

TOSHIBA Multi-Chip Module

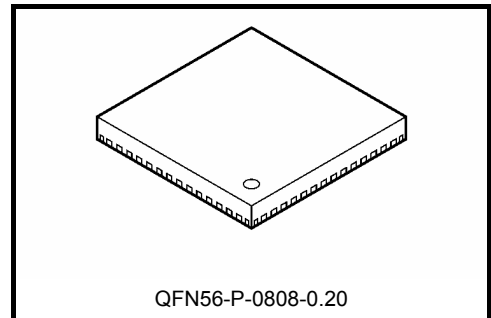
# TB7004AFL

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

The TB7004AFL is a synchronous buck converter (step-down chopper) module. A DC-DC converter can be formed by combining the TB7004AFL with a PWM control IC, inductors, and input and output capacitors.

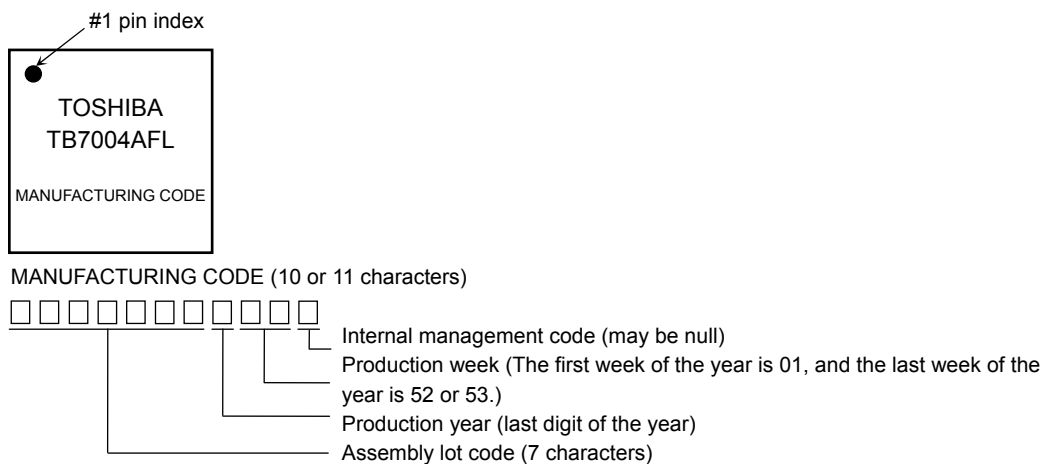
### Features

- 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, 5-V or 3.3-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 can receive 3.3-V logic input.  
H: GH = H, GL = L  
L: GH = L, GL = H
- 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.)



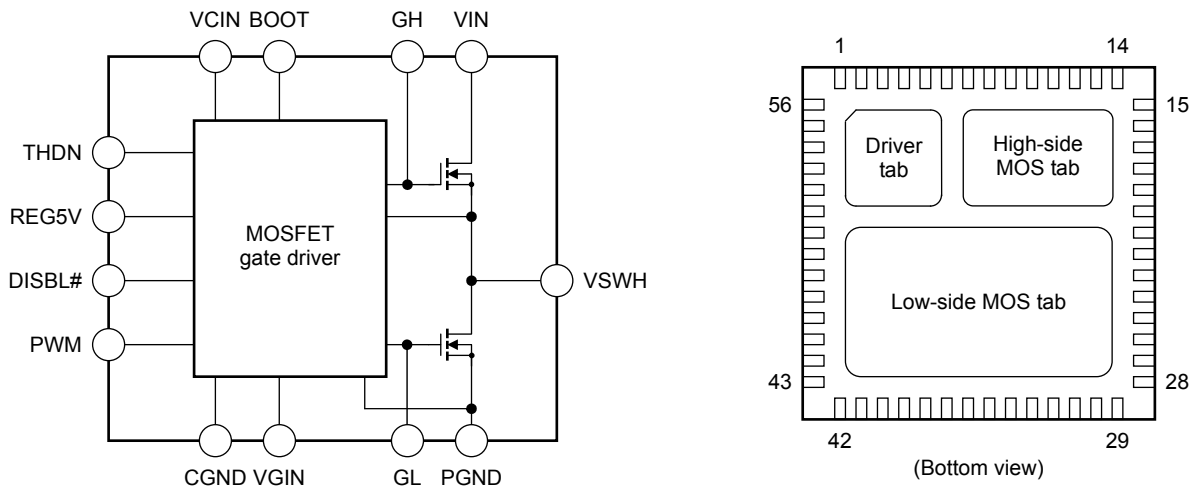
Weight: 0.19 g (typ.)

### Marking

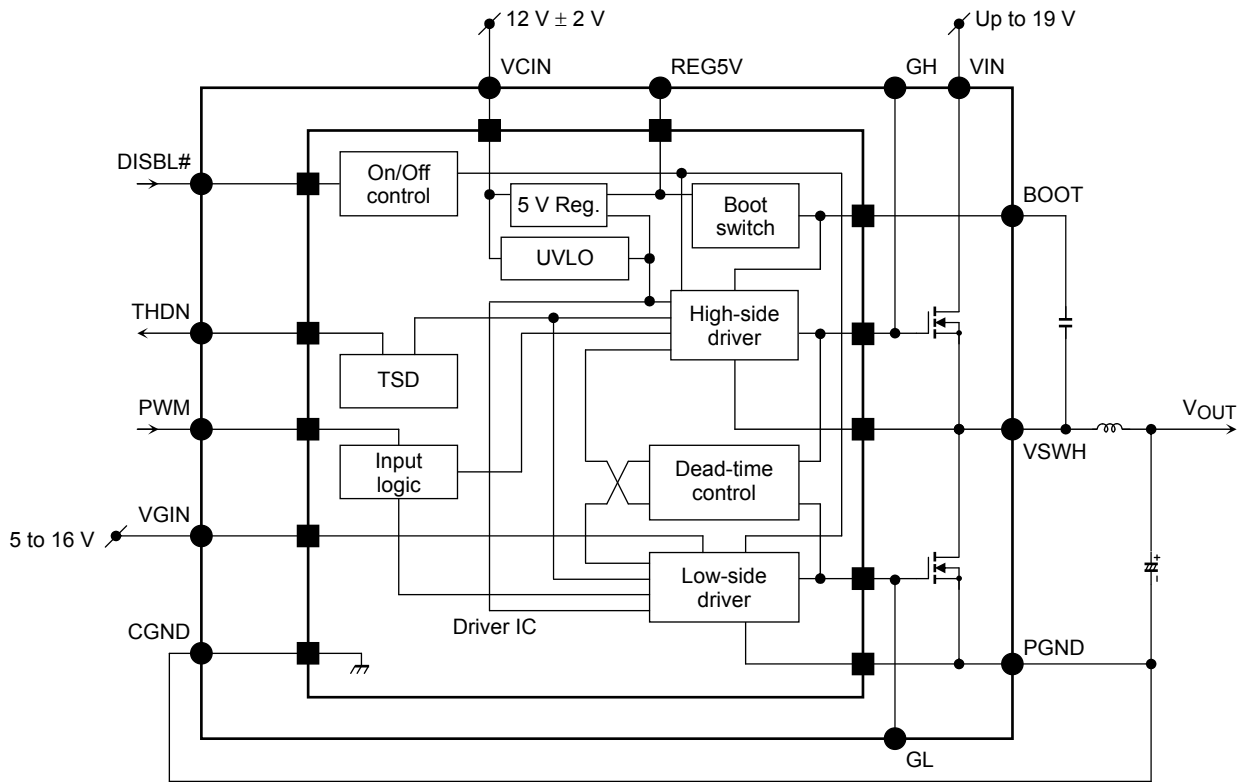


Care should be taken for static electricity when handling this product since it has a MOS structure.

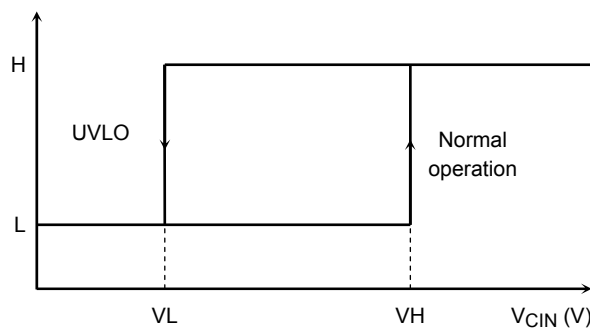
**Simplified Block Diagram**



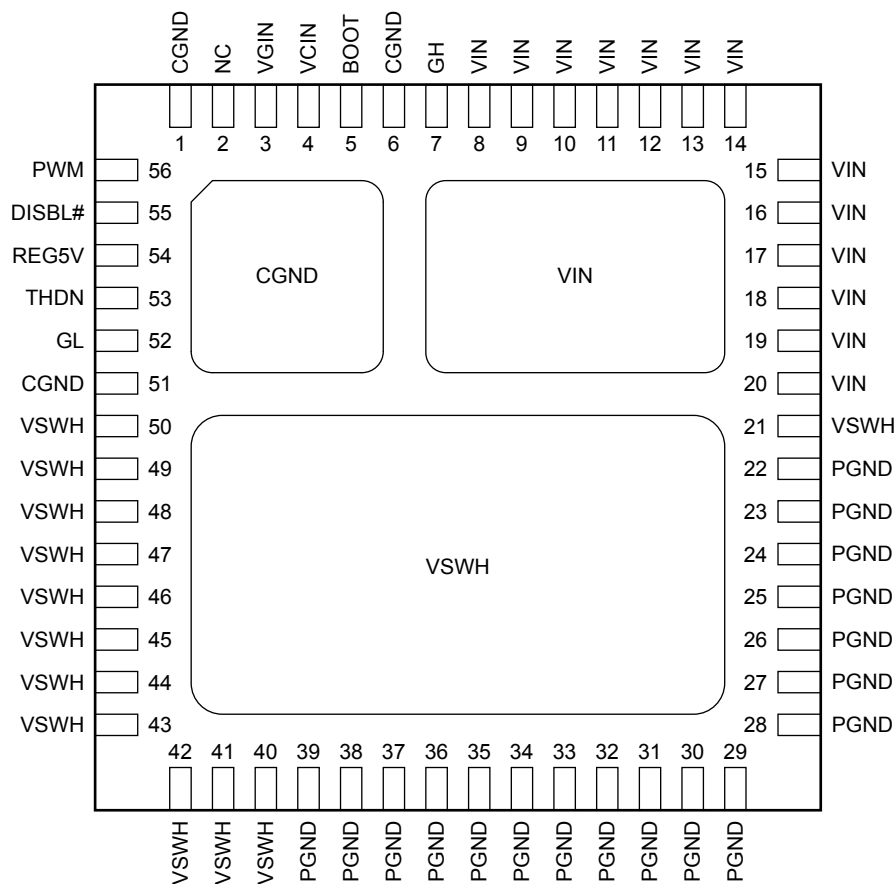
**Detailed Block Diagram**



**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	3.3-V logic input	

## Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	
VIN to PGND voltage	V <sub>IN</sub>	30	V	
VCIN to CGND voltage	V <sub>CIN</sub>	-0.3 to 16	V	
VSWH to PGND voltage	V <sub>SWH</sub>	-2 to 30	V	
VGIN to CGND voltage	V <sub>GIN</sub>	-0.3 to 16	V	
BOOT to VSWH voltage	V <sub>BOOT-VSWH</sub>	-0.3 to REG5V + 0.3	V	
BOOT to CGND voltage	V <sub>BOOT</sub>	-0.3 to 30	V	
PWM to CGND voltage	V <sub>PWM</sub>	-0.3 to 5.3	V	
DISBL# to CGND voltage	V <sub>DISBL#</sub>	-0.3 to VCIN + 0.3	V	
THDN to CGND voltage	V <sub>THDN</sub>	-0.3 to 6	V	
Output RMS current	I <sub>OUT</sub>	35	A	
Operating duty cycle	D	70	%	
REG5V current	I <sub>REG5V</sub>	-10 to 0.1	mA	
Power dissipation	T <sub>pcb</sub> = 25°C	P <sub>D</sub> (25)	25	W
	T <sub>pcb</sub> = 110°C	P <sub>D</sub> (110)	8	W
Channel temperature	T <sub>ch</sub>	-40 to 150	°C	
Storage temperature	T <sub>stg</sub>	-55 to 150	°C	

Note1: 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

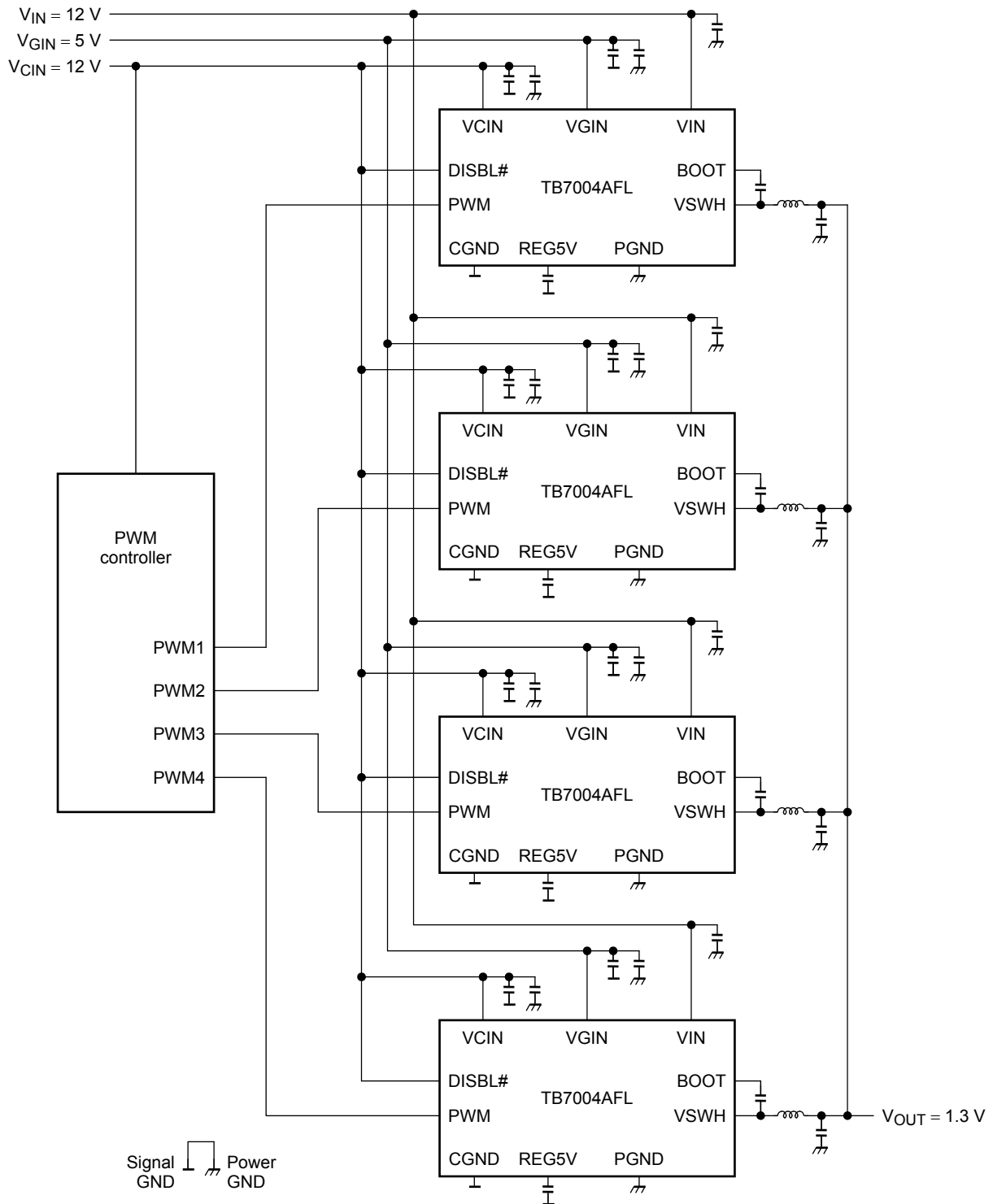
( $V_{\text{CIN}} = 12 \text{ V}$ ,  $V_{\text{GIN}} = 5 \text{ V}$ ,  $V_{\text{DISBL\#}} = 12 \text{ V}$ ,  $T_a = 25^\circ\text{C}$ , unless otherwise specified)

Characteristics	Symbol	Pin	Test Condition	Min	Typ.	Max	Unit
Power supply							
Operating input voltage	$V_{\text{IN (OPR)}}$	VIN	—	—	—	19	V
Operating input voltage	$V_{\text{CIN (OPR)}}$	VCIN	—	10	12	14	V
Quiescent current	$I_{\text{CIN (OFF)}}$	VCIN	$V_{\text{DISBL\#}} = 0$ , $V_{\text{PWM}} = 0$	—	—	1.3	mA
Operating VGIN current	$I_{\text{GIN (OPR)}}$	VGIN	$f_{\text{C}} = 1 \text{ MHz}$ , duty = 10%	—	—	60	mA
Undervoltage lockout threshold	$V_{\text{UVLO}}$	VCIN	—	6.5	7.2	7.9	V
Undervoltage lockout hysteresis	$V_{\text{hys-UVLO}}$	VCIN	—	—	2.0	—	V
PWM signal input							
PWM input rising threshold	$V_{\text{H (PWM)}}$	PWM	—	2.0	—	—	V
PWM input falling threshold	$V_{\text{L (PWM)}}$	PWM	—	—	—	0.8	V
PWM input resistance	$R_{\text{PWM}}$	PWM	$V_{\text{PWM}} = 3.3 \text{ V}$	33	50	77	k $\Omega$
DISBL# signal input							
DISBL# input rising threshold	$V_{\text{H (DISBL\#)}}$	DISBL#	—	2.0	—	—	V
DISBL# input falling threshold	$V_{\text{L (DISBL\#)}}$	DISBL#	—	—	—	0.8	V
DISBL# input current	$I_{\text{DISBL\#}}$	DISBL#	$V_{\text{DISBL\#}} = 0$	—	—	5.0	$\mu\text{A}$
REG5V output							
REG5V output voltage	$V_{\text{OUT (REG5V)}}$	REG5V	$I_{\text{REG5V}} = -10 \text{ mA}$	4.75	5.0	5.25	V
Line regulation	Reg · line	REG5V	$I_{\text{REG5V}} = -10 \text{ mA}$ , $V_{\text{CIN}} = 10 \text{ to } 14 \text{ V}$	—	—	20	mV
Load regulation	Reg · load	REG5V	$I_{\text{REG5V}} = 0 \text{ to } -10 \text{ mA}$	—	—	20	mV
Thermal shutdown							
Thermal shutdown threshold	$T_{\text{tsdn}}$	—	—	—	165	—	$^\circ\text{C}$
Thermal shutdown hysteresis	$T_{\text{hys - tsdn}}$	—	—	—	15 (Note 2)	—	$^\circ\text{C}$
THDN output low voltage	$V_{\text{OUT (THDN)}}$	THDN	$I_{\text{THDN}} = 2 \text{ mA}$	—	—	0.4	V
THDN sink current	$I_{\text{THDN}}$	THDN	—	—	—	5	mA

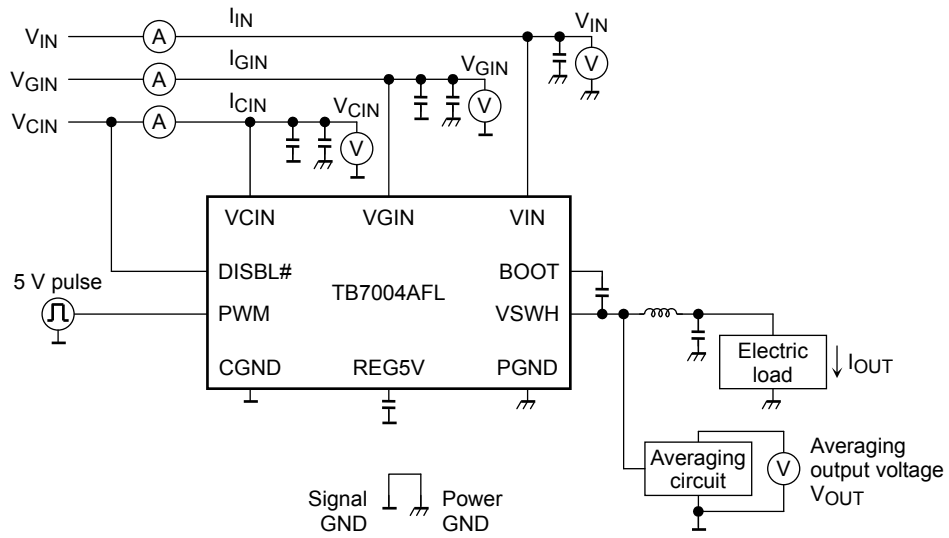
Note 2: Design target only. Not 100% tested in production.

Note 3: Don't use the TB7004AFL 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 12.

**Typical Application**



**Test Circuit**



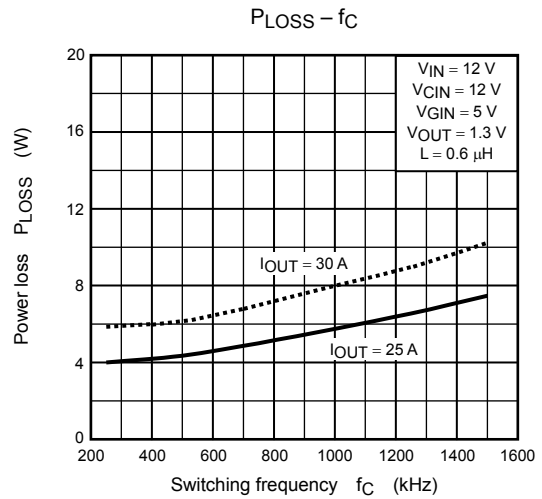
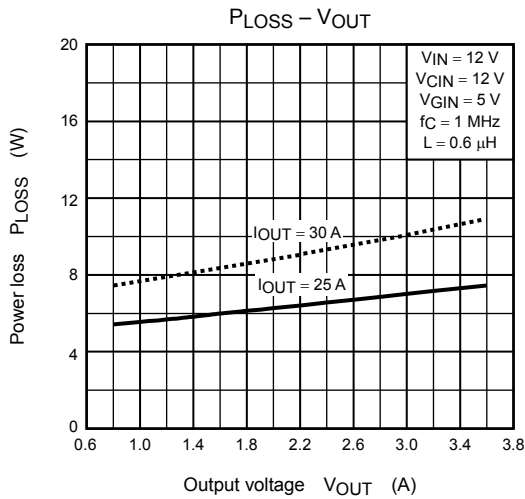
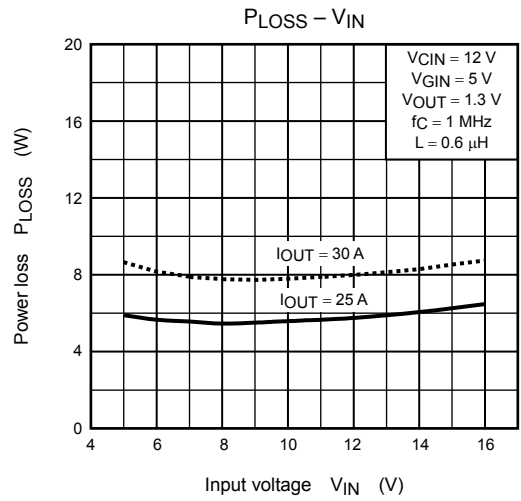
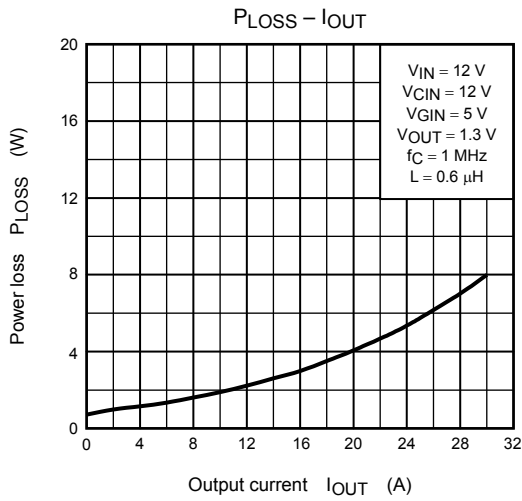
$$P_{IN} = I_{IN} \times V_{IN} + I_{CIN} \times V_{CIN} + I_{GIN} \times V_{GIN}$$

$$P_{OUT} = I_{OUT} \times V_{OUT}$$

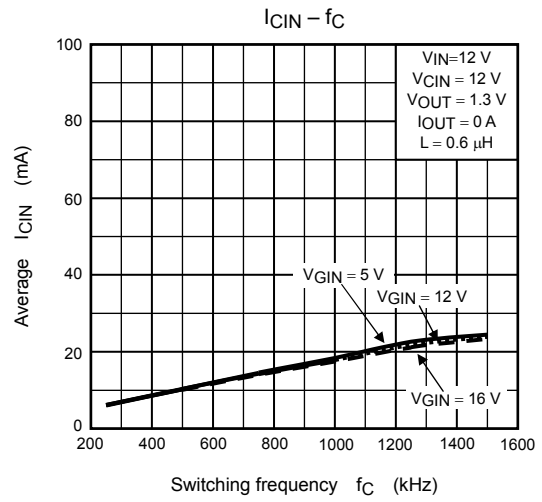
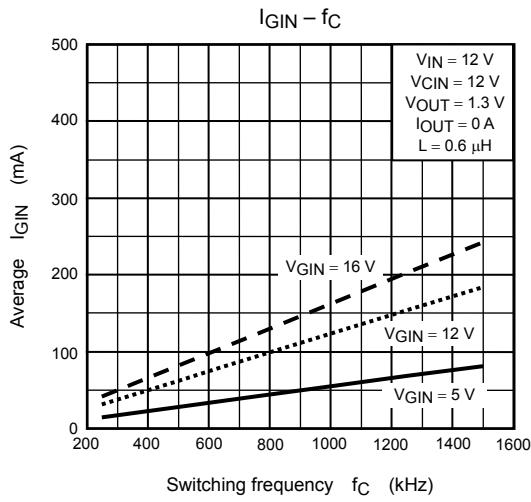
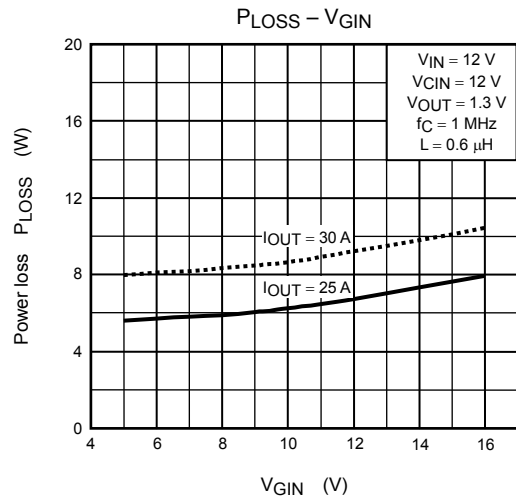
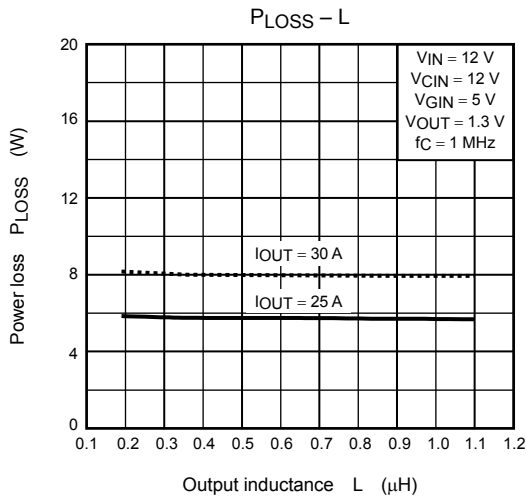
$$\text{Efficiency} = P_{OUT}/P_{IN}$$

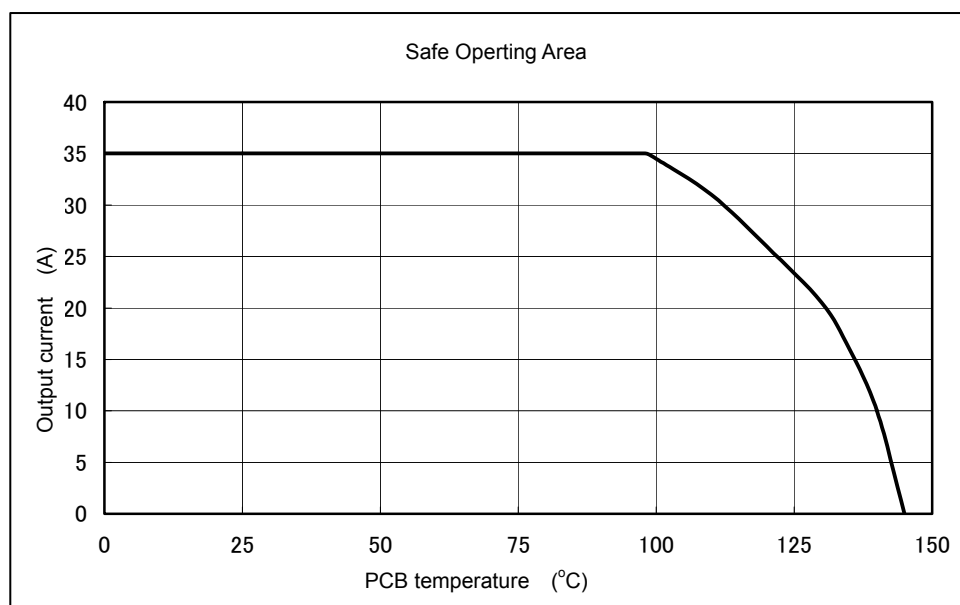
$$P_{LOSS} = P_{IN} - P_{OUT}$$

**Performance Characteristics**









$$V_{IN} = 12 \text{ V}, V_{CIN} = 12 \text{ V}, V_{GIN} = 5 \text{ V}, V_{OUT} = 1.3 \text{ V}, f_C = 1 \text{ MHz}, L = 0.6 \mu\text{H}$$

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  $\mu\text{m}$

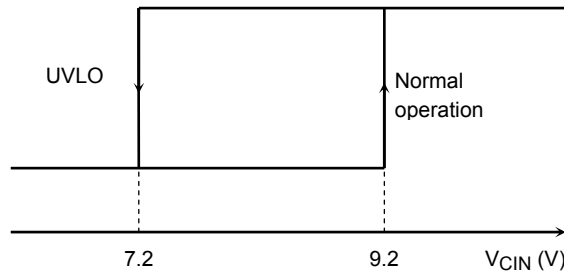
Board size: 75 mm  $\times$  55 mm

Board thickness: 2.4 mm

**Operational Description**

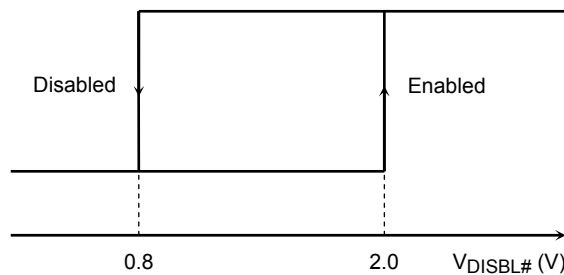
**Power Supplies**

- 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 TB7004AFL 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: 2.0 V (min)
- Falling threshold voltage: 0.8 V (max)
- 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: 2.0 V (min)
- Falling threshold voltage: 0.8 V (max)

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

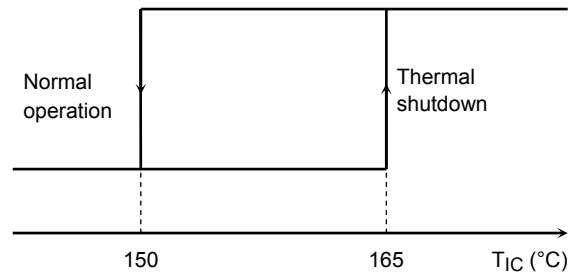
## Thermal Shutdown

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 TB7004AFL 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.

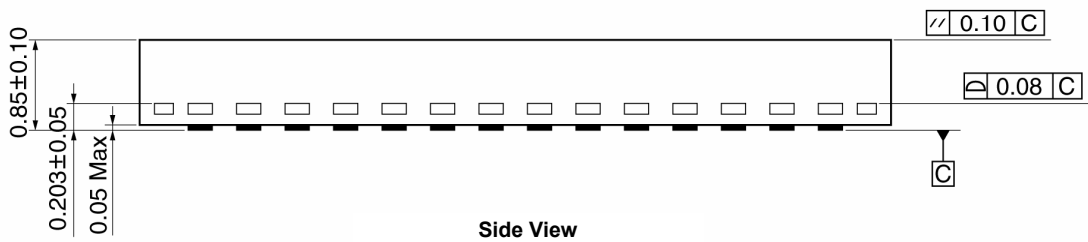
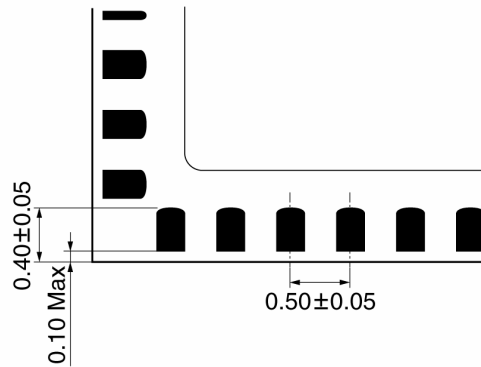
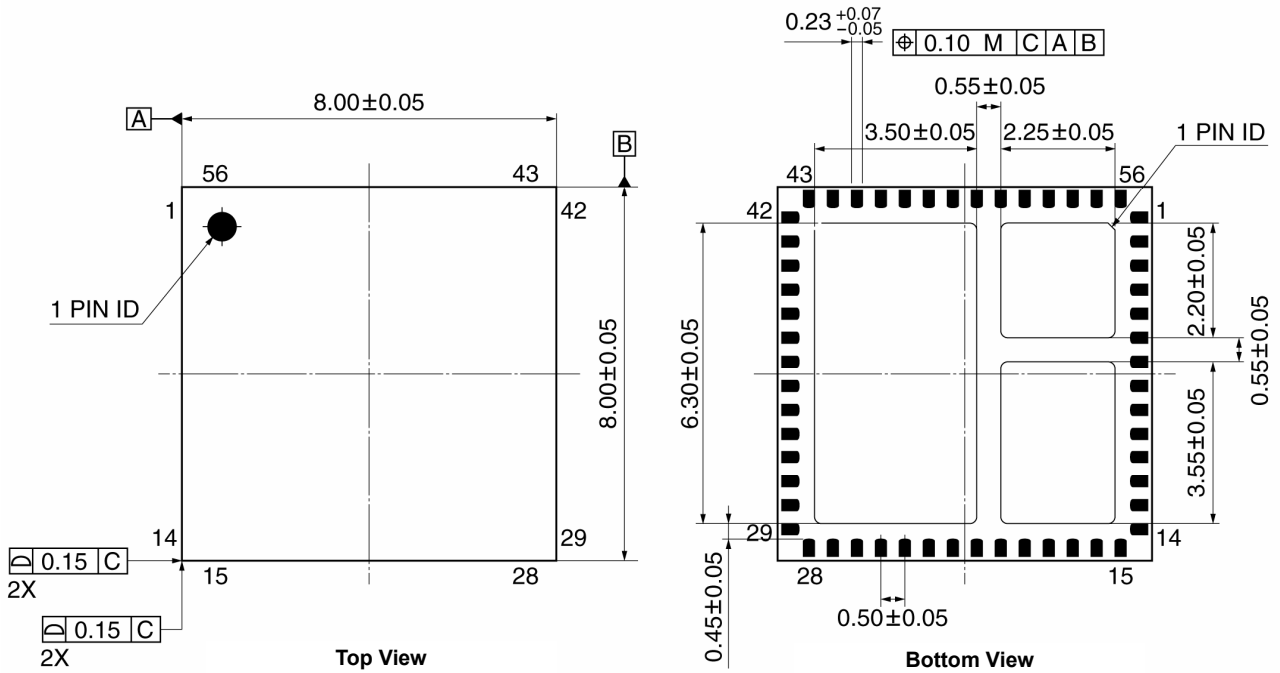
While the PWM signal is Low (i.e., the high-side MOSFET is off), the bootstrap capacitor is charged from the internal 5-V regulator. Be sure to use a sufficiently large capacitor.

Typical capacitance:  $> 0.2 \mu\text{F}$  ( $V_{IN} = 12 \text{ V}$ ,  $V_{OUT} = 1.3 \text{ V}$ ,  $f_C = 1 \text{ MHz}$ )

## Package Dimensions

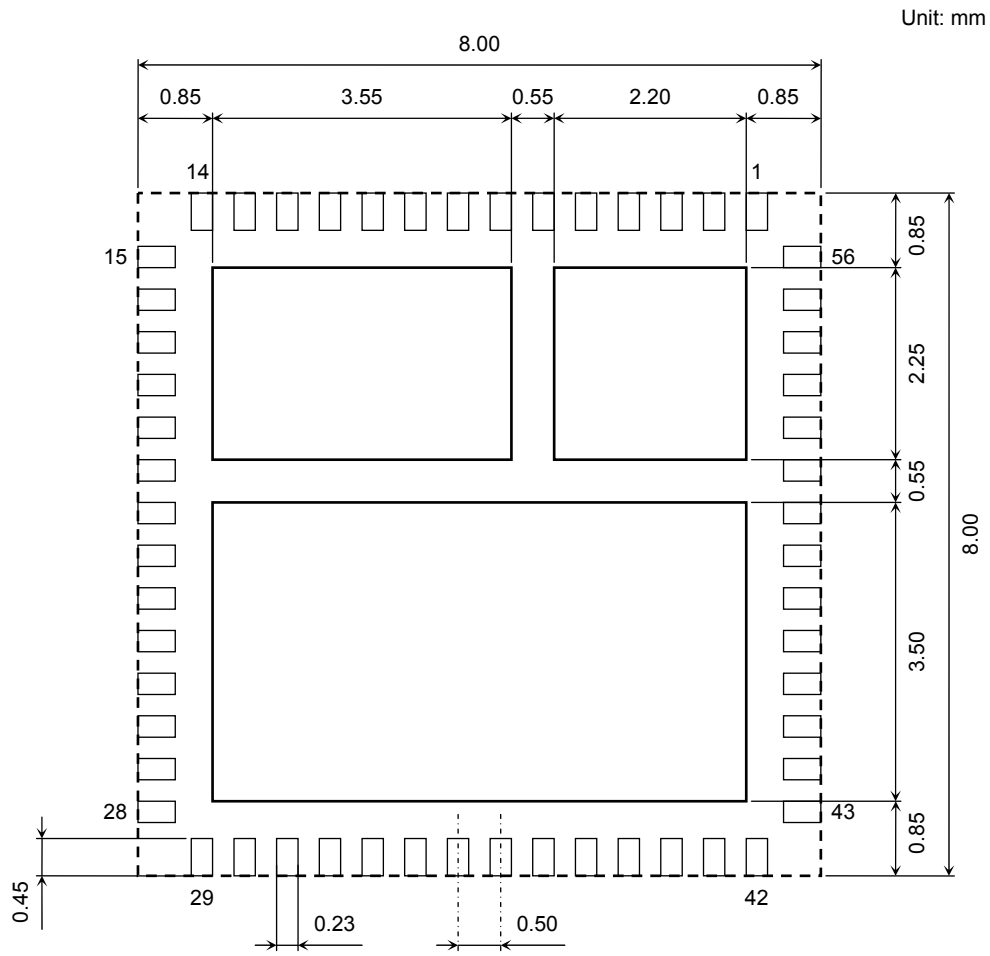
QFN56-P-0808-0.20

Unit: mm



Weight: 0.19 g (typ.)

**Recommended PCB Footprint**



**Note On Drypacking**

After the drypack is opened, the TB7004AFL should be soldered either within 168 hours of exposure to 30°C / 60% RH or within 96 hours of exposure to 30°C / 70% RH.

**RESTRICTIONS ON PRODUCT USE**

20070701-EN GENERAL

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