R2J20654NP

Integrated Driver - MOS FET (DrMOS)

R07DS0246EJ0100
Rev.1.00
Jan 25, 2011

Description

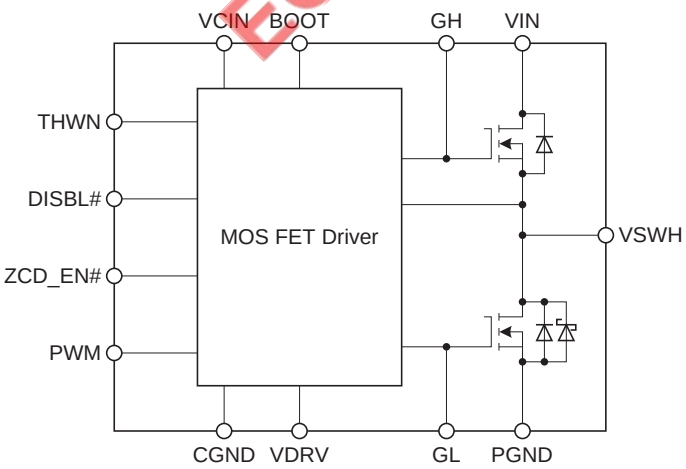
The R2J20654NP multi-chip module incorporates a high-side MOS FET, low-side MOS FET, and MOS-FET driver in a single QFN package. The on and off timing of the power MOS FET is optimized by the built-in driver, making this device suitable for large-current buck converters. The chip also incorporates a high-side bootstrap switch, eliminating the need for an external SBD for this purpose.

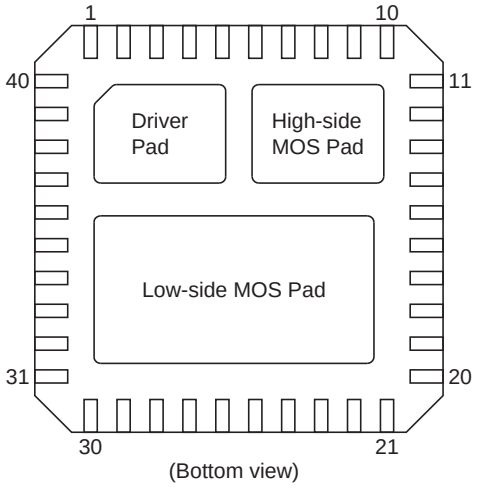
Features

- Compliant with Intel 6 × 6 DrMOS Specification.
- Built-in power MOS FET suitable for Desktop, Server application.
- Low-side MOS FET with built-in SBD for lower loss and reduced ringing.
- Built-in driver circuit which matches the power MOS FET
- Built-in tri-state input function which can support a number of PWM controllers
- High-frequency operation (above 1 MHz) possible
- VIN operating-voltage range: 20 Vmax
- Large average output current (Max.40 A)
- Achieve low power dissipation
- Controllable driver: Remote on/off
- Zero current detection for a diode emulation operation
- Double thermal protection: Thermal Warning & Thermal Shutdown
- Built-in bootstrapping Switch
- Small package: QFN40 (6 mm × 6 mm × 0.95 mm)
- Terminal Pb-free/Halogen-free

Outline

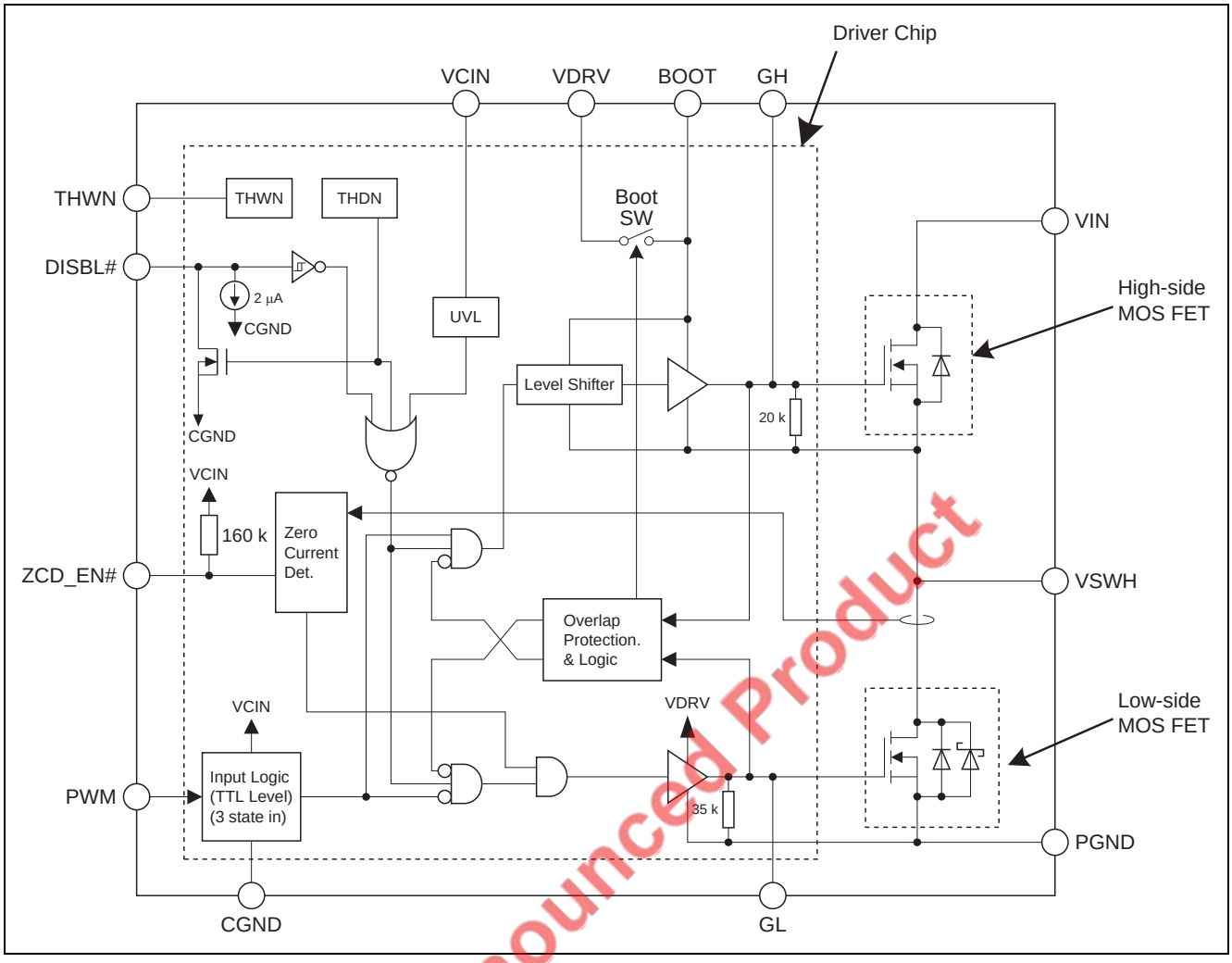
Integrated Driver-MOS FET (DrMOS)
QFN40 package 6 mm × 6 mm





(Bottom view)

Block Diagram



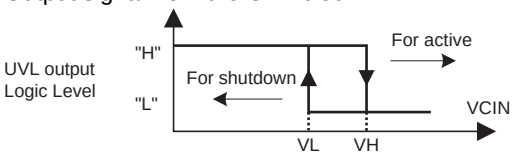
Notes: 1. Truth table for the DISBL# pin

DISBL# Input	Driver Chip Status
"L"	Shutdown (GL, GH = "L")
"Open"	Shutdown (GL, GH = "L")
"H"	Enable (GL, GH = "Active")

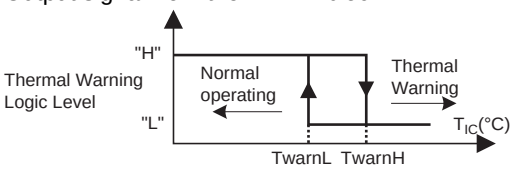
2. Truth table for the ZCD_EN# pin

ZCD_EN# Input	GL Status
"L"	"Diode Emulation Mode"
"Open"	"Continuous Conduction Mode"
"H"	"Continuous Conduction Mode"

3. Output signal from the UVL block



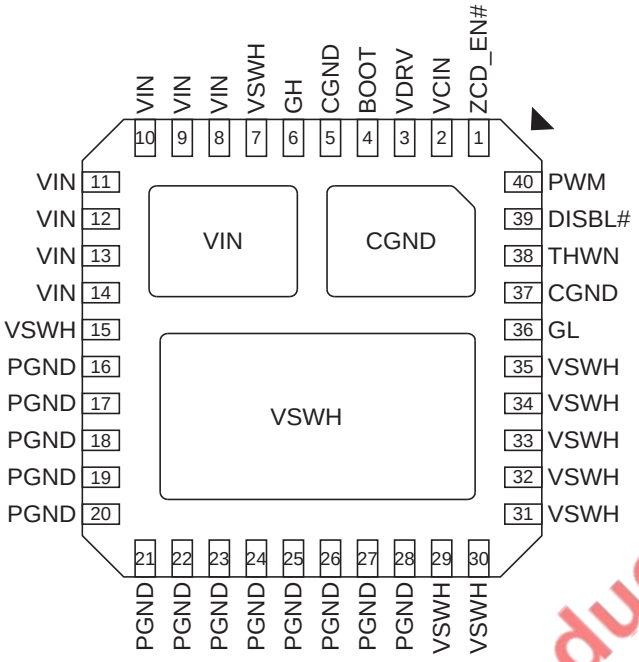
4. Output signal from the THWN block



5. Truth table for the THDN block

Driver IC Temp.	Driver Chip Status
< 150°C	Enable (GL, GH = "Active")
> 150°C	Shutdown (GL, GH = "L") (latch-off)

Pin Arrangement



(Top view)

Note: All die-pads (three pads in total) should be soldered to PCB.

Pin Description

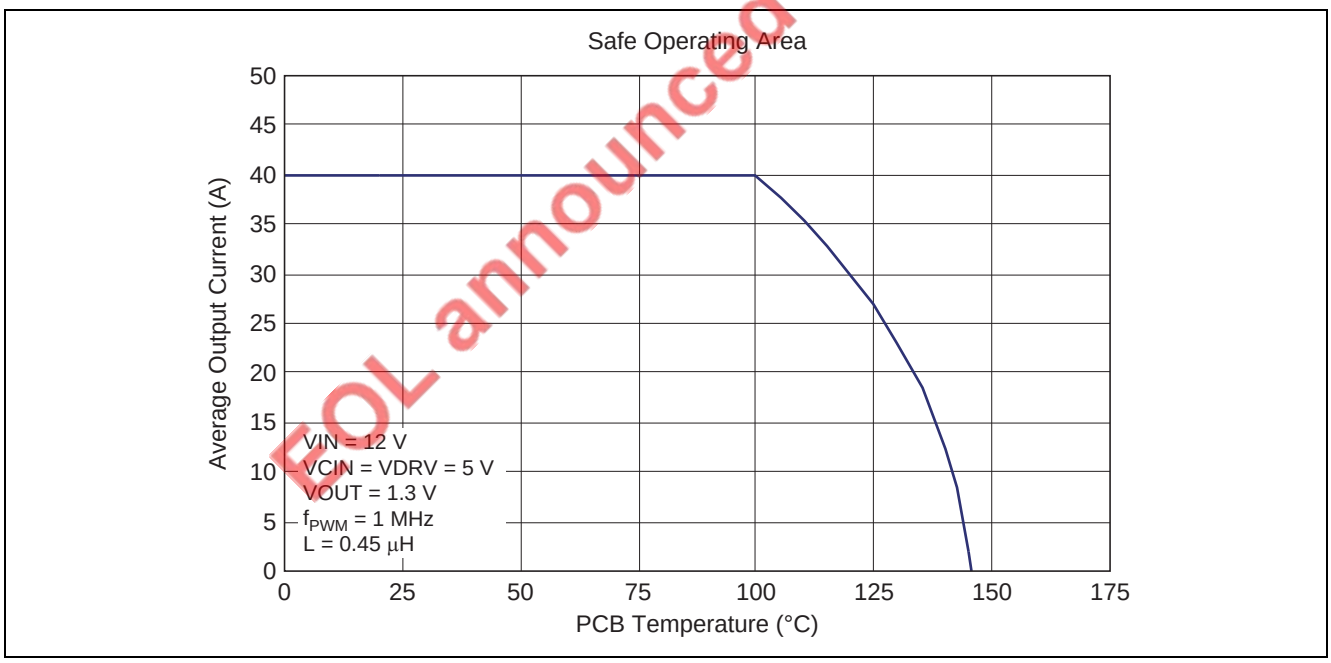
Pin Name	Pin No.	Description	Remarks
ZCD_EN#	1	Zero current detection enable	When asserted "L" signal, zero crossing detection is enabled
VCIN	2	Control input voltage (+5 V input)	Driver Vcc input
VDRV	3	Gate supply voltage (+5 V input)	5 V gate drive
BOOT	4	Bootstrap voltage pin	To be supplied +5 V through internal switch
CGND	5, 37, Pad	Control signal ground	Should be connected to PGND externally
GH	6	High-side gate signal	Pin for monitor
VIN	8 to 14, Pad	Input voltage	
VSWH	7, 15, 29 to 35, Pad	Phase output/Switch output	
PGND	16 to 28	Power ground	
GL	36	Low-side gate signal	Pin for monitor
THWN	38	Thermal warning	Thermal warning when over 115°C
DISBL#	39	Signal disable	Disabled when DISBL# is "L". This Pin is pulled low when internal IC over the thermal shutdown level, 150°C.
PWM	40	PWM drive logic input	Capable of both 3.3 V and 5 V logic input

Absolute Maximum Ratings

(Ta = 25°C)

Item	Symbol	Rating	Units	Note
Power dissipation	Pt(25)	25	W	1
	Pt(110)	8		
Average output current	Iout	40	A	
Input voltage	VIN(DC)	–0.3 to +20	V	2
	VIN(AC)	30		2, 4
Supply voltage & Drive voltage	VCIN & VDRV	–0.3 to +6	V	2
Switch node voltage	VSWH(DC)	20	V	2
	VSWH(AC)	30		2, 4
BOOT voltage	VBOOT(DC)	25	V	2
	VBOOT(AC)	36		2, 4
I/O voltage	Vpwm, Vdisbl, Vlsdbl, Vthwn	–0.3 to VCIN + 0.3	V	2, 5
THWN/THDN current	Ithwn, Idisbl	0 to 1.0	mA	3
Operating junction temperature	Tj-opr	–40 to +150	°C	
Storage temperature	Tstg	–55 to +150	°C	

Notes: 1. Pt(25) represents a PCB temperature of 25°C, and Pt(110) represents 110°C.
2. Rated voltages are relative to voltages on the CGND and PGND pins.
3. For rated current, (+) indicates inflow.
4. The specification values indicated "AC" is limited within 10 ns.
5. VCIN + 0.3 V < 6 V



Recommended Operating Condition

Item	Symbol	Rating	Units	Note
Input voltage	VIN	4.5 to 16	V	
Supply voltage & Drive voltage	VCIN & VDRV	4.5 to 5.5	V	

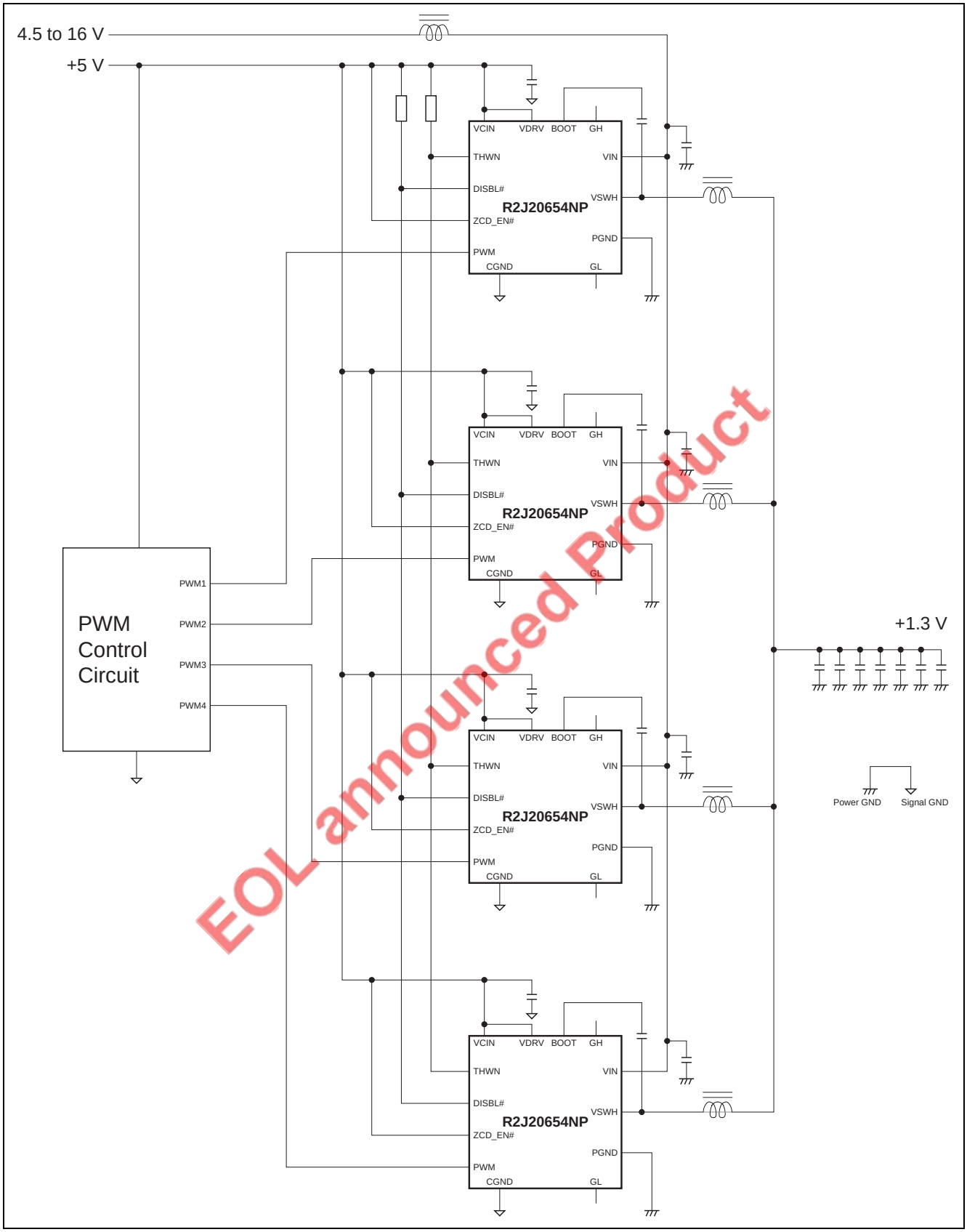
Electrical Characteristics

(Ta = 25°C, VCIN = 5 V, VDRV = 5 V, VSWH = 0 V, unless otherwise specified)

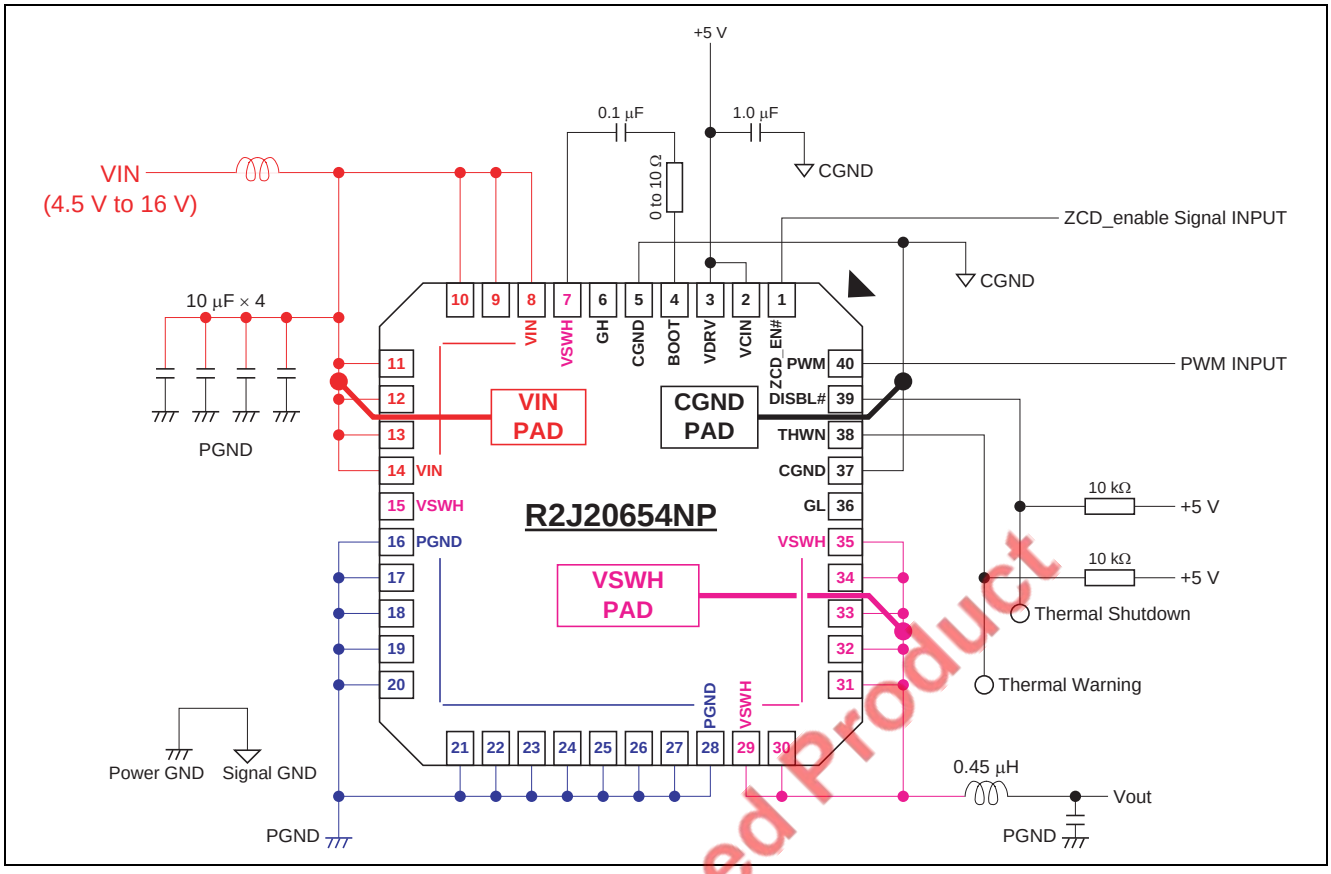
Item		Symbol	Min	Typ	Max	Units	Test Conditions
Supply	VCIN start threshold	V_H	4.1	4.3	4.5	V	
	VCIN shutdown threshold	V_L	3.6	3.8	4.0	V	
	UVLO hysteresis	dUVL	—	0.5	—	V	$V_H - V_L$
	VCIN operating current	I_{CIN}	—	62	—	mA	f_{PWM} = 1 MHz, Ton_pwm = 120 ns
	VCIN disable current	$I_{CIN-DISBL}$	—	—	350	µA	DISBL# = 0 V, PWM = LSDBL# = Open
PWM input	PWM input high level	V_{H-PWM}	2.6	—	—	V	3.3 V/5.0 V PWM interface
	PWM input low level	V_{L-PWM}	—	—	0.8	V	
	PWM input resistance	R_{IN-PWM}	6.5	12.5	25	kΩ	PWM = 1 V
	PWM input tri-state range	V_{IN-tri}	1.4	—	2.0	V	3.3 V/5.0 V PWM interface
	Shutdown hold-off time	$t_{HOLD-OFF}$ *1	—	150	—	ns	
DISBL# input	Enable level	V_{ENBL}	2.0	—	—	V	
	Disable level	V_{DISBL}	—	—	0.8	V	
	Input current	I_{DISBL}	—	2.0	5.0	µA	DISBL# = 1 V
	THDN on resistance	R_{THDN} *1	0.2	0.5	1.0	kΩ	DISBL# = 0.2 V
ZCD_EN#	ZCD disable level	Vzcddisbl	2.0	—	—	V	
	ZCD enable level	Vzcden	—	—	0.8	V	
	Input current	Izcden	–52	–25	–12	µA	ZCD_EN# = 1 V
Thermal warning	Warning temperature	T_{THWN} *1	100	115	130	°C	Driver IC temperature
	Temperature hysteresis	T_{HYS} *1	—	15	—	°C	
	THWN on resistance	R_{THWN} *1	0.2	0.5	1.0	kΩ	THWN = 0.2 V
	THWN leakage current	I_{LEAK}	—	—	1.0	µA	THWN = 5 V
Thermal shutdown	Shutdown temperature	Tstdn *1	130	150	—	°C	Driver IC temperature

Note: 1. Reference values for design. Not 100% tested in production.

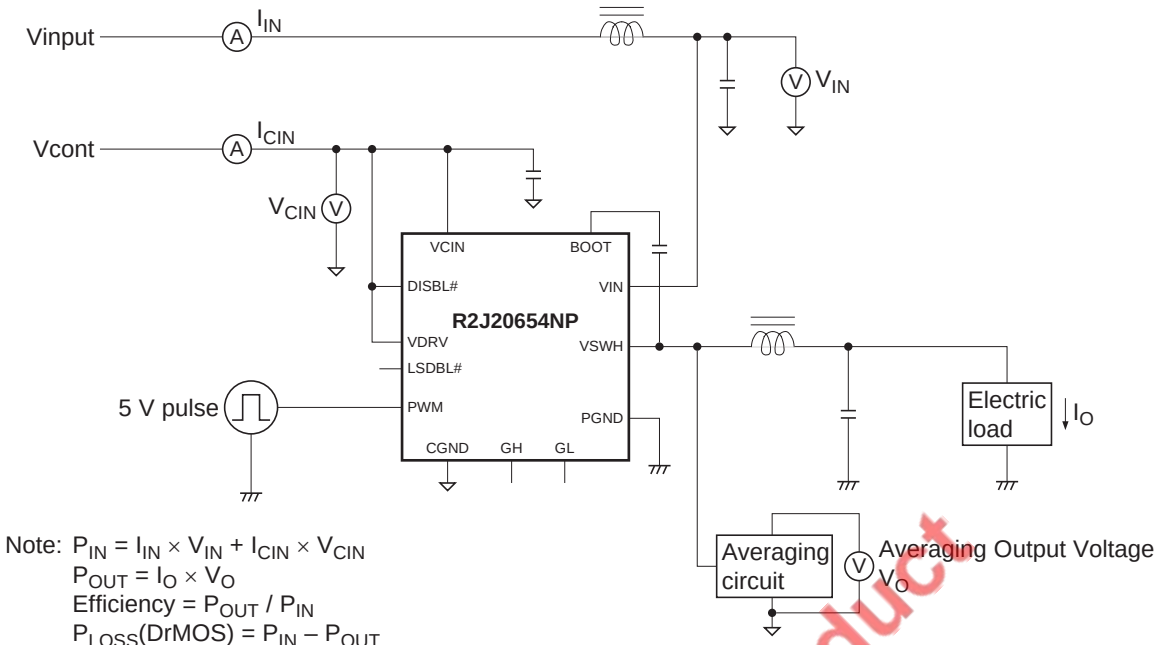
Typical Application



Pin Connection

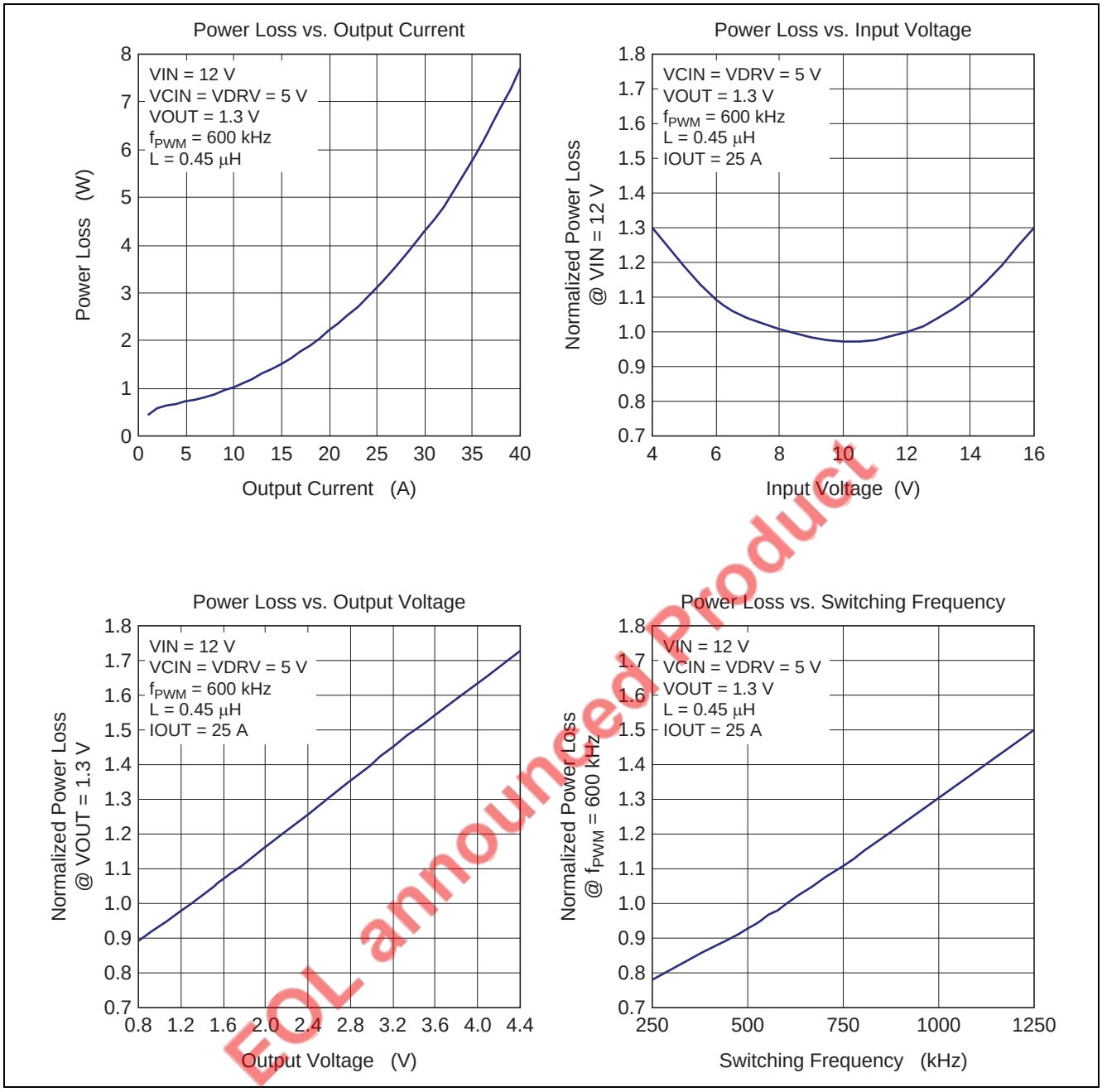


Test Circuit

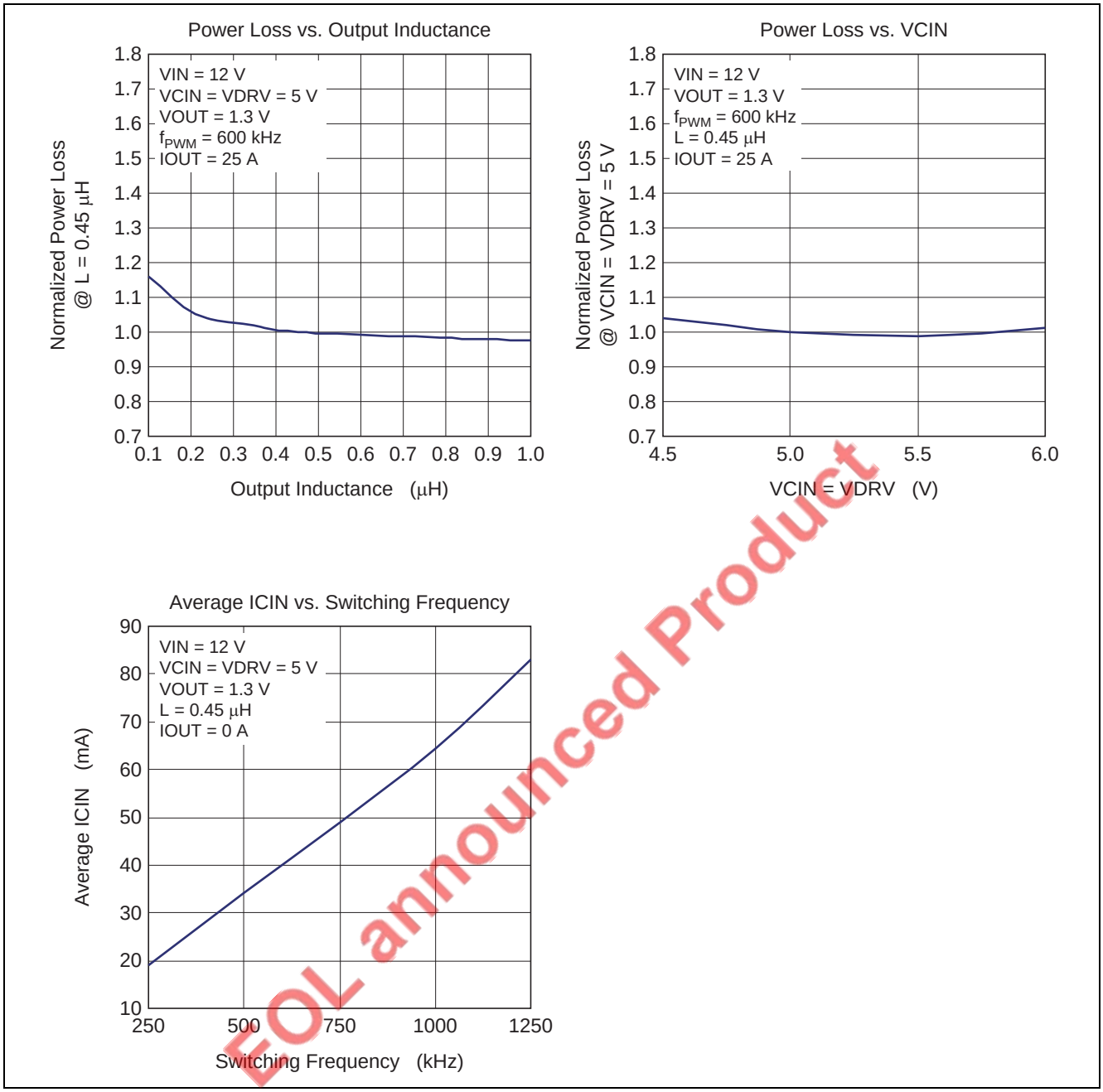


Note: $P_{IN} = I_{IN} \times V_{IN} + I_{CIN} \times V_{CIN}$
$P_{OUT} = I_O \times V_O$
Efficiency = P_{OUT} / P_{IN}
P_{LOSS}(DrMOS) = $P_{IN} - P_{OUT}$
Ta = 27°C

Typical Data



Typical Data (cont.)



Description of Operation

The DrMOS multi-chip module incorporates a high-side MOS FET, low-side MOS FET, and MOS-FET driver in a single QFN package. Since the parasitic inductance between each chip is extremely small, the module is highly suitable for use in buck converters to be operated at high frequencies. The control timing between the high-side MOS FET, low-side MOS FET, and driver is optimized so that high efficiency can be obtained at low output-voltage.

VCIN & DISBL#

The VCIN pin is connected to the UVL (under-voltage lockout) module, so that the driver is disabled as long as VCIN is 4.3 V or less. On cancellation of UVL, the driver remains enabled until the UVL input is driven to 3.8 V or less. The signal on pin DISBL# also enables or disables the circuit.

Voltages from –0.3 V to VCIN can be applied to the DISBL# pin, so on/off control by a logic IC or the use of a resistor, etc., to pull the DISBL# line up to VCIN are both possible.

VCIN	DISBL#	Driver State
L	*	Disable (GL, GH = L)
H	L	Disable (GL, GH = L)
H	H	Active
H	Open	Disable (GL, GH = L)

The pulled-down MOSFET, which is turned on when internal IC temperature becomes over thermal shutdown level, is connected to the DISBL# pin. The detailed function is described in THDN section.

PWM & ZCD_EN#

The PWM pin is the signal input pin for the driver chip. The input-voltage range is –0.3 V to (VCIN + 0.3 V). When the PWM input is high, the gate of the high-side MOS FET (GH) is high and the gate of the low-side MOS FET (GL) is low.

PWM	GH	GL
L	L	H
H	H	L

The ZCD_EN# pin is the Zero Current Detection Operation Enable pin for "Diode Emulation Mode (DEM)" when ZCD_EN# is low. This function improves light load efficiency by preventing negative inductor current from output capacitor. Driver IC monitors inductor current and when inductor current crosses zero, driver IC turn off low-side MOS FET automatically.

Figure 1.1 shows the Typical high side and low side gate switching and Inductor current (IL) during Continuous Conduction Mode (CCM), and Figure 1.2 shows DEM when asserting Zero Current Detection Enable signal.

ZCD_EN# pin is internally pulled up to VCIN with 160 kΩ resistor. When Zero Current Detection function is not used, keep this pin open or pulled up to VCIN.

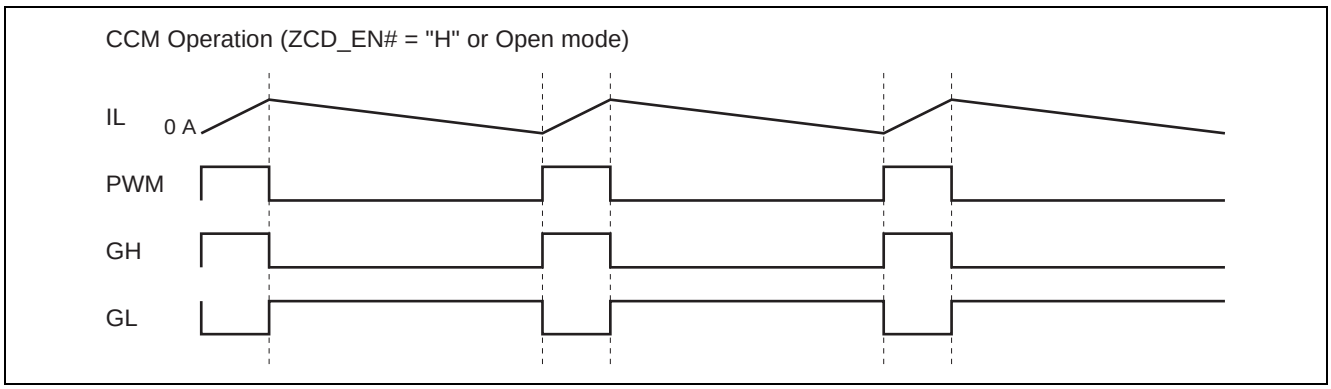


Figure 1.1 Typical Signals during CCM

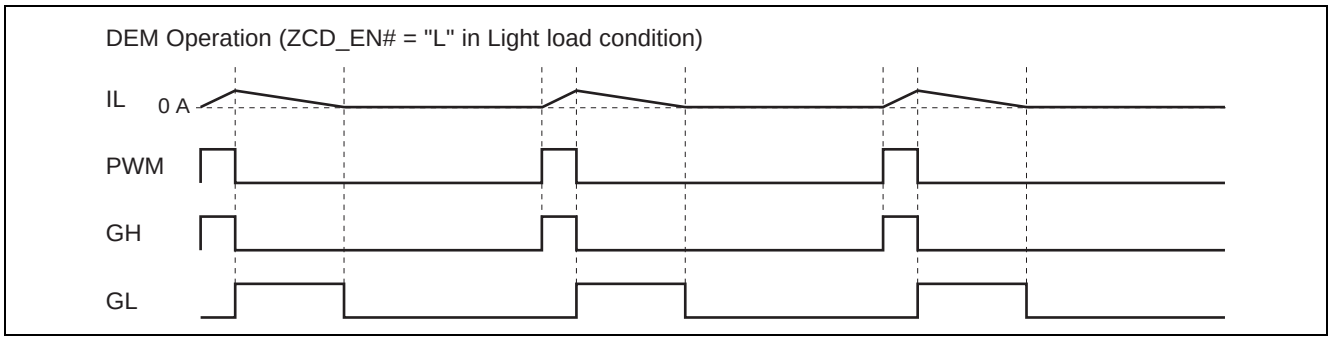


Figure 1.2 Typical Signals during DEM

The PWM input is TTL level and has hysteresis. When the signal route from the control IC is high impedance, the tri-state function turns off the high- and low-side MOS FETs. This function operates when the PWM input signal stays in the input hysteresis window for 150 ns (typ.). After the tri-state mode has been entered and GH and GL have become low, a PWM input voltage of 2.6 V or more is required to make the circuit return to normal operation.

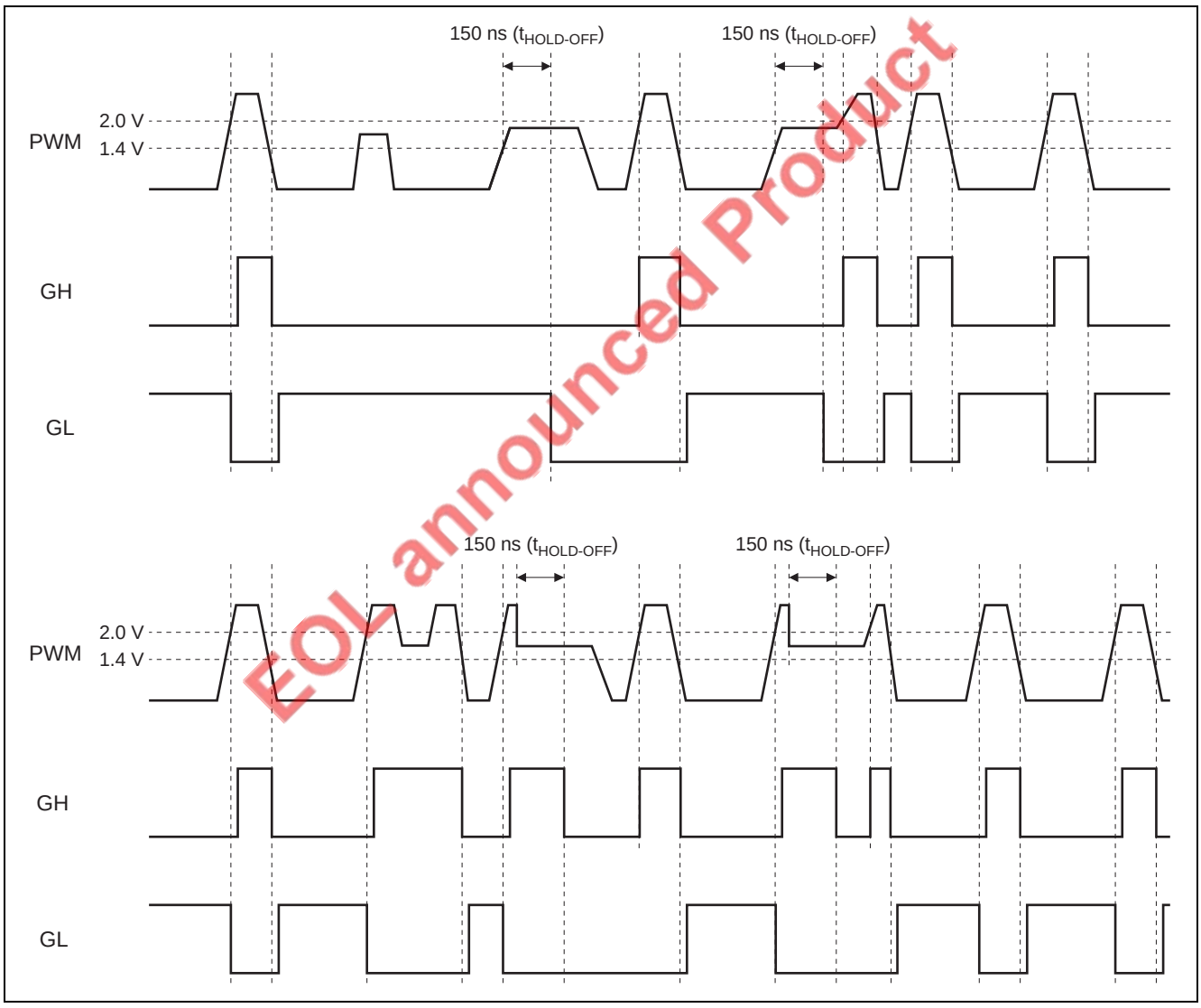


Figure 2 PWM Shutdown-Hold Time Signal

The equivalent circuit for the PWM-pin input is shown in the next figure. M1 is in the ON state during normal operation; after the PWM input signal has stayed in the hysteresis window for 150 ns (typ.) and the tri-state detection signal has been driven high, the transistor M1 is turned off.

When VCIN is powered up, M1 is started in the OFF state regardless of PWM Low or Open state. After PWM is asserted high signal, M1 becomes ON and shifts to normal operation.

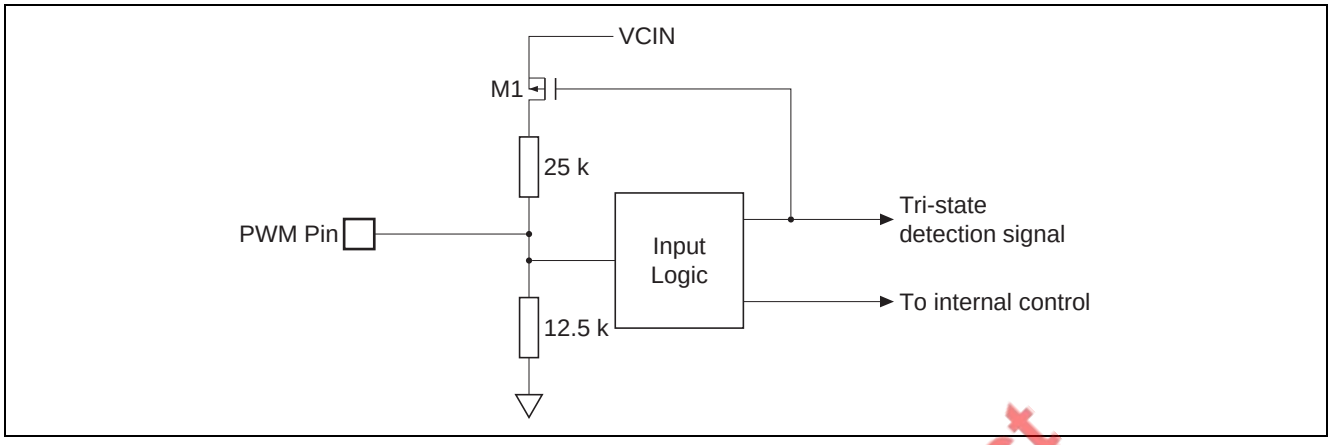


Figure 3 Equivalent Circuit for the PWM-pin Input

THWN & THDN

This device has two level thermal detection, one is thermal warning and the other is thermal shutdown function.

This Thermal Warning feature is the indication of the high temperature status.

THWN is an open drain logic output signal and need to connect a pull-up resistor (ex.51 kΩ) to THWN for Systems with the thermal warning implementation.

When the chip temperature of the internal driver IC becomes over 115°C, Thermal warning function operates.

This signal is only indication for the system controller and does not disable DrMOS operation.

When thermal warning function is not used, keep this pin open.

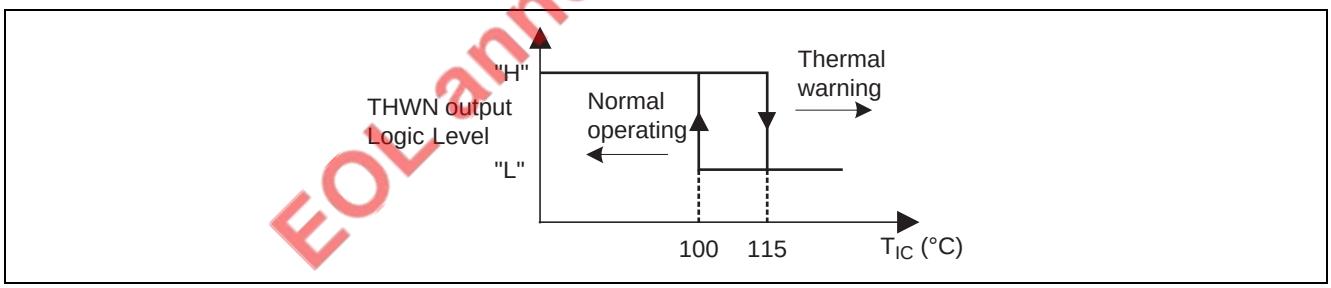


Figure 4 THWN Trigger Temperature

THDN is an internal thermal shutdown signal when driver IC becomes over 150°C.

This function makes High-Side MOS FET and Low-Side MOS FET turn off for the device protection from abnormal high temperature situation and at the same time DISBL# pin is pulled low internally to give notice to the system controller. Once thermal shutdown function operates, driver IC keeps DISBL# pin pulled low until VCIN becomes under UVL level (3.8 V).

Figure 5 shows the example of two types of DISBL# connection with the system controller signal.

Driver IC Temp.	Driver Chip Status
< 150°C	Enable (GL, GH = "Active")
> 150°C	Shutdown (GL, GH = "L")

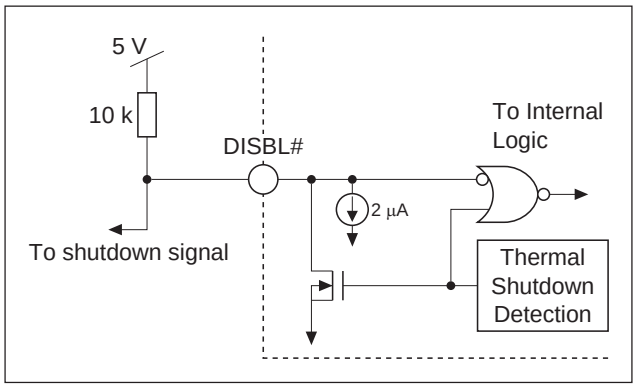


Figure 5.1 THDN Signal to the System Controller

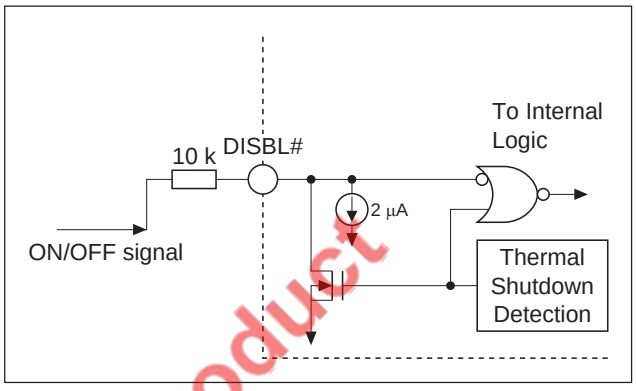


Figure 5.2 ON/OFF Signal from the System Controller

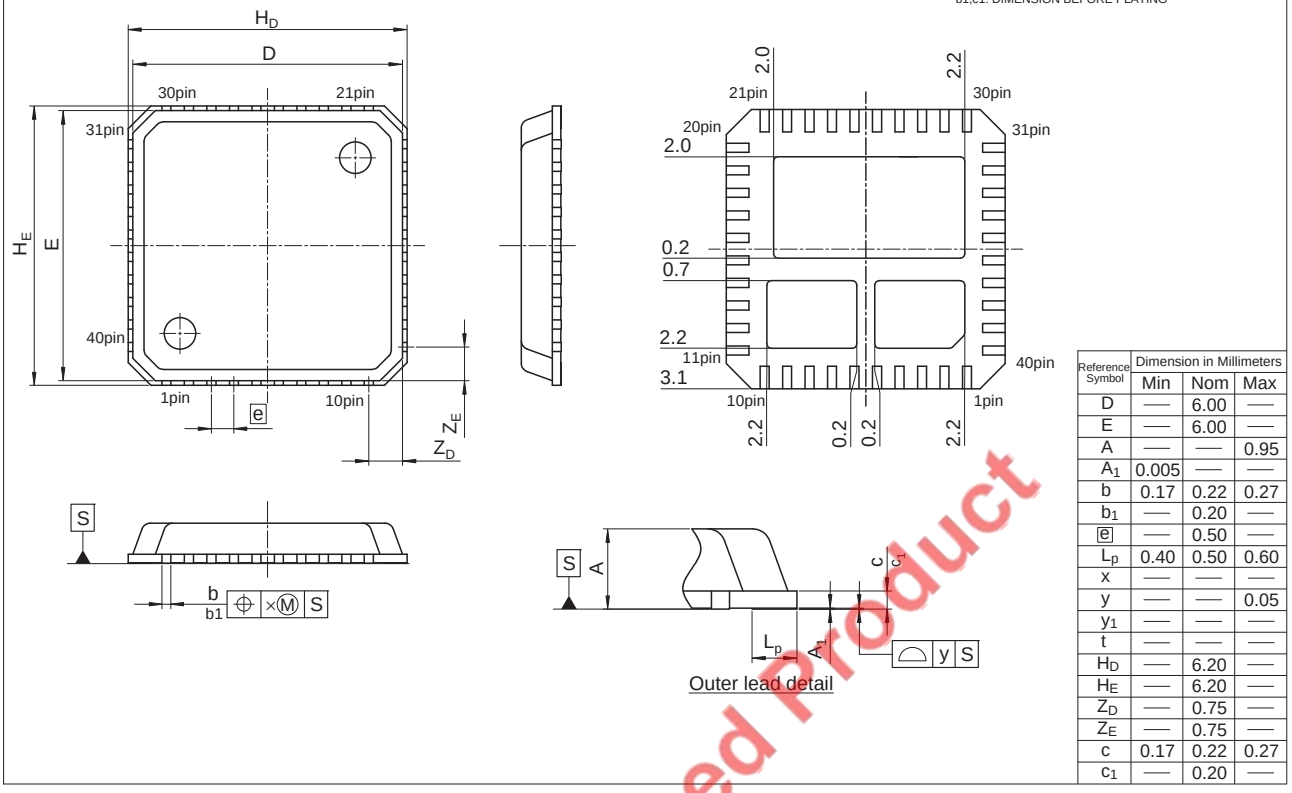
MOS FET

The MOS FETs incorporated in R2J20654NP are highly suitable for synchronous-rectification buck conversion. For the high-side MOS FET, the drain is connected to the VIN pin and the source is connected to the VSWH pin. For the low-side MOS FET, the drain is connected to the VSWH pin and the source is connected to the PGND pin.

Package Dimensions

JEITA Package Code	RENESAS Code	Previous Code	MASS[Typ.]
P-VQFN40-6x6-0.50	PVQN0040KC-A	—	0.10g

NOTE)
b1,c1: DIMENSION BEFORE PLATING



Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	—	6.00	—
E	—	6.00	—
A	—	—	0.95
A_1	0.005	—	—
b	0.17	0.22	0.27
b_1	—	0.20	—
e	—	0.50	—
L_p	0.40	0.50	0.60
x	—	—	—
y	—	—	0.05
y_1	—	—	—
t	—	—	—
H_D	—	6.20	—
H_E	—	6.20	—
Z_D	—	0.75	—
Z_E	—	0.75	—
c	0.17	0.22	0.27
c_1	—	0.20	—

Ordering Information

Part Name	Quantity	Shipping Container
R2J20654NP#G3	2500 pcs	Taping Reel

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