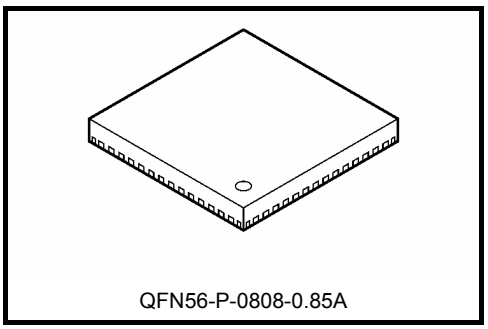
TOSHIBA Multi-Chip Module

TB7004FL

Synchronous Buck Converter Module for High-Current and Low-Voltage Applications

The TB7004FL is a synchronous buck converter (step-down chopper) module. A DC-DC converter can be formed by combining the TB7004FL with a PWM control IC, inductors, and input and output capacitors.



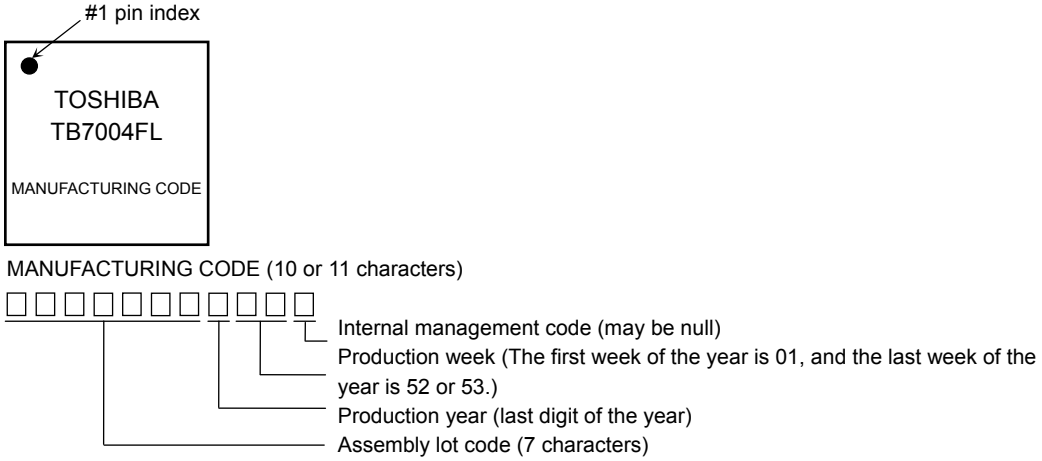
QFN56-P-0808-0.85A

Weight: 0.19 g (typ.)

Features

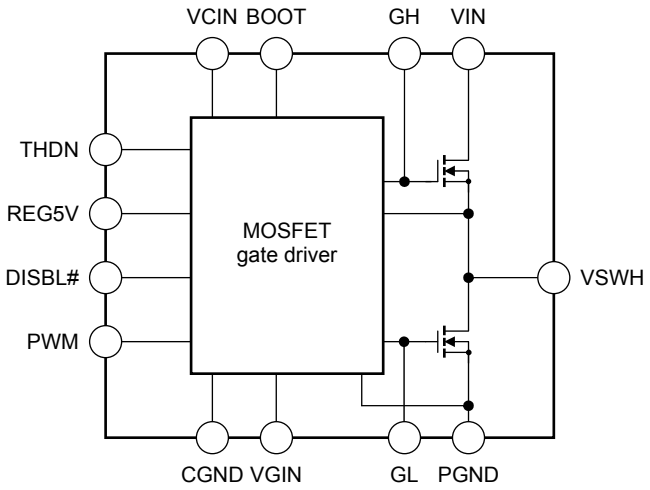
- Operating frequency: up to 1 MHz
- Incorporates 5-V regulator (output current: 10 mA.)
- VCIN undervoltage lockout (UVLO)
  In UVLO mode, the GH and GL outputs are set Low and REG5V is set to 0 V. (The internal voltage regulator is shut down.)
- Thermal shutdown (TSD)
- Low-side MOSFET gate drive voltage: 5 to 12 V (max 16 V)
  The low-side MOSFET gate drive voltage is supplied externally via VGIN.
- DISBL# is a digital input and can receive either a 12-V or 5-V logic High signal.
- DISBL#: H = Enables the internal circuitry.
  L = Disables the internal circuitry and turns off both the high-side and low-side MOSFETs (GH = Low, GL = Low). The internal 5-V regulator remains active.
- The PWM input provides for 3-state output control.
  H: GH = H, GL = L
  L: GH = L, GL = H
  If the PWM input stays between the rising and falling threshold voltages for the 200-ns hold-off time, the TB7004FL turns off both the high-side and low-side MOSFETs. Thereafter, setting the PWM input High causes the TB7004FL to resume normal operation.
- The internal dead time control circuitry optimizes the switching of the high-side and low-side MOSFETs.
- Incorporates boot switch.
  Charge switch for the bootstrap capacitor (The boot switch behaves like a Schottky barrier diode.)

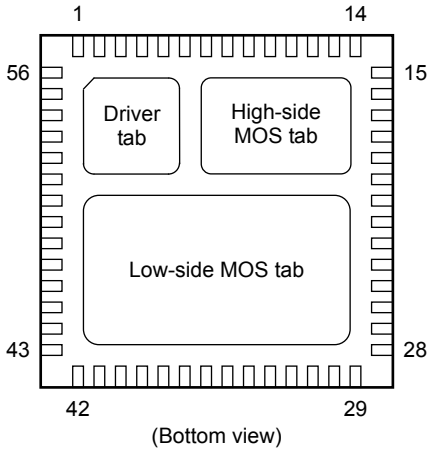
Marking



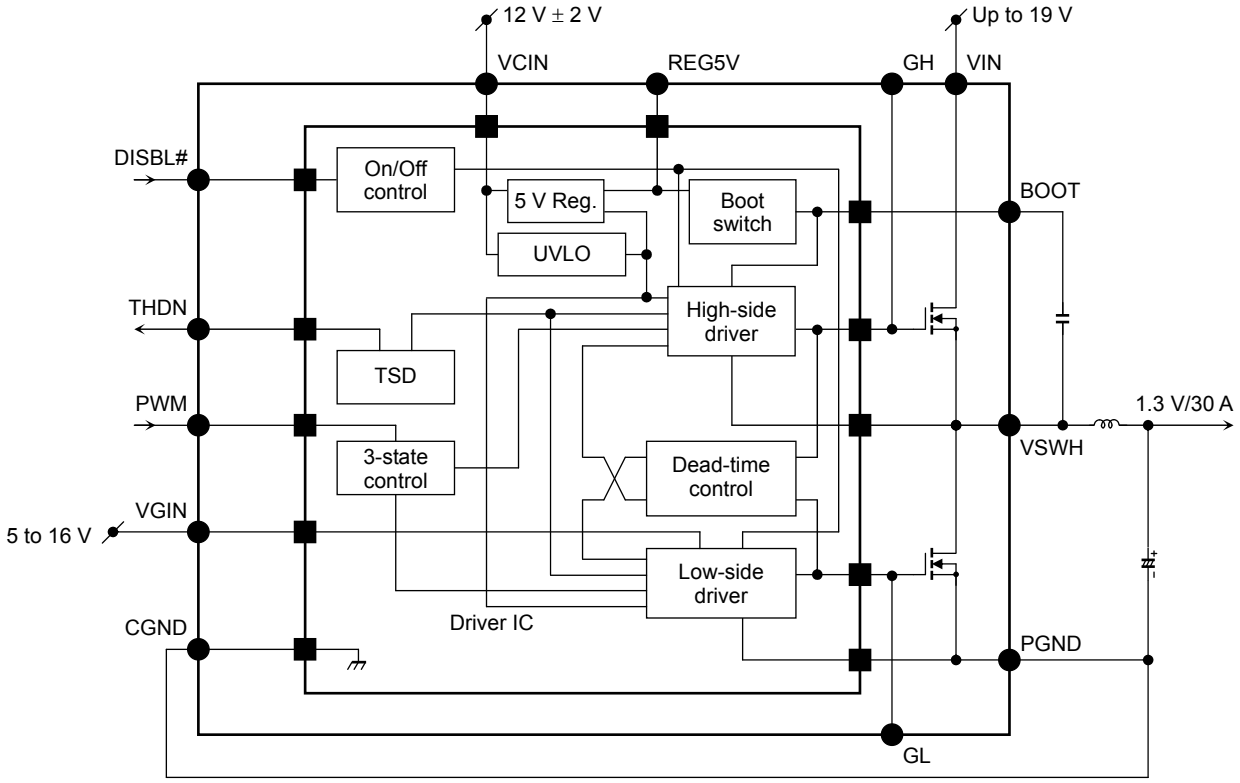
Care should be taken for static electricity when handling this product since it has a MOS structure.

Simplified Block Diagram

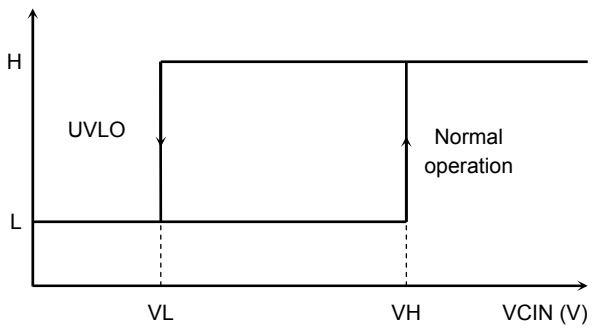




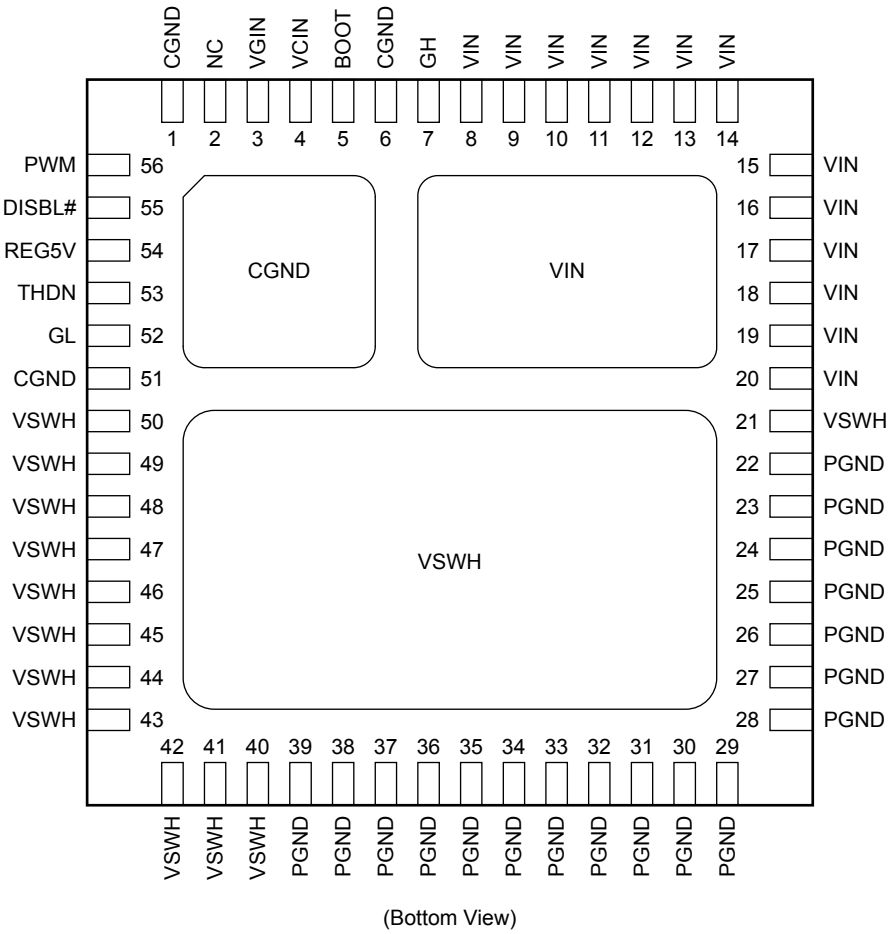
Detailed Block Diagram



Undervoltage Lockout Circuit Output Signal



Pin Configuration



(Bottom View)

Pin Description

Symbol	Pin No.	Description	Notes
CGND	1, 6, 51, Tab	Signal ground for control circuitry	Connect to PGND.
NC	2	No-connect pin	
VGIN	3	Power supply for low-side MOSFET gate drive	
VCIN	4	Power supply for control circuitry	
BOOT	5	Bootstrap capacitor connection	
GH	7	High-side MOSFET gate signal	For monitoring purposes
VIN	8 to 20, Tab	Input pins. Connected to an input of the on-chip the DC-DC converter.	
VSWH	21, 40 to 50, Tab	Output pins. Output inductor connection	
PGND	22 to 39	Power ground	
GL	52	Low-side MOSFET gate signal	For monitoring purposes
THDN	53	Open-drain output that indicates that thermal shutdown (TSD) has been tripped. An external pull-up resistor should be added to the THDN pin. Held Low in thermal shutdown mode.	
REG5V	54	Internal 5-V regulator output	
DISBL#	55	Disable signal for internal circuitry. Setting DISBL# High enables internal circuitry. Setting DISBL# Low disables internal circuitry.	Accepts both 5-V and 12-V signals.
PWM	56	3-state enable input	

Absolute Maximum Ratings (Ta = 25°C)

Characteristics		Symbol	Rating	Unit
VIN to PGND voltage		VIN	30	V
VCIN to CGND voltage		VCIN	−0.3 to 16	V
VSWH to PGND voltage		VSWH	−2 to 30	V
VGIN to CGND voltage		VGIN	−0.3 to 16	V
BOOT to VSWH voltage		V_{BOOT}-V_{SWH}	−0.3 to REG5V + 0.3	V
BOOT to CGND voltage		V_{BOOT}	−0.3 to 30	V
PWM to CGND voltage		V_{PWM}	−0.3 to 5.3	V
DISBL# to CGND voltage		$V_{DISBL\#}$	−0.3 to VCIN + 0.3	V
THDN to CGND voltage		V_{THDN}	−0.3 to 6	V
Output RMS current		I_{OUT}	35	A
Operating duty cycle		D	70	%
REG5V current		I_{REG5V}	−10 to 0.1	mA
Power dissipation	T_{pcb} = 25°C	P_D (25)	25	W
	T_{pcb} = 110°C	P_D (110)	8	W
Channel temperature		T_{ch}	−40 to 150	°C
Storage temperature		T_{stg}	−55 to 150	°C

Note: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may cause this product to decrease in the reliability significantly even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please design the appropriate reliability upon reviewing the Toshiba Semiconductor Reliability Handbook (“Handling Precautions”/“Derating Concept and Methods”) and individual reliability data (i.e. reliability test report and estimated failure rate, etc).

Electrical Characteristics

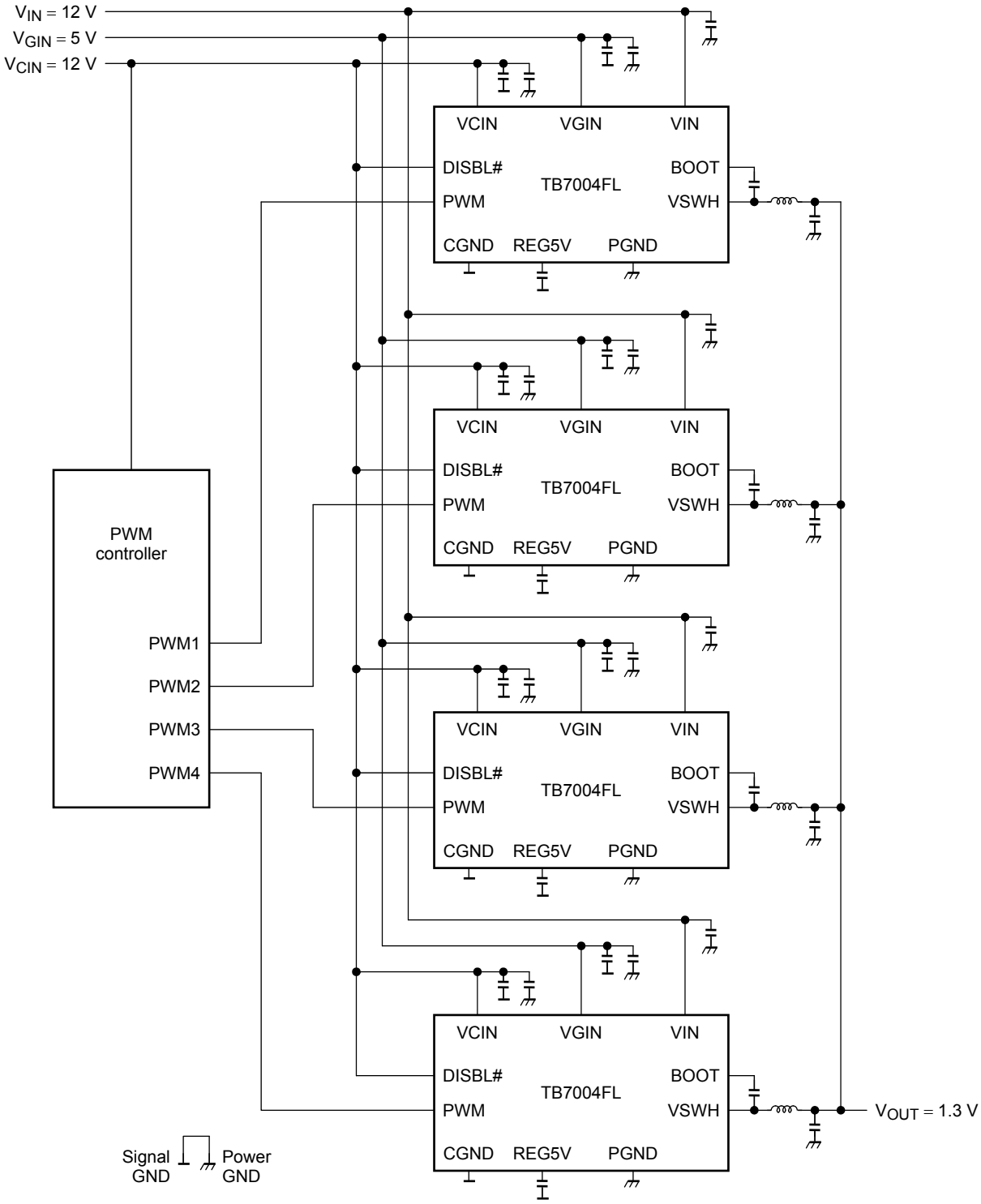
(VCIN = 12 V, VGIN = 5 V, $V_{DISBL\#}$ = 12 V, Ta = 25°C, unless otherwise specified)

Characteristics	Symbol	Pin	Test Condition	Min	Typ.	Max	Unit
Power supply							
Operating input voltage	$V_{IN\ (OPR)}$	VIN	—	—	—	19	V
Operating input voltage	$V_{CIN\ (OPR)}$	VCIN	—	10	12	14	V
Quiescent current	$I_{CIN\ (OFF)}$	VCIN	$V_{DISBL\#}$ = 0, V_{PWM} = 0	—	—	1.3	mA
Operating VGIN current	$I_{GIN\ (OPR)}$	VGIN	f_C = 1 MHz, duty = 10%	—	—	60	mA
Undervoltage lockout threshold	V_{UVLO}	VCIN	—	6.5	7.2	7.9	V
Undervoltage lockout hysteresis	$V_{hys\text{-}UVLO}$	VCIN	—	—	2.0	—	V
PWM signal input							
PWM input rising threshold	$V_{H\ (PWM)}$	PWM	—	3.2	3.5	3.8	V
PWM input falling threshold	$V_{L\ (PWM)}$	PWM	—	1.3	1.5	1.7	V
PWM input resistance	R_{PWM}	PWM	V_{PWM} = 5 V	33	50	77	kΩ
3-state window	$V_{W\ (PWM)}$	PWM	—	$V_{L\ (PWM)}$	—	$V_{H\ (PWM)}$	V
3-state shutdown hold-off time	t_{hold}	PWM	$V_{PWM} = V_{W\ (PWM)}$	—	200 (Note 1)	—	ns
DISBL# signal input							
DISBL# input rising threshold	$V_{H\ (DISBL\#)}$	DISBL#	—	3.2	3.5	3.8	V
DISBL# input falling threshold	$V_{L\ (DISBL\#)}$	DISBL#	—	1.3	1.5	1.7	V
DISBL# input current	$I_{DISBL\#}$	DISBL#	$V_{DISBL\#}$ = 0	—	—	5.0	μA
REG5V output							
REG5V output voltage	$V_{OUT(REG5V)}$	REG5V	I_{REG5V} = −10 mA	4.75	5.0	5.25	V
Line regulation	Reg · line	REG5V	I_{REG5V} = −10 mA, V_{CIN} = 10 to 14 V	—	—	20	mV
Load regulation	Reg · load	REG5V	I_{REG5V} = 0 to −10 mA	—	—	20	mV
Thermal shutdown							
Thermal shutdown threshold	T_{tsdn}	—	—	150	—	—	°C
Thermal shutdown hysteresis	$T_{hys\ -\ tsdn}$	—	—	—	15	—	°C
THDN output low voltage	$V_{OUT\ (THDN)}$	THDN	I_{THDN} = 2 mA	—	—	0.4	V
THDN sink current	I_{THDN}	THDN	—	—	—	5	mA

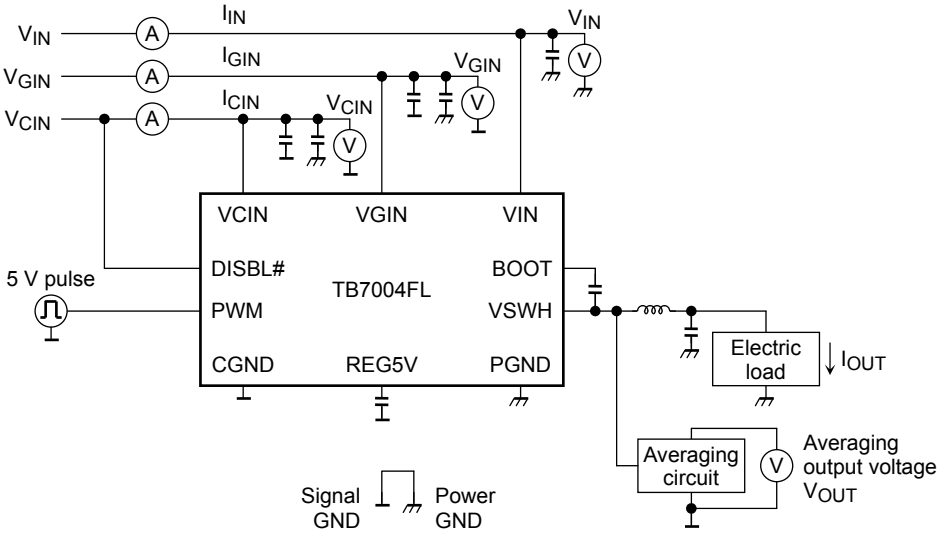
Note 1: Design target only. Not 100% tested in production.

Note 2: Don't use the TB7004FL after thermal shutdown is tripped, because the thermal shutdown circuitry operates beyond the rated absolute maximum temperature. The thermal shutdown circuitry cannot always protect the device from failure. The device may be permanently damaged before thermal shutdown is tripped, depending on usage conditions. Refer to the description of thermal shutdown on page 13.

Typical Application



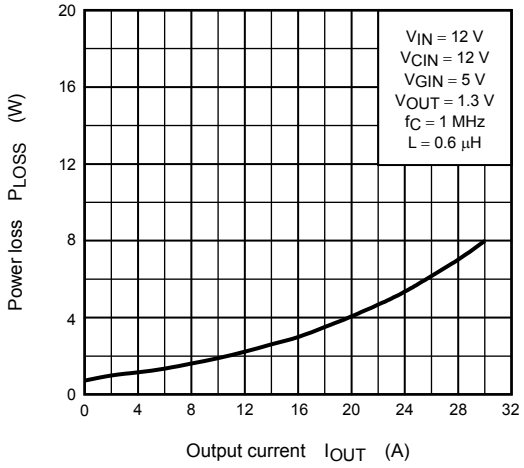
Test Circuit



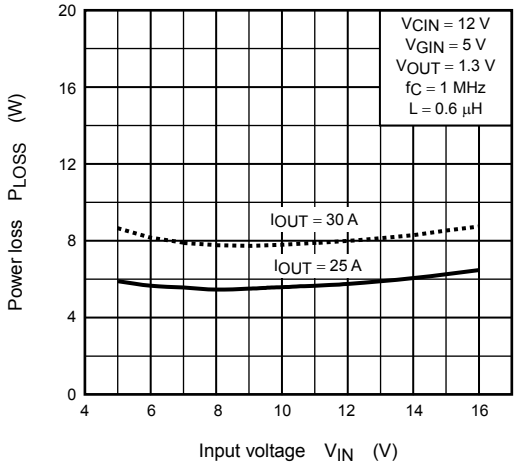
$P_{IN} = I_{IN} \times V_{IN} + I_{CIN} \times V_{CIN} + I_{GIN} \times V_{GIN}$
$P_{OUT} = I_{OUT} \times V_{OUT}$
Efficiency = P_{OUT}/P_{IN}
$P_{LOSS} = P_{IN} - P_{OUT}$

Performance Characteristics

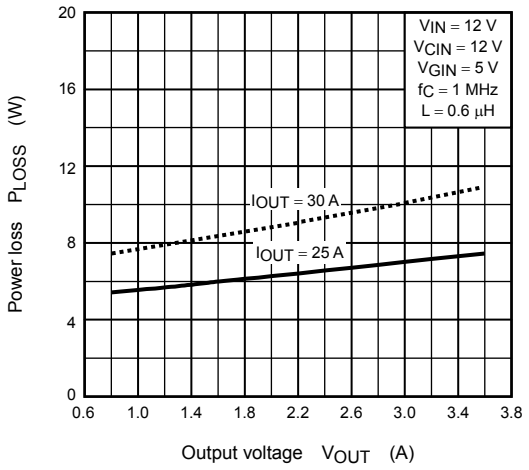
$P_{LOSS} - I_{OUT}$



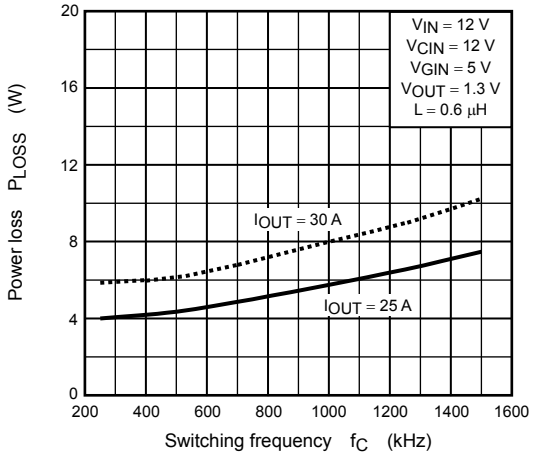
$P_{LOSS} - V_{IN}$



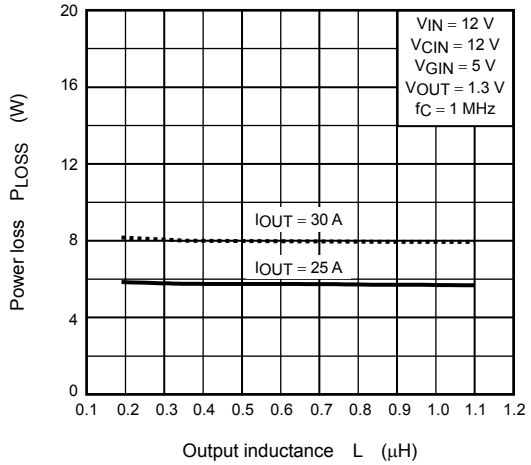
$P_{LOSS} - V_{OUT}$



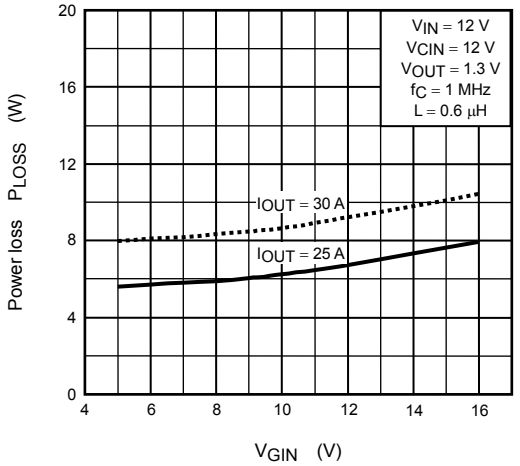
$P_{LOSS} - f_C$



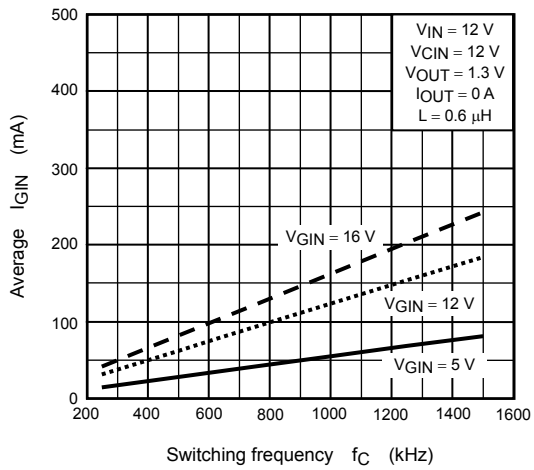
P_{LOSS} – L



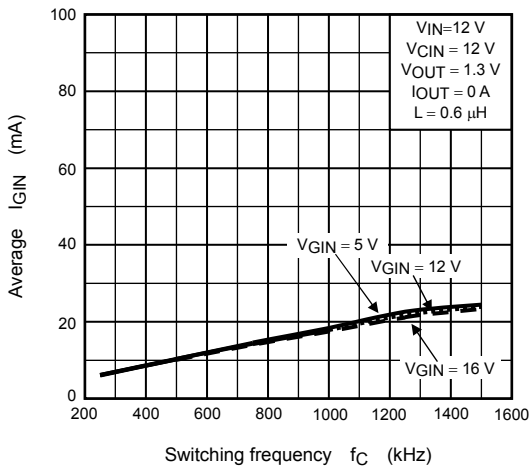
P_{LOSS} – V_{GIN}

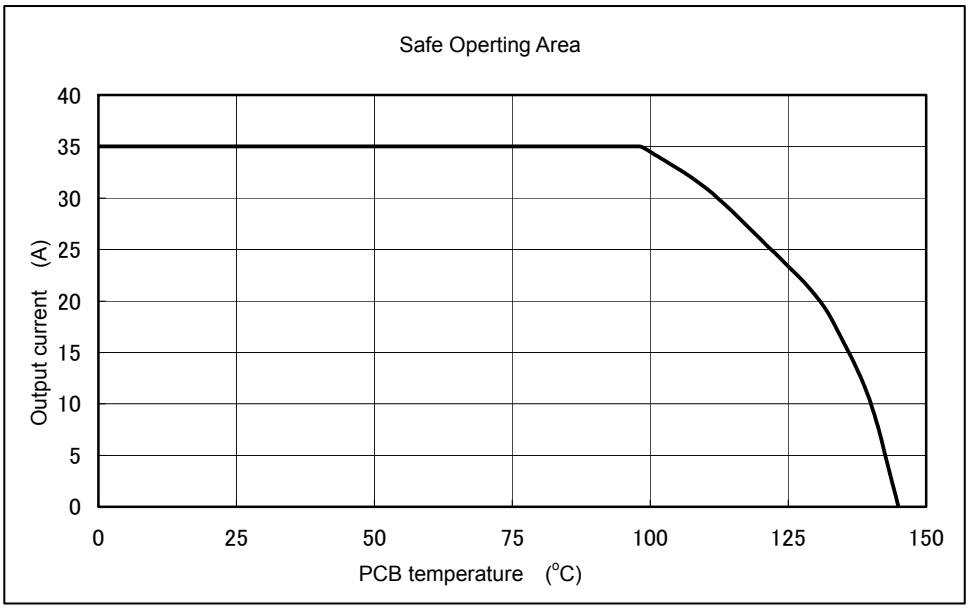


I_{GIN} – f_C



I_{CIN} – f_C





VIN = 12 V, VCIN = 12 V, VGIN = 5 V, VOUT = 1.3 V, f_C = 1 MHz, L = 0.6 μH

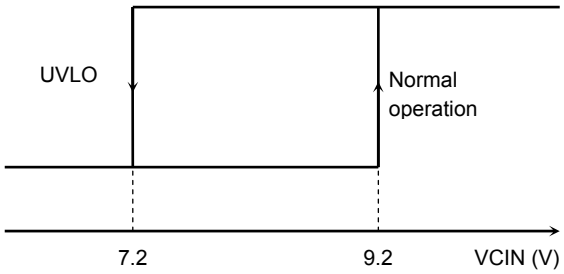
Note: This safe operating area was obtained using the following evaluation board. The safe operating area varies with board conditions.

Board conditions
- Material: FR-4
- Number of layers: 4
- Copper thickness: 35 μm
- Board size: 75 mm × 55 mm
- Board thickness: 2.4 mm

Operational Description

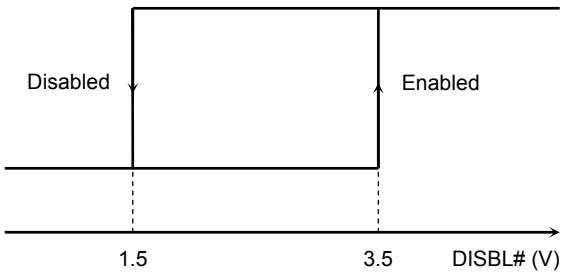
Power Supplies

VGIN: Power supply for low-side MOSFET gate drive
The low-side gate drive voltage can be selected, independent of VCIN.
Supply voltage: 5 to 16 V
VCIN: Power supply for the internal control circuitry
Incorporates undervoltage lockout (UVLO.)
UVLO threshold voltage: 7.2 V (typ.)
UVLO hysteresis voltage: 2.0 V (typ.)
In UVLO mode, the TB7004FL turns off both the high-side and low-side MOSFETs and shuts down the internal 5-V regulator.



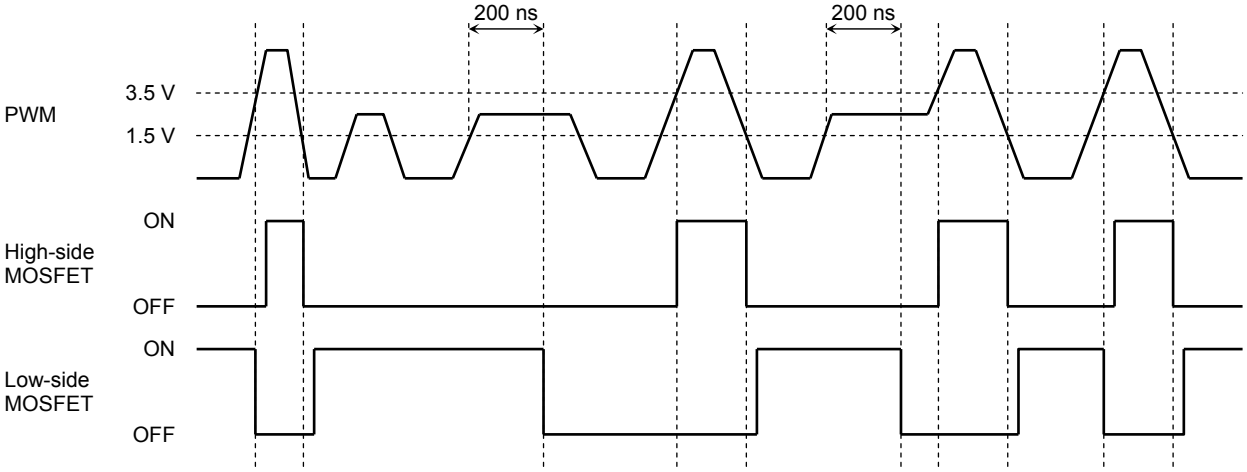
DISBL#

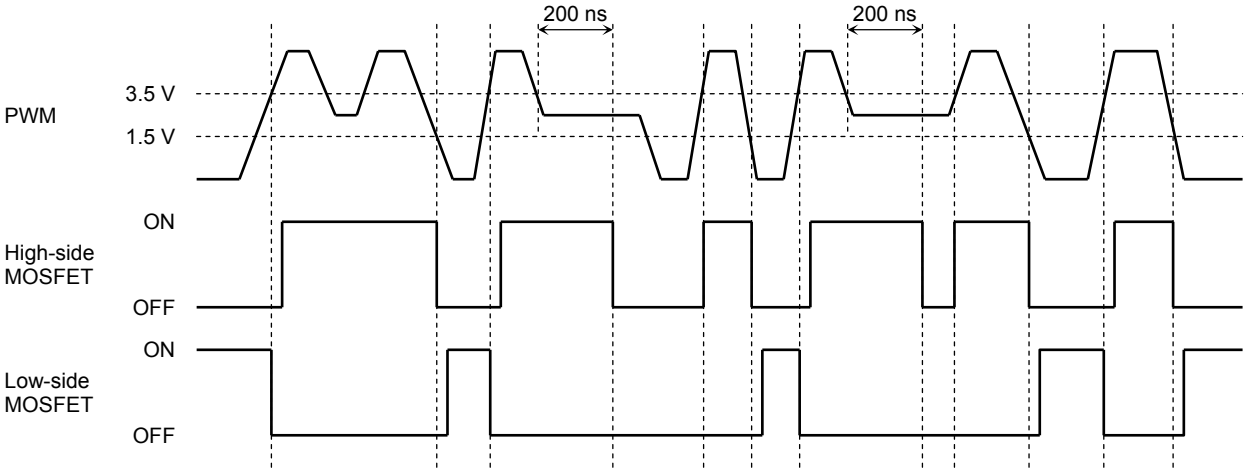
The DISBL# input enables and disables the MOSFET drivers.
H: Normal operation
L: Turns off both the high-side and low-side MOSFETs.
Rising threshold voltage: 3.5 V (typ.)
Falling threshold voltage: 1.5 V (typ.)
While the MOSFET drivers are disabled, the 5-V regulator remains active.



PWM

Control input for the internal power MOSFET drivers
H: Turns on the high-side MOSFET and turns off the low-side MOSFET.
L: Turns off the high-side MOSFET and turns on the low-side MOSFET.
Rising threshold voltage: 3.5 V (typ.)
Falling threshold voltage: 1.5 V (typ.)
If the PWM input stays between the rising and falling threshold voltages for the 200-ns hold-off time, the TB7004FL turns off both the high-side and low-side MOSFETs. Thereafter, setting the PWM input High causes the TB7004FL to resume normal operation.

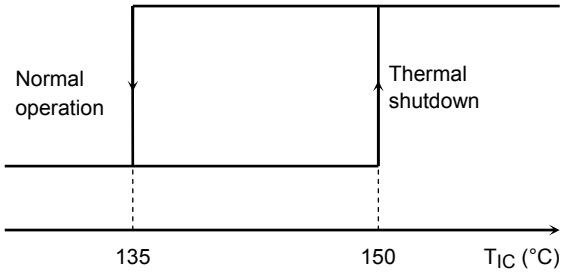




Inputs			Outputs		
VCIN	DISBL#	PWM	REG5V	High-Side MOSFET	Low-Side MOSFET
L	—	—	OFF	OFF	OFF
H	L	—	ON	OFF	OFF
H	Open	—	ON	OFF	OFF
H	H	L	ON	OFF	ON
H	H	H	ON	ON	OFF

Thermal Shutdown

If the integrated driver IC temperature exceeds 165°C, thermal shutdown is tripped.
TSD hysteresis: 15°C (typ.)
If the integrated MOS chip is the heating source, it takes some time for the overtemperature to be detected at the sensor due to the distance between them. The chip temperature might exceed the TSD threshold before the thermal shutdown circuitry is tripped.
In the TSD mode, the TB7004FL turns off both the low-side and high-side MOSFETs and keeps the internal 5-V regulator active.



THDN

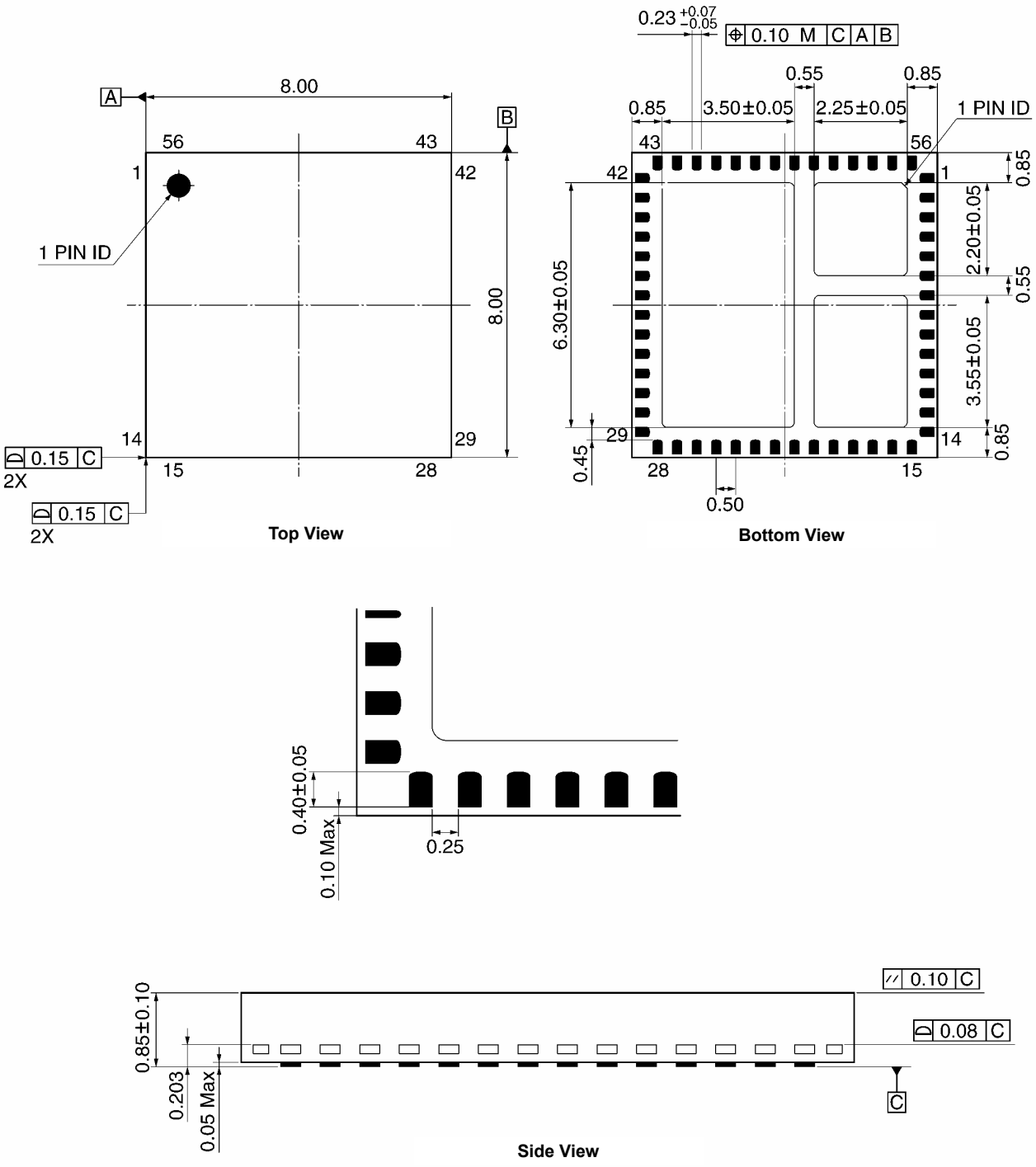
THDN is an open-drain output that indicates thermal shutdown.
An external pull-up resistor should be connected to this pin.
During normal operation, the internal switch is off, causing THDN to be High.
In thermal shutdown mode, the internal switch is on, causing THDN to be Low.

BOOT

BOOT is an input pin from which the bootstrap capacitor is charged.
The bootstrap capacitor should be connected between this pin and VSWH.
While the PWM signal is Low (i.e., the high-side MOSFET is off), the bootstrap capacitor is charged from the internal 5-V regulator. Be sure to use a sufficiently large capacitor.
Typical capacitance: > 0.2 μF (V_{IN} = 12 V, V_{OUT} = 1.3 V, f_C = 1 MHz)

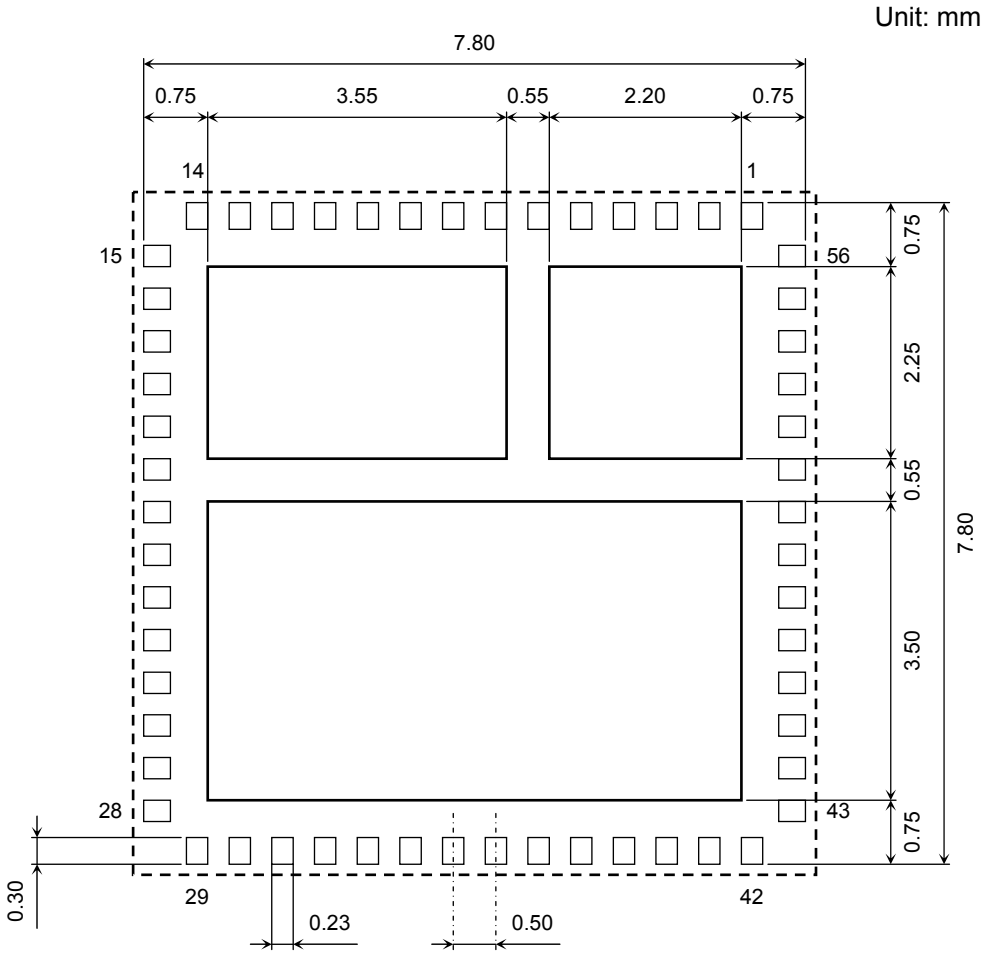
Package Dimensions

QFN56-P-0808-0.20 Unit: mm



Weight: 0.19 g (typ.)

Recommended PCB Footprint



Note On Drypacking

After the drypack is opened, the devices should be soldered within 168 hours of exposure to 30°C / 60% RH.

RESTRICTIONS ON PRODUCT USE

20070701-EN

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