leads are Readily Solderable
- Lead and Mounting Surface Temperature for Soldering Purposes: 220°C Max. for 10 Seconds, 1/16" from case
- Shipped in plastic bags, 5,000 per bag
- Available Tape and Reeled, 1500 per reel, by adding a "RL" suffix to the part number
- Polarity: Cathode indicated by Polarity Band
- Marking: U420, U460

MUR420
MUR460

MUR420 and MUR460 are Motorola Preferred Devices

ULTRAFAST RECTIFIERS
4.0 AMPERES
200–600 VOLTS



CASE 267–03
PLASTIC

MAXIMUM RATINGS

Rating	Symbol	MUR 420	MUR 460	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	200	600	Volts
Average Rectified Forward Current (Square Wave) (Mounting Method #3 Per Note 1)	$I_{F(AV)}$	4.0 @ T_A = 80°C	4.0 @ T_A = 40°C	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	125	70	Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	– 65 to +175		°C

THERMAL CHARACTERISTICS

Rating	Symbol	MUR 420	MUR 460	Unit
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	See Note 1		°C/W

ELECTRICAL CHARACTERISTICS

Rating	Symbol	MUR 420	MUR 460	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 3.0 Amps, T_J = 150°C) (i_F = 3.0 Amps, T_J = 25°C) (i_F = 4.0 Amps, T_J = 25°C)	v_F	 0.710 0.875 0.890	 1.05 1.25 1.28	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_J = 150°C) (Rated dc Voltage, T_J = 25°C)	i_R	 150 5.0	 250 10	µA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/µs) (I_F = 0.5 Amp, i_R = 1.0 Amp, I_{REC} = 0.25 Amp)	t_{rr}	 35 25	 75 50	ns
Maximum Forward Recovery Time (I_F = 1.0 A, di/dt = 100 A/µs, Recovery to 1.0 V)	t_{fr}	25	50	ns

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2.0%.

SWITCHMODE is a trademark of Motorola, Inc.
Preferred devices are Motorola recommended choices for future use and best overall value.

Rev 3

MOTOROLA

MUR420

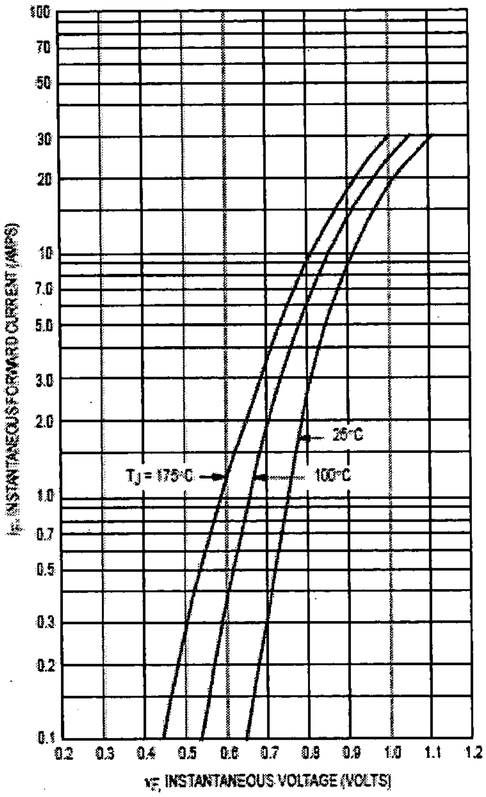


Figure 1. Typical Forward Voltage

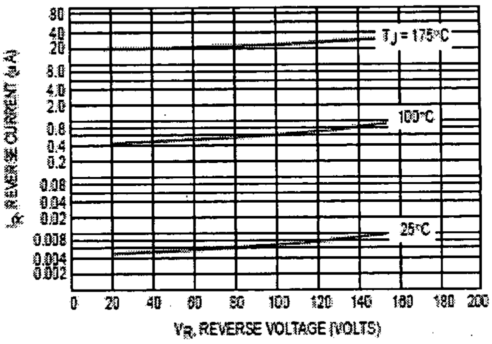


Figure 2. Typical Reverse Current

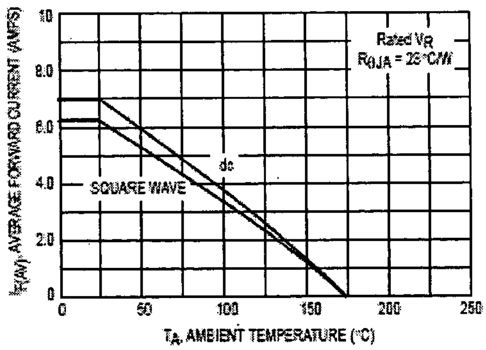


Figure 3. Current Derating
(Mounting Method #3 Per Note 1)

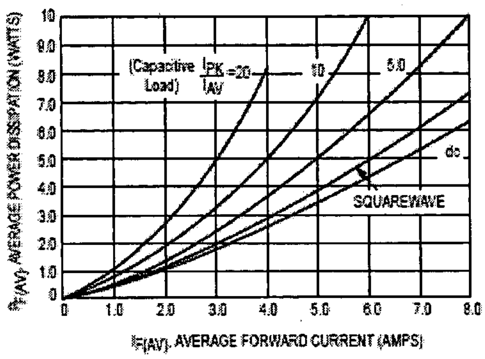


Figure 4. Power Dissipation

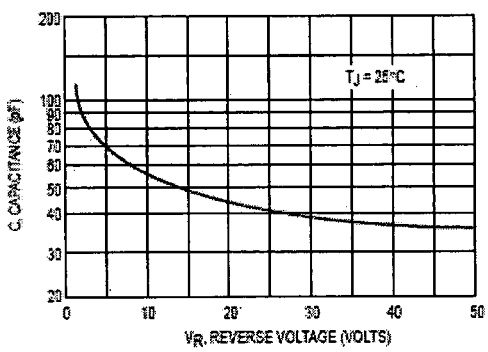


Figure 5. Typical Capacitance

MUR460

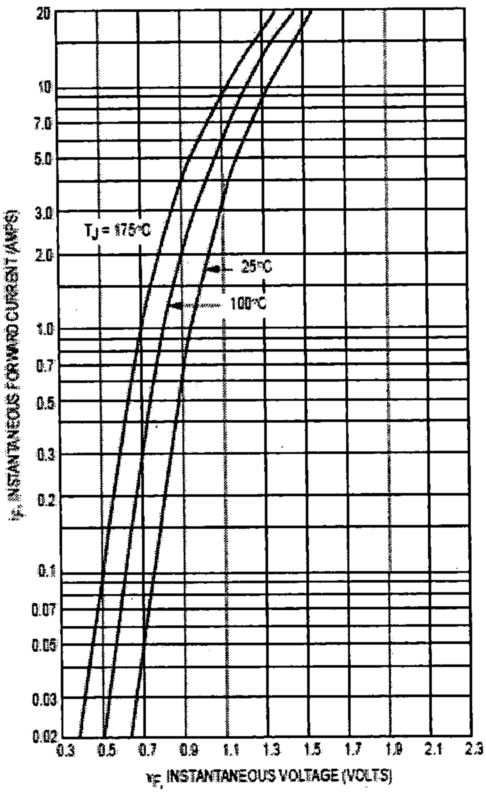


Figure 6. Typical Forward Voltage

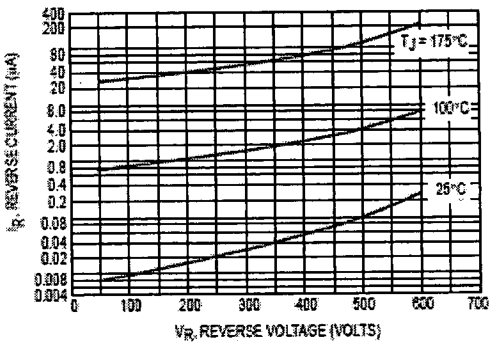


Figure 7. Typical Reverse Current

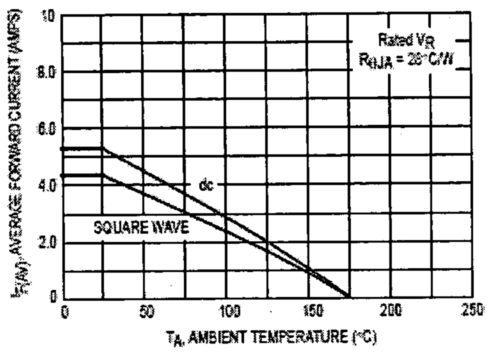


Figure 8. Current Derating (Mounting Method #3 Per Note 1)

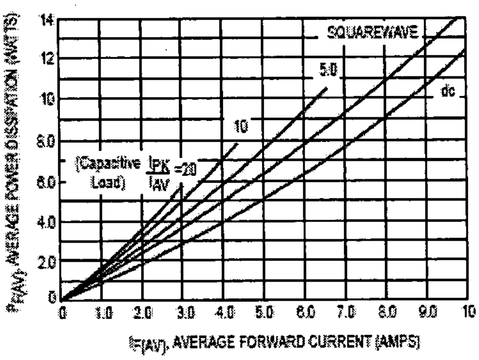


Figure 9. Power Dissipation

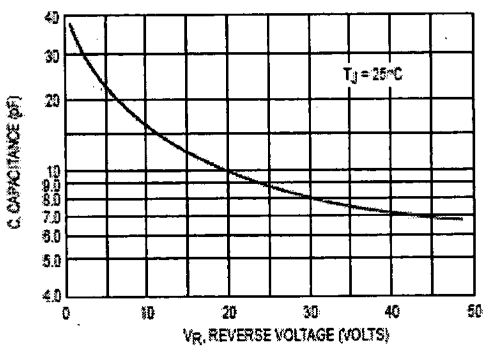


Figure 10. Typical Capacitance

NOTE 1 — AMBIENT MOUNTING DATA

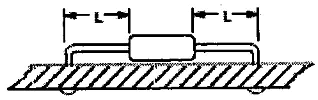
Data shown for thermal resistance junction–to–ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

Mounting Method		Lead Length, L (IN) 1/8	1/4	1/2	3/4	Units
1	$R_{\theta JA}$	50	51	53	55	°C/W
2	$R_{\theta JA}$	58	59	61	63	°C/W
3	$R_{\theta JA}$	28				°C/W

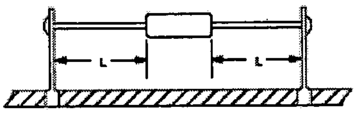
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



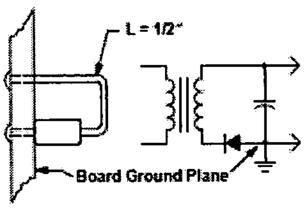
MOUNTING METHOD 2

Vector Push–In Terminals T–28

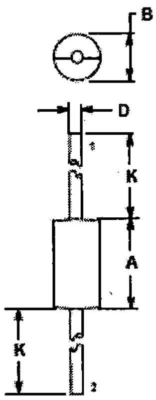


MOUNTING METHOD 3

P.C. Board with 1–1/2" x 1–1/2" Copper Surface



PACKAGE DIMENSIONS



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.370	0.380	9.40	9.65
B	0.190	0.210	4.83	5.33
D	0.048	0.052	1.22	1.32
K	1.000	—	25.40	—

STYLE 1:
PIN 1. CATHODE
2. ANODE

CASE 267–03
ISSUE C

TOSHIBA Photocoupler GaAlAs Ired & Photo−IC

TLP250

Transistor Inverter
Inverter For Air Conditionor
IGBT Gate Drive
Power MOS FET Gate Drive

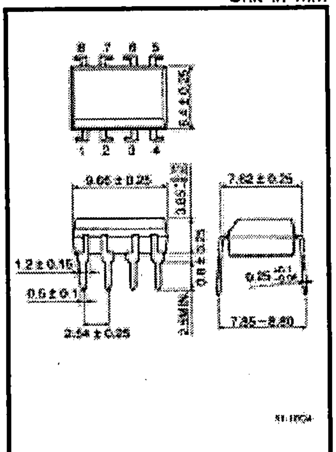
The TOSHIBA TLP250 consists of a GaAlAs light emitting diode and a integrated photodetector.
This unit is 8−lead DIP package.
TLP250 is suitable for gate driving circuit of IGBT or power MOS FET.

- Input threshold current: I_F=5mA(max.)
- Supply current (I_{CC}): 11mA(max.)
- Supply voltage (V_{CC}): 10−35V
- Output current (I_O): ±1.5A (max.)
- Switching time (t_{pLH}/t_{pHL}): 1.5μs(max.)
- Isolation voltage: 2500V_{rms}(min.)
- UL recognized: UL1577, file No.E67349
- Option (D4) type
  VDE approved: DIN VDE0884/06.92.certificate No.76823
  Maximum operating insulation voltage: 630V_{PK}
  Highest permissible over voltage: 4000V_{PK}

(Note) When a VDE0884 approved type is needed, please designate the "option (D4)"

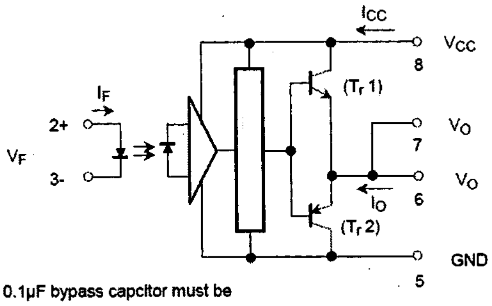
- Creepage distance: 6.4mm(min.)
  Clearance: 6.4mm(min.)

Unit in mm



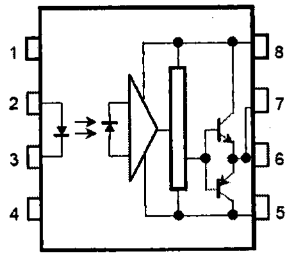
TOSHIBA 11−10C4
Weight: 0.54 g

Schmatic



A 0.1μF bypass capcitor must be connected between pin 8 and 5 (See Note 5).

Pin Configuration (top view)



1 : N.C.
2 : Anode
3 : Cathode
4 : N.C.
5 : GND
6 : V_O (Output)
7 : V_O
8 : V_{CC}

Truth Table

		Tr1	Tr2
Input LED	On	On	Off
	Off	Off	On

Absolute Maximum Ratings (Ta = 25°C)

	Characteristic		Symbol	Rating	Unit
LED	Forward current		I_F	20	mA
	Forward current derating (Ta ≥ 70°C)		$\Delta I_F / \Delta Ta$	−0.36	mA / °C
	Peak transient forward curent (Note 1)		I_{FPT}	1	A
	Reverse voltage		V_R	5	V
	Junction temperature		Tj	125	°C
Detector	"H"peak output current (P_W ≤ 2.5μs,f ≤ 15kHz) (Note 2)		I_{OPH}	−1.5	A
	"L"peak output current (P_W ≤ 2.5μs,f ≤ 15kHz) (Note 2)		I_{OPL}	+1.5	A
	Output voltage	(Ta ≤ 70°C)	V_O	35	V
		(Ta = 85°C)		24	
	Supply voltage	(Ta ≤ 70°C)	V_{CC}	35	V
		(Ta = 85°C)		24	
	Output voltage derating (Ta ≥ 70°C)		$\Delta V_O / \Delta Ta$	−0.73	V / °C
	Supply voltage derating (Ta ≥ 70°C)		$\Delta V_{CC} / \Delta Ta$	−0.73	V / °C
	Junction temperature		Tj	125	°C
Operating frequency (Note 3)			f	25	kHz
Operating temperature range			T_{opr}	−20~85	°C
Storage temperature range			T_{stg}	−55~125	°C
Lead soldering temperature (10 s) (Note 4)			T_{sol}	260	°C
Isolation voltage (AC, 1 min., R.H.≤ 60%) (Note 5)			BV_S	2500	Vrms

Note 1: Pulse width P_W ≤ 1μs, 300pps

Note 2: Exporenential wavefom

Note 3: Exporenential wavefom, I_{OPH} ≤ −1.0A(≤ 2.5μs), I_{OPL} ≤ +1.0A(≤ 2.5μs)

Note 4: It is 2 mm or more from a lead root.

Note 5: Device considerd a two terminal device: Pins 1, 2, 3 and 4 shorted together, and pins 5, 6, 7 and 8 shorted together.

Note 6: A ceramic capacitor(0.1μF) should be connected from pin 8 to pin 5 to stabilize the operation of the high gain linear amplifier. Failure to provide the bypassing may impair the switching proparty. The total lead length between capacitor and coupler should not exceed 1cm.

Recommended Operating Conditions

Characteristic	Symbol	Min.	Typ.	Max.		Unit
Input current, on (Note 7)	$I_{F(ON)}$	7	8	10		mA
Input voltage, off	$V_{F(OFF)}$	0	—	0.8		V
Supply voltage	V_{CC}	15	—	30	20	V
Peak output current	I_{OPH}/I_{OPL}	—	—	±0.5		A
Operating temperature	T_{opr}	−20	25	70	85	°C

Note 7: Input signal rise time (fall time) < 0.5 μs.

Electrical Characteristics (Ta = −20~70°C, unless otherwise specified)

Characteristic		Symbol	Test Circuit	Test Condition		Min.	Typ.*	Max.	Unit
Input forward voltage		V_F	—	I_F = 10 mA, Ta = 25°C			1.6	1.8	V
Temperature coefficient of forward voltage		$\Delta V_F / \Delta Ta$	—	I_F = 10 mA		—	−2.0	—	mV / °C
Input reverse current		I_R	—	V_R = 5V, Ta = 25°C			—	10	μA
Input capacitance		C_T	—	V = 0, f = 1MHz, Ta = 25°C		—	45	250	pF
Output current	"H" level	I_{OPH}	3	V_{CC} = 30V (*1)	I_F = 10 mA, V_{8-6} = 4V	−0.5	−1.5	—	A
	"L" level	I_{OPL}	2		I_F = 0, V_{6-5} = 2.5V	0.5	2	—	
Output voltage	"H" level	V_{OH}	4	V_{CC1} = +15V, V_{EE1} = −15V, R_L = 200Ω, I_F = 5mA		11	12.8	—	V
	"L" level	V_{OL}	5	V_{CC1} = +15V, V_{EE1} = −15V, R_L = 200Ω, V_F = 0.8V		—	−14.2	−12.5	
Supply current	"H" level	I_{CCH}	—	V_{CC} = 30V, I_F = 10mA, Ta = 25°C		—	7	—	mA
				V_{CC} = 30V, I_F = 10mA		—	—	11	
	"L" level	I_{CCL}	—	V_{CC} = 30V, I_F = 0mA, Ta = 25°C		—	7.5	—	
				V_{CC} = 30V, I_F = 0mA		—	—	11	
Threshold input current	"Output L→H"	I_{FLH}	—	V_{CC1} = +15V, V_{EE1} = −15V, R_L = 200Ω, V_O > 0V		—	1.2	5	mA
Threshold input voltage	"Output H→L"	I_{FHL}	—	V_{CC1} = +15V, V_{EE1} = −15V, R_L = 200Ω, V_O < 0V		0.8	—	—	V
Supply voltage		V_{CC}	—			10	—	35	V
Capacitance (input–output)		C_S	—	V_S = 0, f = 1MHz, Ta = 25•		—	1.0	2.0	pF
Resistance(input–output)		R_S	—	V_S = 500V, Ta = 25°C, R.H.≤ 60%		1×10^{12}	10^{14}	—	Ω

* All typical values are at Ta = 25°C (*1): Duration of I_O time ≤ 50μs

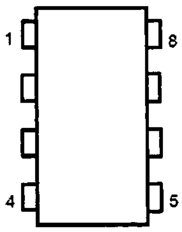
Switching Characteristics (Ta = −20~70°C , unless otherwise specified)

Characteristic		Symbol	Test Circuit	Test Condition	Min.	Typ.*	Max.	Unit
Propagation delay time	L→H	t_{pLH}	6	I_F = 8mA (Note 7) V_{CC1} = +15V, V_{EE1} = −15V R_L = 200Ω	—	0.15	0.5	μs
	H→L	t_{pHL}			—	0.15	0.5	
Output rise time		t_r			—	—	—	
Output fall time		t_f			—	—	—	
Common mode transient immunity at high level output		C_{MH}	7	V_{CM} = 600V, I_F = 8mA V_{CC} = 30V, Ta = 25°C	-5000	—	—	V / μs
Common mode transient immunity at low level output		C_{ML}	7	V_{CM} = 600V, I_F = 0mA V_{CC} = 30V, Ta = 25°C	5000	—	—	V / μs

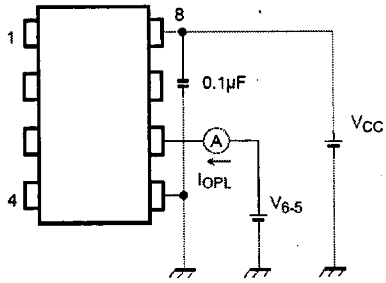
* All typical values are at Ta = 25°C

Note 7: Input signal rise time (fall time) < 0.5 μs.

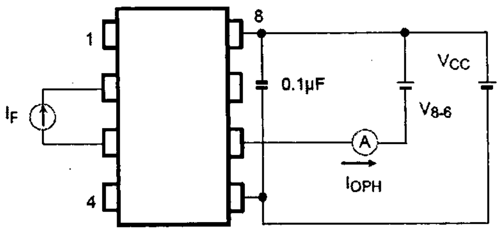
Test Circuit 1 :



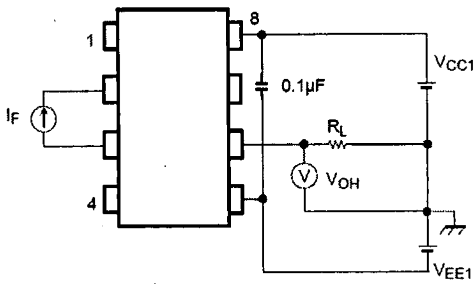
Test Circuit 2 : IOPL



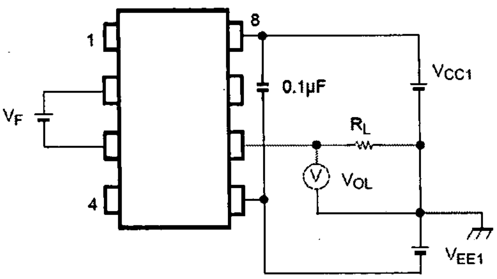
Test Circuit 3 : IOPH



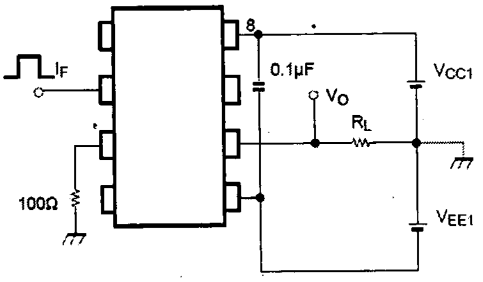
Test Circuit 4 : VOH

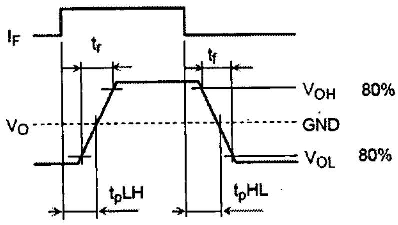


Test Circuit 5 : V_{OL}

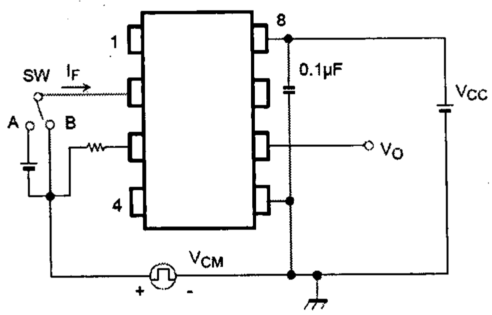


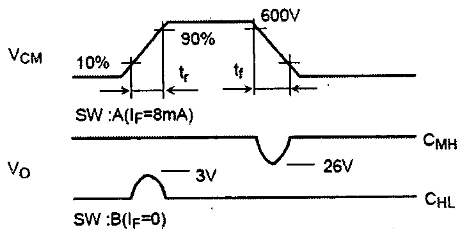
Test Circuit 6: t_{pLH}, t_{pHL}, t_r, t_f





Test Circuit 7: C_{MH}, C_{ML}

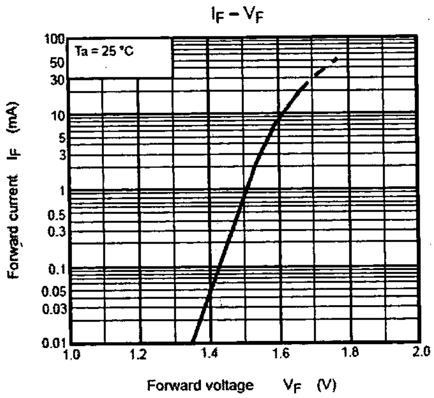


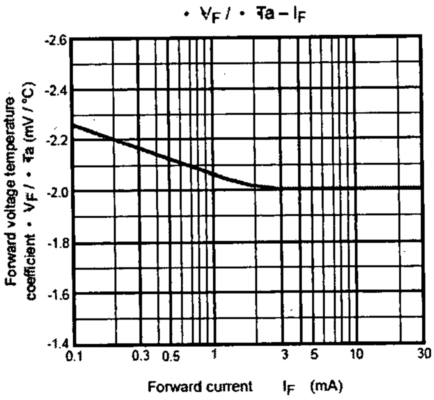


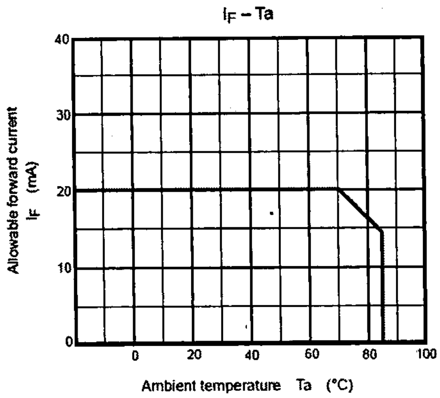
$$C_{ML} = \frac{480\ (V)}{t_r\ (\mu s)}$$

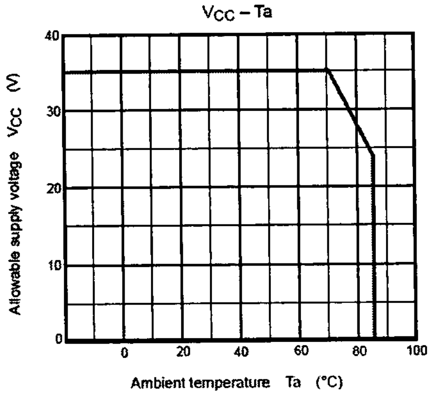
$$C_{MH} = \frac{480\ (V)}{t_f\ (\mu s)}$$

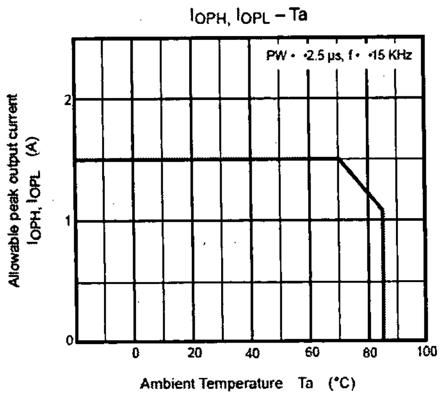
C_{ML}(C_{MH}) is the maximum rate of rise (fall) of the common mode voltage that can be sustained with the output voltage in the low (high) state.


IF – VF
Ta = 25 °C
Forward current IF (mA)
Forward voltage VF (V)
100
50
30
10
5
3
1
0.5
0.3
0.1
0.05
0.03
0.01
1.0
1.2
1.4
1.6
1.8
2.0


∆VF / ∆Ta – IF
Forward voltage temperature coefficient ∆VF / ∆Ta (mV / °C)
Forward current IF (mA)
-2.6
-2.4
-2.2
-2.0
-1.8
-1.6
-1.4
0.1
0.3
0.5
1
3
5
10
30


IF – Ta
Allowable forward current IF (mA)
Ambient temperature Ta (°C)
40
30
20
10
0
0
20
40
60
80
100


VCC – Ta
Allowable supply voltage VCC (V)
Ambient temperature Ta (°C)
40
30
20
10
0
0
20
40
60
80
100


IOPH, IOPL – Ta
PW ≤ 2.5 μs, f ≤ 15 KHz
Allowable peak output current IOPH, IOPL (A)
Ambient Temperature Ta (°C)
2
1
0
0
20
40
60
80
100

MICROCHIP

dsPIC30F2010

28-pin dsPIC30F2010 Enhanced Flash 16-bit Digital Signal Controller

Note: This data sheet summarizes features of this group of dsPIC30F devices and is not intended to be a complete reference source. For more information on the CPU, peripherals, register descriptions and general device functionality, refer to the *dsPIC30F Family Reference Manual* (DS70046). For more information on the device instruction set and programming, refer to the *dsPIC30F Programmer's Reference Manual* (DS70030).

High-Performance Modified RISC CPU:

- Modified Harvard architecture
- C compiler optimized instruction set architecture
- 84 base instructions with flexible addressing modes
- 24-bit wide instructions, 16-bit wide data path
- 12 Kbytes on-chip Flash program space
- 512 bytes on-chip data RAM
- 1 Kbyte non-volatile data EEPROM
- 16 x 16-bit working register array
- Up to 30 MIPs operation:
  - DC to 40 MHz external clock input
  - 4 MHz-10 MHz oscillator input with PLL active (4x, 8x, 16x)
- 27 interrupt sources
- Three external interrupt sources
- 8 user selectable priority levels for each interrupt
- 4 processor exceptions and software traps

DSP Engine Features:

- Modulo and Bit-Reversed modes
- Two, 40-bit wide accumulators with optional saturation logic
- 17-bit x 17-bit single cycle hardware fractional/integer multiplier
- Single cycle Multiply-Accumulate (MAC) operation
- 40-stage Barrel Shifter
- Dual data fetch

Peripheral Features:

- High current sink/source I/O pins: 25 mA/25 mA
- Three 16-bit timers/counters; optionally pair up 16-bit timers into 32-bit timer modules
- Four 16-bit Capture input functions
- Two 16-bit Compare/PWM output functions
  - Dual Compare mode available
- 3-wire SPI™ modules (supports 4 Frame modes)
- I^{2}C™ module supports Multi-Master/Slave mode and 7-bit/10-bit addressing
- Addressable UART modules with FIFO buffers

Motor Control PWM Module Features:

- 6 PWM output channels
  - Complementary or Independent Output modes
  - Edge and Center Aligned modes
- 4 duty cycle generators
- Dedicated time base with 4 modes
- Programmable output polarity
- Dead time control for Complementary mode
- Manual output control
- Trigger for synchronized A/D conversions

Quadrature Encoder Interface Module Features:

- Phase A, Phase B and Index Pulse input
- 16-bit up/down position counter
- Count direction status
- Position Measurement (x2 and x4) mode
- Programmable digital noise filters on inputs
- Alternate 16-bit Timer/Counter mode
- Interrupt on position counter rollover/underflow

Analog Features:

- 10-bit Analog-to-Digital Converter (A/D) with:
  - 500 Ksps (for 10-bit A/D) conversion rate
  - Six input channels
  - Conversion available during Sleep and Idle
- Programmable Brown-out Detection and Reset generation

dsPIC30F2010

Special Microcontroller Features:

- Enhanced Flash program memory:
  - 10,000 erase/write cycle (min.) for industrial temperature range, 100K (typical)
- Data EEPROM memory:
  - 100,000 erase/write cycle (min.) for industrial temperature range, 1M (typical)
- Self-reprogrammable under software control
- Power-on Reset (POR), Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Flexible Watchdog Timer (WDT) with on-chip low power RC oscillator for reliable operation
- Fail-Safe clock monitor operation
- Detects clock failure and switches to on-chip low power RC oscillator
- Programmable code protection
- In-Circuit Serial Programming™ (ICSP™)
- Selectable Power Management modes
  - Sleep, Idle and Alternate Clock modes

CMOS Technology:

- Low power, high speed Flash technology
- Wide operating voltage range (2.5V to 5.5V)
- Industrial and Extended temperature ranges
- Low power consumption

dsPIC30F Motor Control and Power Conversion Family*

Device	Pins	Program Mem. Bytes/ Instructions	SRAM Bytes	EEPROM Bytes	Timer 16-bit	Input Cap	Output Comp/Std PWM	Motor Control PWM	A/D 10-bit 500 Ksps	Quad Enc	UART	SPI™	I²C™	CAN
dsPIC30F2010	28	12K/4K	512	1024	3	4	2	6 ch	6 ch	Yes	1	1	1	–
dsPIC30F3010	28	24K/8K	1024	1024	5	4	2	6 ch	6 ch	Yes	1	1	1	–
dsPIC30F4012	28	48K/16K	2048	1024	5	4	2	6 ch	6 ch	Yes	1	1	1	1
dsPIC30F3011	40/44	24K/8K	1024	1024	5	4	4	6 ch	9 ch	Yes	2	1	1	–
dsPIC30F4011	40/44	48K/16K	2048	1024	5	4	4	6 ch	9 ch	Yes	2	1	1	1
dsPIC30F5015	64	66K/22K	2048	1024	5	4	4	8 ch	16 ch	Yes	1	2	1	1
dsPIC30F6010	80	144K/48K	8192	4096	5	8	8	8 ch	16 ch	Yes	2	2	1	2

* This table provides a summary of the dsPIC30F2010 peripheral features. Other available devices in the dsPIC30F Motor Control and Power Conversion Family are shown for feature comparison.

Pin Diagrams

28-Pin SDIP and SOIC

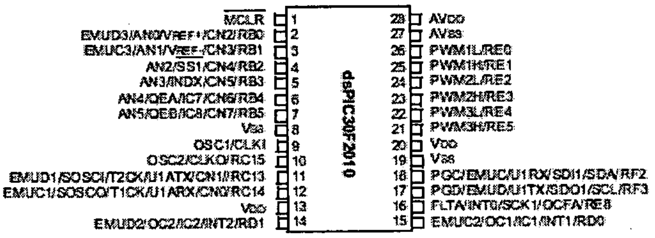


FIGURE 1-1: dsPIC30F2010 BLOCK DIAGRAM

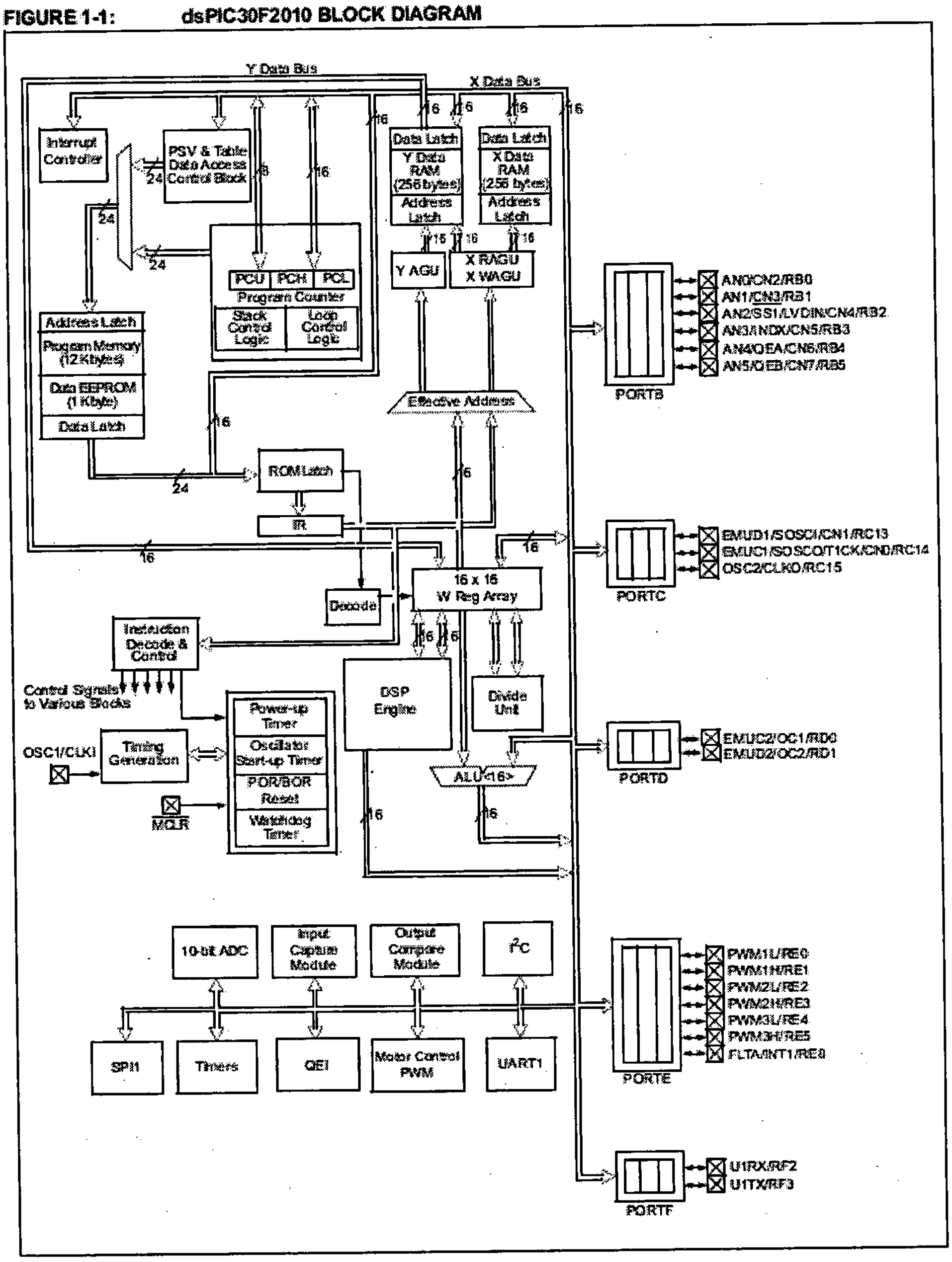


Table 1-1 provides a brief description of device I/O pinouts and the functions that may be multiplexed to a port pin. Multiple functions may exist on one port pin. When multiplexing occurs, the peripheral module's functional requirements may force an override of the data direction of the port pin.

TABLE 1-1: PINOUT I/O DESCRIPTIONS

Pin Name	Pin Type	Buffer Type	Description
AN0-AN5	I	Analog	Analog input channels.
AVDD	P	P	Positive supply for analog module.
AVSS	P	P	Ground reference for analog module.
CLKI CLKO	I O	ST/CMOS —	External clock source input. Always associated with OSC1 pin function. Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. Optionally functions as CLKO in RC and EC modes. Always associated with OSC2 pin function.
CN0-CN7	I	ST	Input change notification inputs. Can be software programmed for internal weak pull-ups on all inputs.
EMUD EMUC EMUD1 EMUC1 EMUD2 EMUC2 EMUD3 EMUC3	I/O I/O I/O I/O I/O I/O I/O I/O	ST ST ST ST ST ST ST ST	ICD Primary Communication Channel data input/output pin. ICD Primary Communication Channel clock input/output pin. ICD Secondary Communication Channel data input/output pin. ICD Secondary Communication Channel clock input/output pin. ICD Tertiary Communication Channel data input/output pin. ICD Tertiary Communication Channel clock input/output pin. ICD Quaternary Communication Channel data input/output pin. ICD Quaternary Communication Channel clock input/output pin.
IC1, IC2, IC7, IC8	I	ST	Capture inputs. The dsPIC30F2010 has 4 capture inputs. The inputs are numbered for consistency with the inputs on larger device variants.
INDX QEA QEB	I I I	ST ST ST	Quadrature Encoder Index Pulse input. Quadrature Encoder Phase A input in QEI mode. Auxiliary Timer External Clock/Gate input in Timer mode. Quadrature Encoder Phase A input in QEI mode. Auxiliary Timer External Clock/Gate input in Timer mode.
INT0 INT1 INT2	I I I	ST ST ST	External interrupt 0 External interrupt 1 External interrupt 2
FLTA PWM1L PWM1H PWM2L PWM2H PWM3L PWM3H	I O O O O O O	ST — — — — — —	PWM Fault A input PWM 1 Low output PWM 1 High output PWM 2 Low output PWM 2 High output PWM 3 Low output PWM 3 High output
MCLR	I/P	ST	Master Clear (Reset) input or programming voltage input. This pin is an active low Reset to the device.
OCFA OC1-OC2	I O	ST —	Compare Fault A input (for Compare channels 1, 2, 3 and 4). Compare outputs.
OSC1 OSC2	I I/O	ST/CMOS —	Oscillator crystal input. ST buffer when configured in RC mode; CMOS otherwise. Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. Optionally functions as CLKO in RC and EC modes.

Legend: CMOS =CMOS compatible input or output Analog= Analog input
ST =Schmitt Trigger input with CMOS levels O= Output
I =Input P = Power

TABLE 1-1: PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Type	Buffer Type	Description
PGD PGC	I/O I	ST ST	In-Circuit Serial Programming data input/output pin. In-Circuit Serial Programming clock input pin.
RB0-RB5	I/O	ST	PORTB is a bidirectional I/O port.
RC13-RC14	I/O	ST	PORTC is a bidirectional I/O port.
RD0-RD1	I/O	ST	PORTD is a bidirectional I/O port.
RE0-RE5, RE8	I/O	ST	PORTE is a bidirectional I/O port.
RF2, RF3	I/O	ST	PORTF is a bidirectional I/O port.
SCK1 SDI1 SDO1 SS1	I/O I O I	ST ST — ST	Synchronous serial clock input/output for SPI™ #1. SPI #1 Data In. SPI #1 Data Out. SPI #1 Slave Synchronization.
SCL SDA	I/O I/O	ST ST	Synchronous serial clock input/output for I^2C. Synchronous serial data input/output for I^2C.
SOSCO SOSCI	O I	— ST/CMOS	32 kHz low power oscillator crystal output. 32 kHz low power oscillator crystal input. ST buffer when configured in RC mode; CMOS otherwise.
T1CK T2CK	I I	ST ST	Timer1 external clock input. Timer2 external clock input.
U1RX U1TX U1ARX U1ATX	I O I O	ST — ST —	UART1 Receive. UART1 Transmit. UART1 Alternate Receive. UART1 Alternate Transmit.
V_{DD}	P	—	Positive supply for logic and I/O pins.
V_{SS}	P	—	Ground reference for logic and I/O pins.
V_{REF+}	I	Analog	Analog Voltage Reference (High) input.
V_{REF-}	I	Analog	Analog Voltage Reference (Low) input.

Legend: CMOS =CMOS compatible input or output Analog= Analog input
ST =Schmitt Trigger input with CMOS levels O= Output
I =Input P = Power

ภาคผนวก ข.

โปรแกรมสร้างสัญญาณควบคุมด้วยภาษาซี

โปรแกรมสำหรับ "Single Phase Full Wave Rectifier"

```
#include <30F2010.h>
#device adc=10
#FUSES NOWDT            //No Watch Dog Timer
#FUSES HS               //High speed Osc (> 4mhz for PCM/PCH) (>10mhz for PCD)
#FUSES PR               //Primary Oscillator
#FUSES NOCKSFSM         //Clock Switching is disabled, fail Safe clock monitor is disabled
#FUSES WPSB16           //Watch Dog Timer PreScalar B 1:16
#FUSES WPSA512          //Watch Dog Timer PreScalar A 1:512
#FUSES PUT64            //Power On Reset Timer value 64ms
#FUSES NOBROWNOUT       //No brownout reset
#FUSES BORV47           //Brownout reset at 4.7V
#FUSES LPOL_HIGH        //Low-Side Transistors Polarity is Active-High (PWM 0,2,4 and 6)
                        //PWM module low side output pins have active high output polar
#FUSES HPOL_HIGH        //High-Side Transistors Polarity is Active-High (PWM 1,3,5 and 7)
                        //PWM module high side output pins have active high output polarity
#FUSES NOPWMPIN         //PWM outputs drive active state upon Reset
#FUSES MCLR             //Master Clear pin enabled
#FUSES NOPROTECT        //Code not protected from reading
#FUSES NOWRT            //Program memory not write protected
#FUSES NODEBUG          //No Debug mode for ICD
#FUSES NOCOE            //Device will reset into operational mode
#FUSES ICSP1            //ICD uses PGC1/PGD1 pins
#FUSES RESERVED         //Used to set the reserved FUSE bits
#use delay(clock=20000000)
```

```
int1 flg_ext0;
int1 flg_ext1;
int16 trig;
int32 trig_1;
#int_EXT0
void EXT0_isr(void)
{flg_ext0=1;}
#int_EXT1
void EXT1_isr(void)
{flg_ext1=1;}
#use rs232(UART1,baud=9600,parity=N,bits=8)
void ain()
{setup_spi(SPI_SS_DISABLED);
  setup_wdt(WDT_ON);
  setup_timer1(TMR_DISABLED|TMR_DIV_BY_1);
   SETUP_ADC_PORTS(sAN0|VSS_VDD );
   SETUP_ADC(ADC_CLOCK_INTERNAL);
  enable_interrupts(INT_EXT0);
  enable_interrupts(INT_EXT1);
  enable_interrupts(INTR_GLOBAL);
  ext_int_edge( 0, L_TO_H);
  ext_int_edge( 1, H_TO_L);
  // TODO: USER CODE!!
    FLG_EXT0=FLG_EXT1=0;
  while(true)
  {
   set_adc_channel(0);
```

```
trig_1 = read_adc();
trig_1*=10000;
trig_1/=1024;
trig=trig_1;
if(flg_ext0)
{
 flg_ext0=0;
 delay_us(trig);
 output_high(pin_e0);
 output_high(pin_e1);
 while(input(pin_e8));
 output_low(pin_e0);
 output_low(pin_e1);
}
if(flg_ext1)
{
 flg_ext1=0;
 delay_us(trig);
 output_high(pin_e2);
 output_high(pin_e3);
 while(!input(pin_d0));
 output_low(pin_e2);
 output_low(pin_e3);
}
}
}
```

โปรแกรมสำหรับ " DC Converter"

```
#include <30F2010.h>
#FUSES NOWDT              //No Watch Dog Timer
#FUSES HS                 //High speed Osc (> 4mhz for PCM/PCH) (>10mhz for PCD)
#FUSES PR                 //Primary Oscillator
#FUSES NOCKSFSM           //Clock Switching is disabled, fail Safe clock monitor is disabled
#FUSES WPSB16             //Watch Dog Timer PreScalar B 1:16
#FUSES WPSA512            //Watch Dog Timer PreScalar A 1:512
#FUSES PUT64              //Power On Reset Timer value 64ms
#FUSES NOBROWNOUT         //No brownout reset
#FUSES BORV47             //Brownout reset at 4.7V
#FUSES LPOL_HIGH          //Low-Side Transistors Polarity is Active-High (PWM 0,2,4 and 6)
                          //PWM module low side output pins have active high output polar
#FUSES HPOL_HIGH          //High-Side Transistors Polarity is Active-High (PWM 1,3,5 and 7)
                          //PWM module high side output pins have active high output polarity
#FUSES NOPWMPIN           //PWM outputs drive active state upon Reset
#FUSES MCLR               //Master Clear pin enabled
#FUSES NOPROTECT          //Code not protected from reading
#FUSES NOWRT              //Program memory not write protected
#FUSES NODEBUG            //No Debug mode for ICD
#FUSES NOCOE              //Device will reset into operational mode
//#FUSES ICS0             //ICD communication channel 0
#FUSES RESERVED           //Used to set the reserved FUSE bits
#use delay(clock=20000000)    //The cycle time will be (1/clock)*PRx prescale*(period+1)
#use rs232(UART1,baud=9600,parity=N,bits=8)
```

```
void main()
            {  setup_compare(2,COMPARE_PWM | COMPARE_TIMER2 );
    setup_timer2(TMR_INTERNAL | TMR_DIV_BY_8,500 );
    // duty cycle 100 % at 500
     setup_spi(SPI_SS_DISABLED);
     setup_wdt(WDT_OFF);
    setup_timer1(TMR_DISABLED|TMR_DIV_BY_1);
    set_pwm_duty(2,100);// pwm output on pin rd1 (pin number 14)
     // TODO: USER CODE!!
 while(true)  {  }
```

โปรแกรมสำหรับ "Three Phase 180° Conduction FFM Inverter"

```
#include <30f2010.h>
#Fuses hs,noWDT
#Fuses BORV27
#fuses PUT64
#fuses BROWNOUT
#FUSES MCLR
#use delay(clock=20000000)
#use rs232(baud=9600, xmit=PIN_f2,rcv=PIN_f3)
//#FUSES HPOL_low //High.Side Transistors Polarity is Active.High (PWM 1,3,5
and 7)
//#FUSES LPOL_low //Low.Side Transistors Polarity is Active.Low (PWM 0,2,4
and 6)
int16 PTCON;
#locate PTCON = 0x1C0
#bit PTEN    = PTCON.15
#bit PTSIDL  = PTCON.13
#bit PTOPS3 = PTCON.7
#bit PTOPS2 = PTCON.6
#bit PTOPS1 = PTCON.5
#bit PTOPS0 = PTCON.4
#bit PTCKPS1 = PTCON.3
#bit PTCKPS0 = PTCON.2
```

```
#BIT PTMOD1  =PTCON.1

#BIT PTMOD0  =PTCON.0


INT16 PTMR;

#LOCATE  PTMR = 0X1C2

INT16 PTPER;

#LOCATE PTPER = 0X1C4

INT16 SEVTCPP;

#LOCATE SEVTCPP = 0X1C6

INT16 PWMCON1;

#locate PWMCON1 = 0x1c8

#bit PMOD3 = PWMCON1.10

#bit PMOD2 = PWMCON1.9

#bit PMOD1 = PWMCON1.8

#bit PEN3H = PWMCON1.6

#bit PEN2H = PWMCON1.5

#bit PEN1H = PWMCON1.4

#bit PEN3L = PWMCON1.2

#bit PEN2L = PWMCON1.1

#bit PEN1L = PWMCON1.0

INT16 PWMCON2;

#locate PWMCON2 = 0x1ca

#bit SEVOPS3 = PWMCON2.11

#bit SEVOPS2 = PWMCON2.10
```

```
#bit SEVOPS1 = PWMCON2.9

#bit SEVOPS0 = PWMCON2.8

#bit OSYNC   = PWMCON2.1

#bit UDIS    = PWMCON2.0


INT16 DTCON1;

#LOCATE DTCON1 = 0X1CC

#BIT DTAPS1 = DTCON1.7

#BIT DTAPS0 = DTCON1.6

#BIT DTIME5 = DTCON1.5

#BIT DTIME4 = DTCON1.4

#BIT DTIME3 = DTCON1.3

#BIT DTIME2 = DTCON1.2

#BIT DTIME1 = DTCON1.1

#BIT DTIME0 = DTCON1.0

int16 ifs2;
```

```
#BIT  FAOV1H  = FLTACON.9
#BIT  FAOV1L  = FLTACON.8
#BIT  FLTAM   = FLTACON.7
#BIT  FAEN3   = FLTACON.2
#BIT  FAEN2   = FLTACON.1
#BIT  FAEN1   = FLTACON.0
INT16 OVDCON;
#LOCATE OVDCON = 0X1D4
#BIT  POVD3H = OVDCON.13
#BIT  POVD3L = OVDCON.12
#BIT  POVD2H = OVDCON.11
#BIT  POVD2L = OVDCON.10
#BIT  POVD1H = OVDCON.9
#BIT  POVD1L = OVDCON.8
#BIT  POUT4H = OVDCON.7
#BIT  POUT3H = OVDCON.5
#BIT  POUT3L = OVDCON.4
#BIT  POUT2H = OVDCON.3
#BIT  POUT2L = OVDCON.2
#BIT  POUT1H = OVDCON.1
#BIT  POUT1L = OVDCON.0
INT16 PDC1;
#LOCATE PDC1 = 0X1D6
INT16 PDC2;
```

```
#LOCATE PDC2 = 0X1D8

INT16 PDC3;

#LOCATE PDC3 = 0X1DA

void main(void)

{

 ptper=0x01ff;

 ptmr=0x00ff;

 //PMOD3(PWM3 MODE) PMDO2(PWM2MODE) AND

PMOD1(PWM1MODE) FOR SELECT COMPLEMENTARY OR Independent

mode

 PMOD3=1;//PWM3

 PMOD2=1;//PWM2

 PMOD1=1;// PWM1

 pten=1;    // ENABLE INPUT CLOCK FOR PWM

 PTSIDL=0;

 //PTMOD0 AND PTMOD1 FOR SELECT MODE PWM

 ptmod0=0;   // 00 Free Running mode

 ptmod1=1;   // 01  Single-shot mode

            // 10  Continuous Up/Down Counting mode.

            // 11   Continuous Up/Down mode with interrupts for double PWM

 //PTCKPS0 AND PTCKPS1 BIT FOR PTMR PRESCALE

 ptckps0=1;  // 00 (1:1 prescale)

 ptckps1=0;  // 01 (1:4 prescale)

            // 10 (1:16 prescale)
```

```
        // 11 (1:64 prescale)
//PENxh PENxl for enable pwmoutput
pen3h=1;
pen2h=1;
pen1h=1;
pen3l=1;
pen2l=1;
pen1l=1;
pdc1=0x120;
pdc2=0x120;
pdc3=0x120;
 OSYNC=1;UDIS=0;
 POVD1H =1;
 POVD1L =1;
 POVD2H =1;
 POVD2L =1;
 POVD3H =1;
 povd3l =0;
 Pout3L =1;
while(true)
{
  OVDCON = 0x001a;
  delay_ms(3333);
  OVDCON = 0x0019;
```

```
delay_ms(3333);
OVDCON = 0x0029;
delay_ms(3333);
OVDCON = 0x0025;
delay_ms(3333);
OVDCON = 0x0026;
delay_ms(3333);
OVDCON = 0x0016;
delay_ms(3333);
}}
```

STEP 1

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**1**	**1**	**0**	**1**	**0**

OVDCON = 0X0006

STEP 2

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**1**	**1**	**0**	**0**	**1**

OVDCON = 0X0012

STEP 3

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**1**	**0**	**1**	**0**	**0**	**1**

OVDCON = 0X0018

STEP 4

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**1**	**0**	**0**	**1**	**0**	**1**

OVDCON = 0X0009

STEP 5

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**1**	**0**	**0**	**1**	**1**	**0**

STEP 6

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**1**	**0**	**1**	**1**	**0**

โปรแกรมสำหรับ "Three Phase 120° Conduction FFM Inverter"

```
#include <30f2010.h>
#Fuses  hs,noWDT
#Fuses  BORV27
#fuses  PUT64
#fuses BROWNOUT
#FUSES MCLR
#use delay(clock=20000000)
#use rs232(baud=9600, xmit=PIN_f2,rcv=PIN_f3)
//#FUSES HPOL_low //High.Side Transistors Polarity is Active.High (PWM 1,3,5 1and 7)
//#FUSES LPOL_low //Low.Side Transistors Polarity is Active.Low (PWM 0,2,4 and 6)
int16 PTCON;
#locate PTCON = 0x1C0
#bit PTEN     = PTCON.15
#bit PTSIDL   = PTCON.13
#bit PTOPS3 = PTCON.7
#bit PTOPS2 = PTCON.6
#bit PTOPS1 = PTCON.5
#bit PTOPS0 = PTCON.4
#bit PTCKPS1 = PTCON.3
#bit PTCKPS0 = PTCON.2
#BIT PTMOD1  =PTCON.1
#BIT PTMOD0  =PTCON.0

   INT16 PTMR;
```

```
#LOCATE  PTMR = 0X1C2
INT16 PTPER;
#LOCATE PTPER = 0X1C4
INT16 SEVTCPP;
#LOCATE SEVTCPP = 0X1C6
INT16 PWMCON1;
#locate PWMCON1 = 0x1c8
#bit PMOD3 = PWMCON1.10
#bit PMOD2 = PWMCON1.9
#bit PMOD1 = PWMCON1.8
#bit PEN3H = PWMCON1.6
#bit PEN2H = PWMCON1.5
#bit PEN1H = PWMCON1.4
#bit PEN3L = PWMCON1.2
#bit PEN2L = PWMCON1.1
#bit PEN1L = PWMCON1.0
INT16 PWMCON2;
#locate PWMCON2 = 0x1ca
#bit SEVOPS3 = PWMCON2.11
#bit SEVOPS2 = PWMCON2.10
#bit SEVOPS1 = PWMCON2.9
#bit SEVOPS0 = PWMCON2.8
#bit OSYNC   = PWMCON2.1
#bit UDIS    = PWMCON2.0
INT16 DTCON1;
#LOCATE DTCON1 = 0X1CC
#BIT DTAPS1 = DTCON1.7
```

```
#BIT DTAPS0 = DTCON1.6
#BIT DTIME5 = DTCON1.5
#BIT DTIME4 = DTCON1.4
#BIT DTIME3 = DTCON1.3
#BIT DTIME2 = DTCON1.2
#BIT DTIME1 = DTCON1.1
#BIT DTIME0 = DTCON1.0
int16 ifs2;
#locate ifs2=0x088
#bit   fltaif = ifs2.11
INT16 FLTACON;
#LOCATE FLTACON = 0X1D0
#BIT   FAOV3H  = FLTACON.13
#BIT   FAOV3L  = FLTACON.12
#BIT   FAOV2H  = FLTACON.11
#BIT   FAOV2L  = FLTACON.10
#BIT   FAOV1H  = FLTACON.9
#BIT   FAOV1L  = FLTACON.8
#BIT   FLTAM   = FLTACON.7
#BIT   FAEN3   = FLTACON.2
#BIT   FAEN2   = FLTACON.1
#BIT   FAEN1   = FLTACON.0
INT16 OVDCON;
#LOCATE OVDCON  =  0X1D4
#BIT   POVD3H  =  OVDCON.13
#BIT   POVD3L  =  OVDCON.12
#BIT   POVD2H  =  OVDCON.11
```

```
#BIT   POVD2L  =  OVDCON.10

#BIT   POVD1H  =  OVDCON.9

#BIT   POVD1L  =  OVDCON.8

#BIT   POUT4H  =  OVDCON.7

#BIT   POUT3H  = OVDCON.5

#BIT   POUT3L  = OVDCON.4

#BIT   POUT2H  = OVDCON.3

#BIT   POUT2L  = OVDCON.2

#BIT   POUT1H  = OVDCON.1

#BIT   POUT1L  = OVDCON.0

INT16 PDC1;

#LOCATE PDC1 = 0X1D6

INT16 PDC2;

#LOCATE PDC2 = 0X1D8

INT16 PDC3;

#LOCATE PDC3 = 0X1DA

void main(void)

{  ptper=0x01ff;

 ptmr=0x00ff;

 //PMOD3(PWM3 MODE) PMDO2(PWM2MODE) AND PMOD1(PWM1MODE) FOR
SELECT COMPLEMENTARY OR Independent mode

 PMOD3=1;//PWM3

 PMOD2=1;//PWM2

 PMOD1=1;// PWM1

 pten=1;     // ENABLE INPUT CLOCK FOR PWM

 PTSIDL=0;  //===========PTMOD0 AND PTMOD1 FOR SELECT MODE PWM

 ptmod0=0;   // 00 Free Running mode
```

```
ptmod1=1;  // 01  Single-shot mode
 // 10  Continuous Up/Down Counting mode.
// 11   Continuous Up/Down mode with interrupts for double PWM
 //============PTCKPS0 AND PTCKPS1 BIT FOR PTMR PRESCALE
 ptckps0=1;  // 00 (1:1 prescale)
ptckps1=0;  // 01 (1:4 prescale)
// 10 (1:16 prescale)
 // 11 (1:64 prescale)
 //============PENxh PENxl for enable pwmoutput===============
 pen3h=1;  //
 pen2h=1;  //
 pen1h=1;  //
 pen3l=1;  //
 pen2l=1;  //
 pen1l=1;  //
//========================================
pdc1=0x120; //
 pdc2=0x120; //
 pdc3=0x120; /
//======================
 OSYNC=1;UDIS=0;
  POVD1H =1;
  POVD1L =1;
  POVD2H =1;
  POVD2L =1;
  POVD3H =1;
  povd3l =0;
```

```
Pout3L =1;
//=======================
while(true)
{    OVDCON = 0x0006;
delay_ms(3333);
OVDCON = 0x0012;
delay_ms(3333);
OVDCON = 0x0018;
delay_ms(3333);
OVDCON = 0x0009;
delay_ms(3333);
OVDCON = 0x0021;
delay_ms(3333);
OVDCON = 0x0024;
delay_ms(3333);
}
}
```

STEP 1

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**0**	**0**	**1**	**1**	**0**

OVDCON = 0X0006

STEP 2

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**1**	**0**	**0**	**1**	**0**

OVDCON = 0X0012

STEP 3

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
			[illegible]	[illegible]			

STEP 4

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**0**	**0**	**1**	**0**	**0**	**1**

OVDCON = 0X0009

STEP 5

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**1**	**0**	**0**	**0**	**0**	**1**

OVDCON = 0X0021

STEP 6

POVD4H	POVD4L	POVD3H	POVD3L	POVD2H	POVD2L	POVD1H	POVD1L
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**

POUT4H	POUT4L	POUT3H	POUT3L	POUT2H	POUT2L	POUT1H	POUT1L
0	**0**	**1**	**0**	**0**	**1**	**0**	**0**

OVDCON = 0X0024