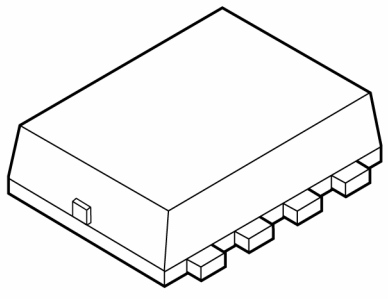
Toshiba BiCD Integrated Circuit Silicon Monolithic

TB7102F

Step-down DC-DC Converter IC

The TB7102F is a single-chip step-down DC-DC converter IC. Equipped with a built-in high-speed and low on-resistance power MOSFET, and utilizing a synchronous rectifier circuit, this IC can achieve high efficiency.



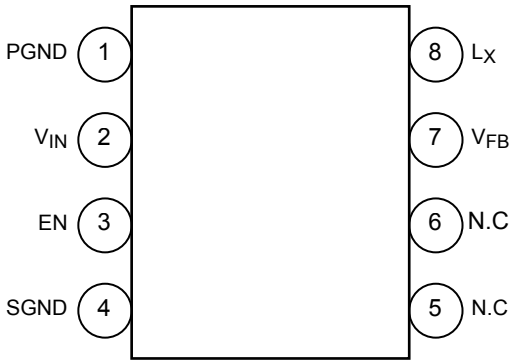
SON8-P-0303-0.65A

Weight : 0.017 g (typ.)

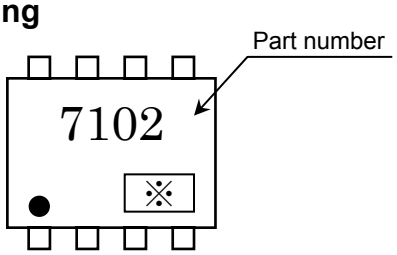
Features

- Capable of high current drive (I_{OUT} = maximum of 1 A), using only a few external components
- High efficiency (η = 95%) (@V_{IN} = 5V, V_{OUT} = 3.3V, and I_{OUT} = 300 mA).
- Operating voltage (V_{IN}) range: 2.7V to 5.5 V
- High oscillation frequency of 1 MHz (typ.), making it possible to use small external components.
- Uses internal phase compensation, achieving high efficiency using only a few external components.
- A small surface mount-type ceramic capacitor can be used as an output smoothing capacitor.
- Housed in a small surface-mount package (PS-8) with low thermal resistance.
- Under voltage lock out (U.V.L.O), Heat protection, and Over Current Protection is built into.

Pin Assignment



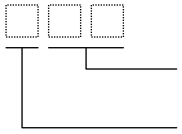
Marking



・The dot (•) on the top surface indicates pin 1.

*: Lot number

* The Lot number comprises three numerals. The first numeral represents the last digit of the year of manufacture, and the following two digits indicate the week of manufacture, beginning with 01 and continuing to either 52 or 53.



Manufacturing week Code
(The first week of the year is 01,continuing up to 52 or 53)

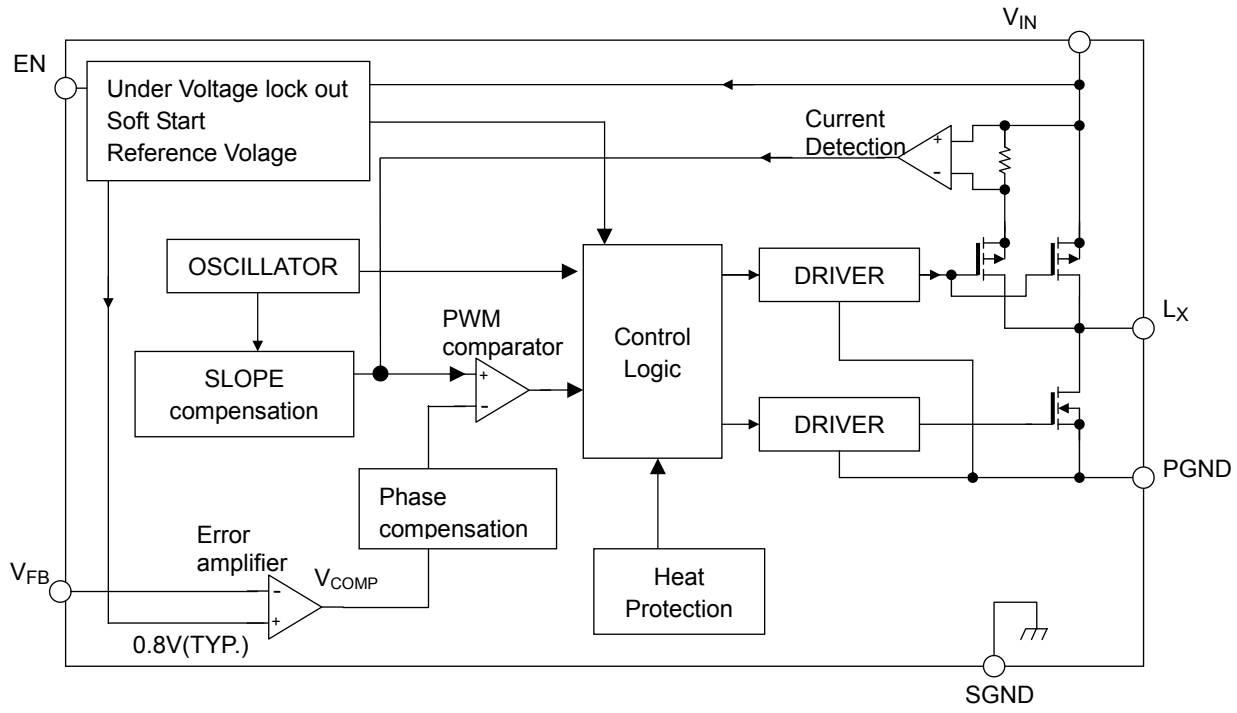
Manufacturing year Code
(Last digit of the year of manufacture)

Due to its MOS structure, this product is sensitive to electrostatic discharge. Handle with care.

How to Order

Product No.	Package Type and Capacity
TB7102F(TE85L,F)	Emboss Taping (3000pcs / reel)

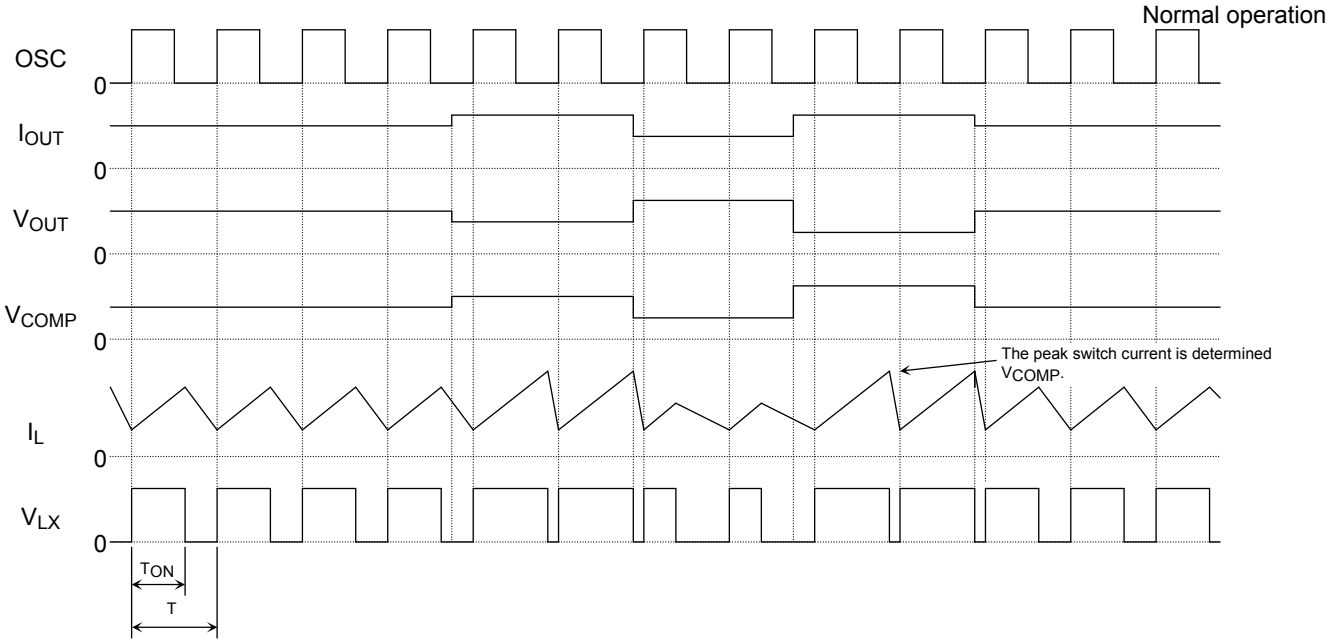
Block Diagram



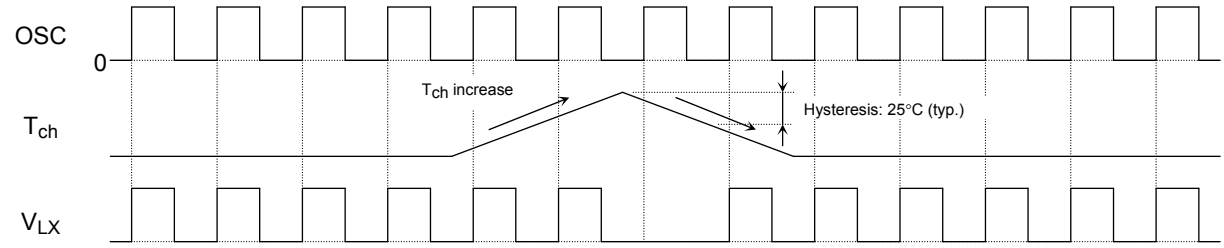
Pin Descriptions

Pin No.	Pin Symbol	Pin Description
1	PGN	Power ground
2	V_{IN}	Input pin. This pin is placed in the standby state if V_{ENB} = low. 1 μA or lower operating current.
3	EN	Enable pin. This pin is connected to the CMOS inverter. Applying 3.5 V or higher (@ V_{IN} = 5 V) to this pin starts the internal circuit switching control.
4	SGND	Signal ground
5	N.C.	No connection
6	N.C.	No connection
7	V_{FB}	Output voltage feedback pin. This is connected to the internal error amplifier, which is supplied with a reference voltage of 0.8 V (typ.).
8	L_X	Switching pin. This pin is connected to high side Pch MOS FET and low side Nch MOS FET.

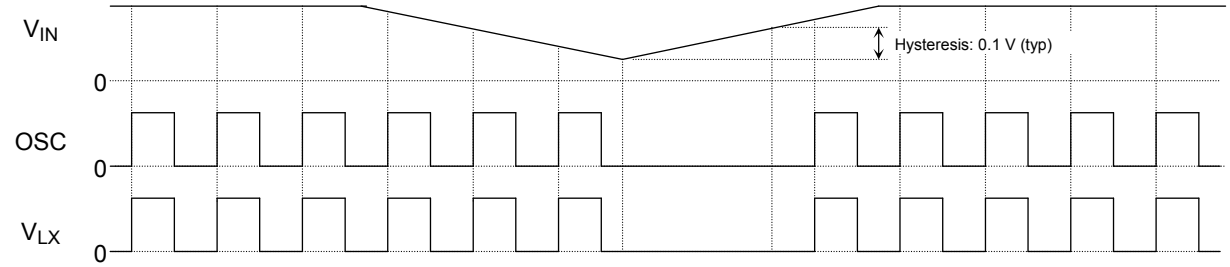
Timing Chart



Overheat state operation



Low Voltage operation



OSC : Internal oscillator output voltage
I_{OUT} : Load current
V_{OUT} : Output voltage
V_{COMP} : Output voltage of Error amplifier
I_L : Inductor current
V_{LX} : LX pin voltage
V_{IN} : Input pin voltage
T_{ch} : Channel temperature

Absolute maximum Ratings (Ta = 25°C)

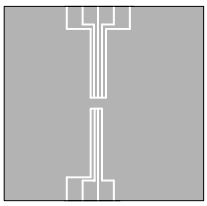
Characteristics	Symbol	Rating	Unit
Input voltage	V_{IN}	-0.3～6	V
Switch pin voltage	V_{LX}	-0.3～6	V
Feedback pin voltage	V_{FB}	-0.3～6	V
Enable pin voltage	V_{EN}	-0.3～6	V
Input-enable pin voltage	V_{EN}-V_{IN}	V_{EN}-V_{IN}<0.3	V
Power dissipation (Note 1)	P_D	0.7	W
Operating temperature	T_{opr}	-40～85	°C
Operating junction temperature	T_{jopr}	-40～125	°C
Channel temperature	T_{ch}	150	°C
Storage temperature	T_{stg}	-55～150	°C

Note 2: Using continuously under heavy loads (e.g. the application of high temperature/current/voltage and the significant change in temperature, etc.) may significantly reduce the reliability of this product even if the operating conditions (i.e. operating temperature/current/voltage, etc.) are within the absolute maximum ratings and the operating ranges.
Please consult 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) when designing the appropriate reliability while.

Thermal Resistance Characteristic

Characteristics	Symbol	Max	Unit
Thermal resistance, channel and ambient	$R_{th\ (ch\text{-}a)}$	178.6 (Note 1)	°C /W

(Note 1)
Glass epoxy board



Material : FR-4
25.4 × 25.4 × 0.8
(Unit: mm)

Electrical Characteristics (unless otherwise specified: Tj = 25°C and V_{IN} = 2.7 to 5.5 V)

Characteristics		Symbol	Test circuit	Test condition	Min	Typ.	Max	Unit
Operating supply voltage		$V_{IN(OPR)}$	—	—	2.7	—	5.5	V
Operating current		$I_{IN(1)}$	—	V_{IN}= 5V, V_{EN}= 5V, V_{FB} =5V	—	0.68	0.9	mA
		$I_{IN(2)}$	—	V_{IN}= 2.7V, V_{EN}= 2.7V, V_{FB} =2.7V	—	0.55	0.7	mA
Standby current		$I_{IN(STBY)(1)}$	—	V_{IN}= 5V, V_{EN}= 0V	—	—	1	μA
		$I_{IN(STBY)(2)}$	—	V_{IN}= 2.7V, V_{EN}= 0V	—	—	1	μA
Enable pin threshold voltage		$V_{IH(EN)(1)}$	—	V_{IN}= 5V	3.5	—	—	V
		$V_{IH(EN)(2)}$	—	V_{IN}= 2.7V	1.9	—	—	V
		$V_{IL(EN)(1)}$	—	V_{IN}= 5V	—	—	1.5	V
		$V_{IL(EN)(2)}$	—	V_{IN}= 2.7V	—	—	0.8	V
Enable pin input current		$I_{IH(EN)(1)}$	—	V_{IN}= 5V, V_{EN}= 5V	6	—	20	μA
		$I_{IH(EN)(2)}$	—	V_{IN}= 2.7V, V_{EN}= 2.7V	3	—	10	μA
Feedback pin voltage		$V_{FB(1)}$	—	V_{IN}= 5V, V_{EN}= 5V	0.776	0.8	0.824	V
		$V_{FB(2)}$	—	V_{IN}= 2.7V, V_{EN}= 2.7V	0.776	0.8	0.824	V
Feedback pin current		$I_{FB(1)}$	—	V_{IN}= 5V, V_{EN}= 5V	-1	—	1	μA
		$I_{FB(1)}$	—	V_{IN}= 2.7V, V_{EN}= 2.7V	-1	—	1	μA
Line regulation		LINE REG	—	V_{IN}= V_{EN}= 2.7V～5.5V V_{OUT}=2.0V I_{OUT}= 10mA	—	3.2	10	mV/V
Load regulation		LOAD REG	—	V_{IN}=5V, V_{OUT}=2.0V I_{OUT}= 10mA～500mA	—	9	40	mV/A
High-side on-state resistance		$R_{DS(ON)(H)(1)}$	—	V_{IN}= 5V, V_{EN}= 5V, I_{LX}= 0.5A	—	0.27	—	Ω
		$R_{DS(ON)(H)(2)}$		V_{IN}= 2.7V, V_{EN}= 2.7V I_{LX}= 0.5A	—	0.36	—	Ω
Low-side on-state resistance		$R_{DS(ON)(L)(1)}$		V_{IN}= 5V, V_{EN}= 5V I_{LX}= 0.5A	—	0.27	—	Ω
		$R_{DS(ON)(L)(2)}$		V_{IN}= 2.7V, V_{EN}= 2.7V I_{LX}= 0.5A	—	0.3	—	Ω
High-side leakage current		$I_{LEAK(H)}$	—	V_{IN}= 5V, V_{EN}= 0V, V_{LX}= 0V	—	—	-1	μA
Low-side leakage current		$I_{LEAK(L)}$	—	V_{IN}= 5V, V_{EN}= 0V, V_{LX}= 5V	—	—	1	μA
Oscillation frequency		$f_{OSC(1)}$	—	V_{IN}= 5V, V_{EN}= 5V	0.85	1	1.15	MHz
		$f_{OSC(2)}$	—	V_{IN}= 2.7V, V_{EN}= 2.7V	0.85	1	1.15	MHz
Soft start time		tss(1)	—	V_{IN}=5V , V_{EN}=5V, (no load)	1	2	—	ms
		tss(2)	—	V_{IN}=2.7V , V_{EN}=2.7V, (no load)	1.3	2.4	—	ms
Undervoltage protection	Detection	V_{UV}	—	—	2.2	2.5	2.7	V
	Hysteresis	ΔV_{UV}	—	—	—	0.1	—	V

Electrical Characteristics Common to All Products

When a pulse test is carried out, Tj = 25°C is the standard condition in the measurements for each item.
Any drift in the electrical characteristic due to a rise in the junction temperature
of the chip may be disregarded.

Protection function (reference data)

Overheat protection	Detection	T_{SD}	–	–	–	160	–	°C
	Hysteresis	ΔT_{SD}		–	–	20	–	°C

Application Circuit Example

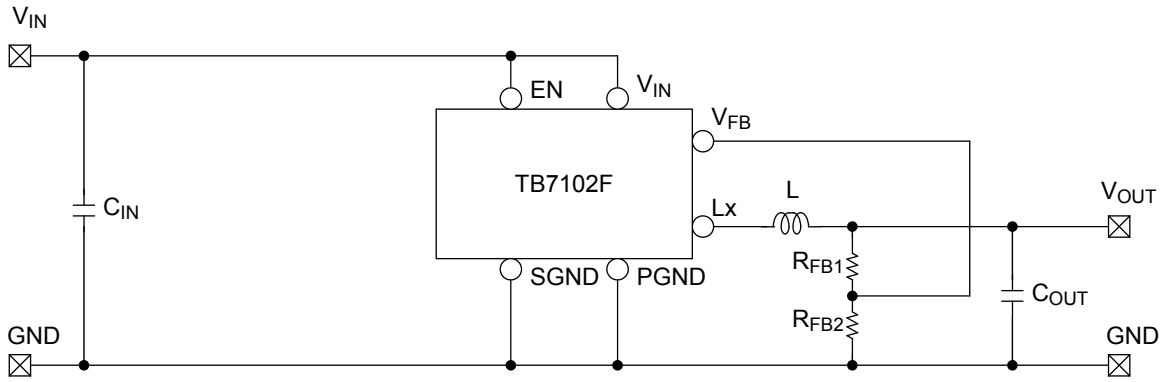


Figure 1: TB7102F application circuit example

Component constants
The following values are given only for your reference and may need tuning depending on your input/output conditions and board layout.

C_{IN}: Input smoothing capacitance of 10 μF
(multilayer ceramic capacitor JMK212BJ106KG, manufactured by Taiyo Yuden Co., Ltd.)
C_{OUT}: Output smoothing capacitance of 10 μF
(multilayer ceramic capacitor JMK212BJ106KG manufactured by Taiyo Yuden Co., Ltd.)
R_{FB1}: Output voltage setting resistance of 75 kΩ (@ V_{IN} = 5 V, V_{OUT} = 3.3 V)
R_{FB2}: Output voltage setting resistance of 24 kΩ (@ V_{IN} = 5 V, V_{OUT} = 3.3 V)
L: Inductor3.3 μH (@ V_{IN} = 5 V, V_{OUT} = 3.3 V); CDRH4D28C/LD series, manufactured by Sumida Corporation

How to use

Setting the Inductance

The required inductance can be calculated by using the following equation:

$$L = \frac{V_{IN} - V_{OUT}}{f_{OSC} \cdot \Delta I_L} \cdot \frac{V_{OUT}}{V_{IN}} \quad \cdots \quad (1)$$

V_{IN}: Input voltage (V)　　f_{OSC}: Oscillation frequency (Hz)
V_{OUT}: Output voltage (V)　　ΔI_L: Inductor ripple current (A)

* Generally, ΔI_L should be set to 30% to 40% of the maximum output current . For the TB7102F, set ΔI_L to 0.3 A, as its maximum current [$I_{LX(MAX)}$] is 1 A (min). Therefore select an inductor whose current rating is no lower than the peak switch current [1.15 A (min)] of the TB7102F. If the current rating is exceeded, the inductor becomes saturated, leading to an unstable DC-DC converter operation.

If V_{IN} = 5 V and V_{OUT} = 3.3 V, the required inductance can be calculated as below. Be sure to select an inductor

with an optimum constant by taking V_{IN} variations into consideration.

$$L = \frac{V_{IN} - V_{OUT}}{f_{OSC} \cdot \Delta I_L} \cdot \frac{V_{OUT}}{V_{IN}}$$
$$= \frac{5V - 3.3V}{1MHz \cdot 300mA} \cdot \frac{3.3V}{5V}$$
$$= 3.7\mu H$$

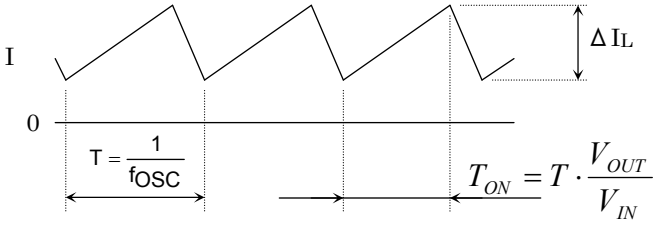


Figure 2: Inductor current waveform

Setting the output voltage

For the TB7102F, the output voltage is set using the voltage dividing resistors R_{FB1} and R_{FB2} according to the reference voltage [0.8 V (typ.)] of the error amplifier connected to the FB pin. The output voltage can be calculated by using equation 2 below. If the R_{FB1} value is extremely large, a delay can occur due to parasitic capacitance at the FB pin. Keep the R_{FB1} value at approximately 10 kΩ. Output voltage that can be set is from 0.8 V (typ.) to Input voltage -1V. It is recommended that a resistor with a precision of ±1% or higher be used for setting the output voltage.

$$V_{OUT} = V_{REF} \cdot (1 + \frac{R_{FB1}}{R_{FB2}})$$
$$= 0.8 \times (1 + \frac{R_{FB1}}{R_{FB2}}) \quad \cdots \quad (2)$$

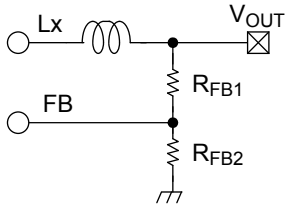


Figure 3: Output voltage setting resistors

Table1 :Example of output voltage setting

Output Voltage	R_{FB1}	R_{FB2}
1.2V	1.2kΩ	2.4kΩ
1.5V	2.1kΩ	2.4kΩ
1.8V	3.0kΩ	2.4kΩ
2.5V	5.1kΩ	2.4kΩ
3.3V	7.5kΩ	2.4kΩ

Output capacitor

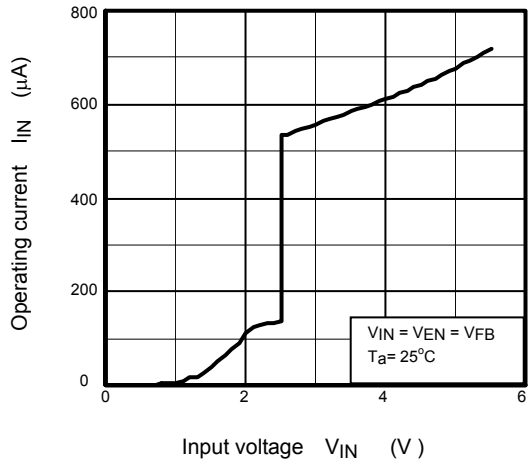
The capacitance of the output ceramic capacitor is greatly affected by temperature. Select a product whose temperature characteristics (such as B-characteristic) are excellent. The capacity value should be adjusted to about 10μF(@Output Voltage 2.0V~4.5V), or about 22μF(@Output Voltage 1.2V~2.0V),and the capacitance set to an optimum value that meets the set's ripple requirement. Ceramic capacitors can be used to achieve low output ripple. It is more difficult to achieve phase compensation with ceramic capacitors because the equivalent series resistance (ESR) of the former is lower. For this reason, perform a careful evaluation when using ceramic capacitors.

Precautions

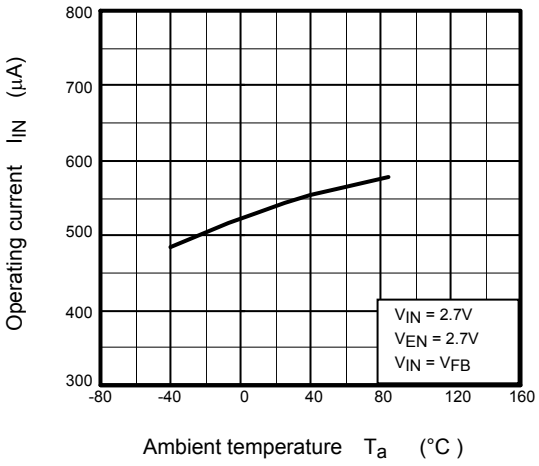
- Please select parts after confirming the actual operation in the customer set and considering the input voltage the output voltage, the output current, the temperature, the characteristics or the kind of capacitor, the inductor and resistance .
- If the voltage between the input and output is low, the influence of the on-state voltage of the switch power MOSFET is greater, causing the voltage across the inductor to decrease. For this reason, it may become impossible for the required inductor current to flow, resulting in lower performance or unstable operation of the DC-DC converter. As a rough standard, keep the input-output voltage potential difference at or above 1 V, taking the on-state voltage of the power MOSFET into consideration.
- The lowest output voltage that can be set is 0.8 V (typ.).
- There is an antistatic diode between the ENB and V_{IN} pins. The voltage between the ENB and V_{IN} pins should satisfy the rating V_{ENB} - V_{IN} < 0.3 V
- If the operation becomes unstable due to the switching noise under a heavy load, please mount a by-pass capacitor C_{cc} between the SGND pin and the VIN pin.

Characteristic data

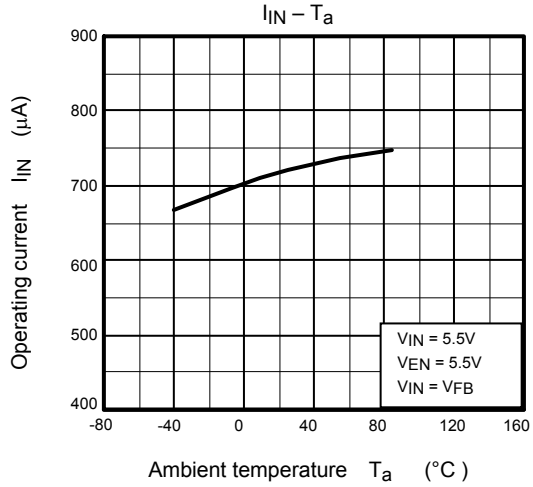
$I_{IN} – V_{IN}$



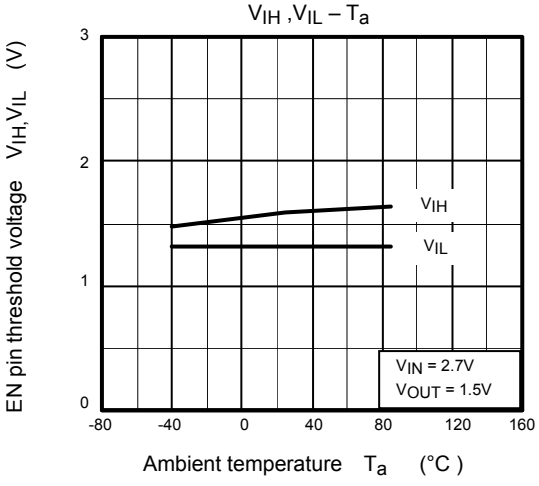
$I_{IN} – T_a$



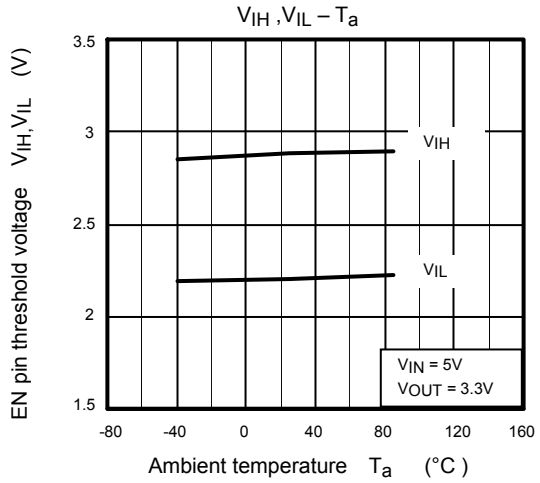
$I_{IN} – T_a$



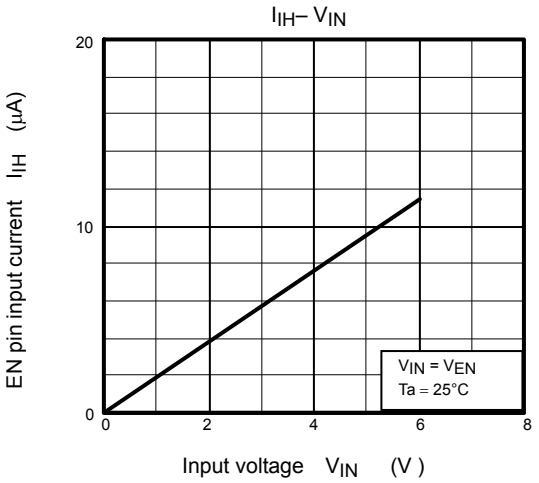
V_{IH} ,V_{IL} – T_a



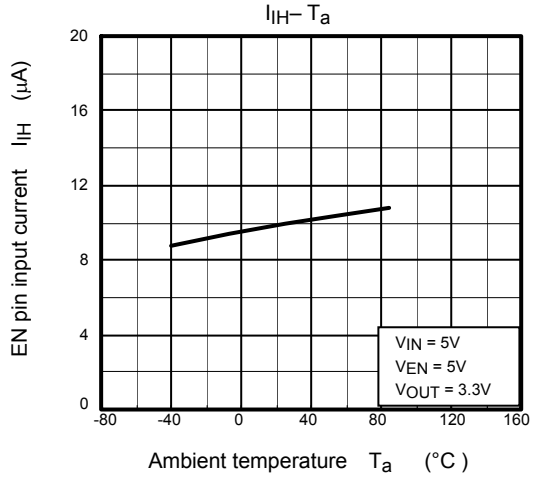
V_{IH} ,V_{IL} – T_a



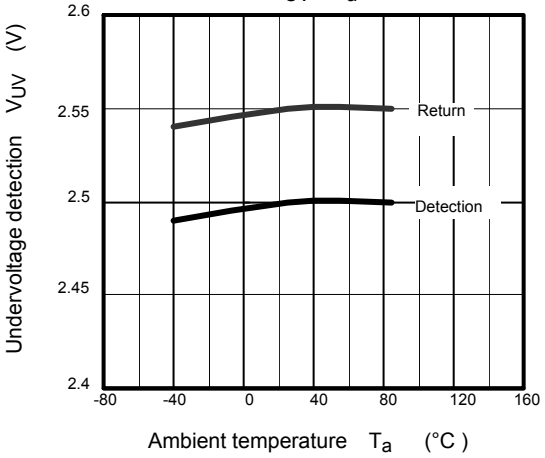
I_{IH}– V_{IN}



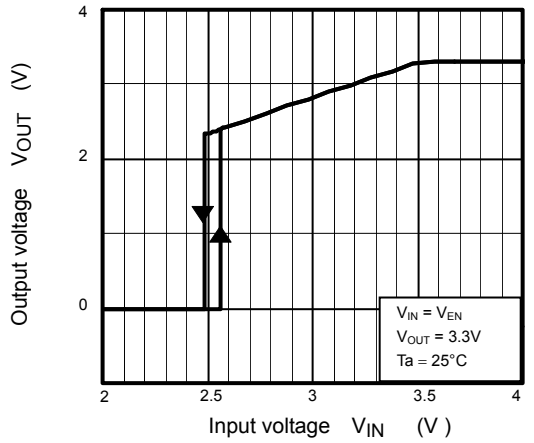
I_{IH} – T_a



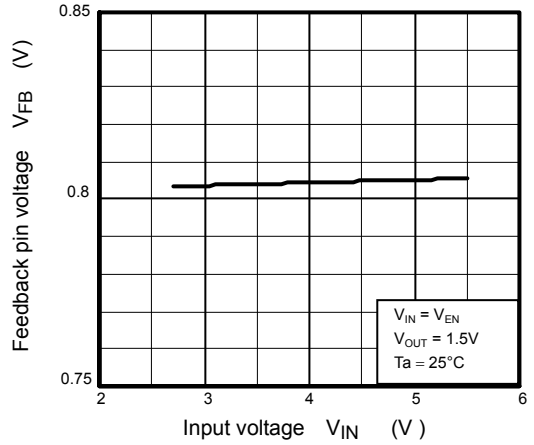
V_{UV} – T_a



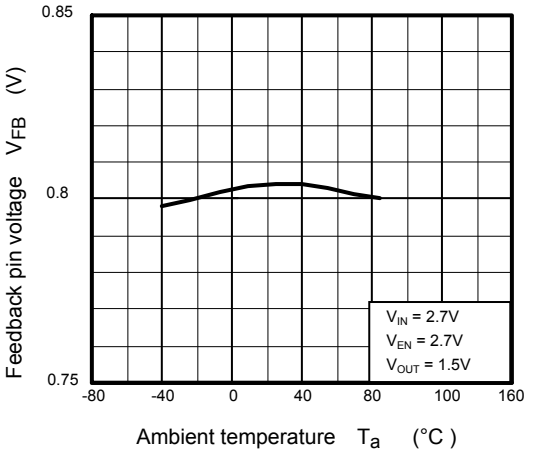
V_{OUT} – V_{IN}



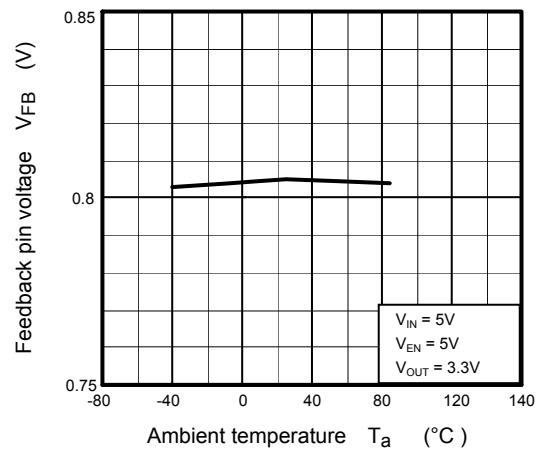
V_{FB} – V_{IN}



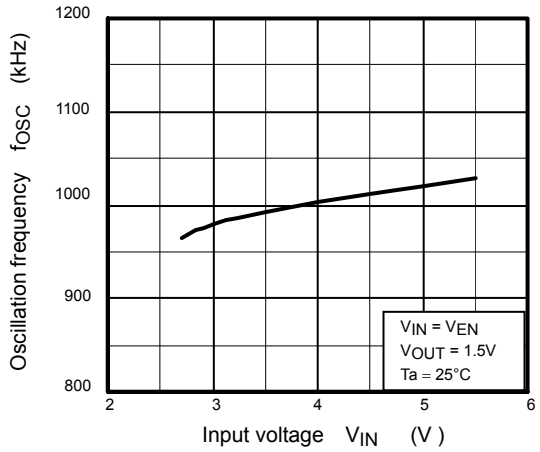
V_{FB} – T_a



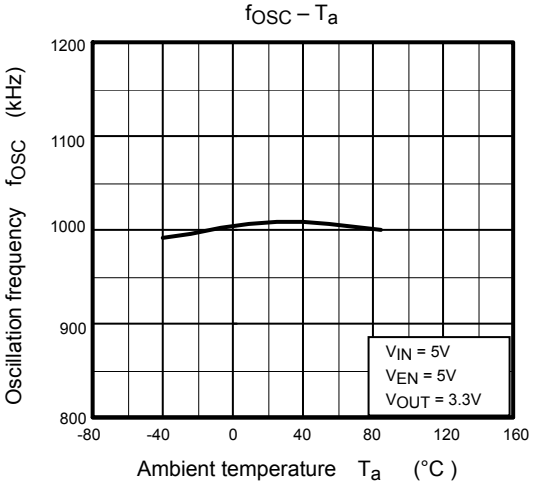
V_{FB} – T_a



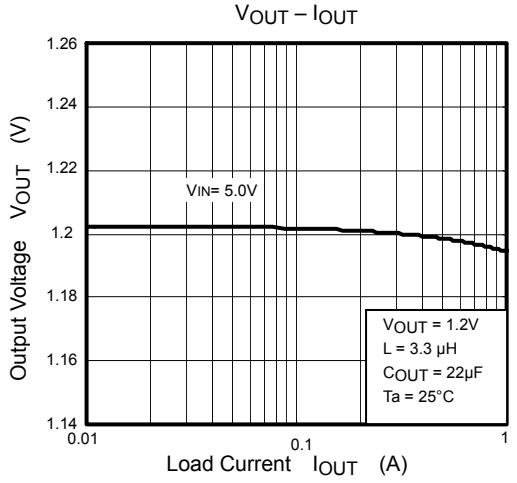
$f_{OSC} - V_{IN}$



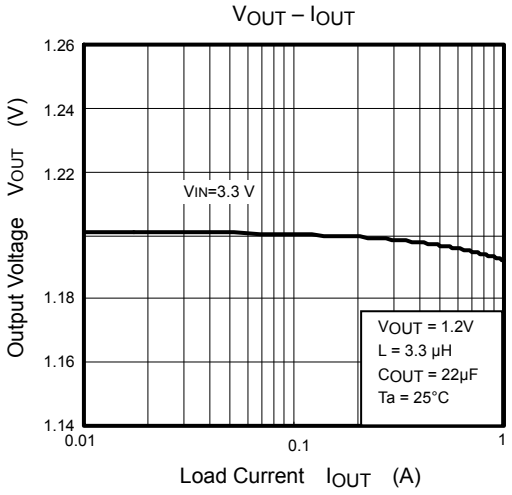
$f_{OSC} - T_a$



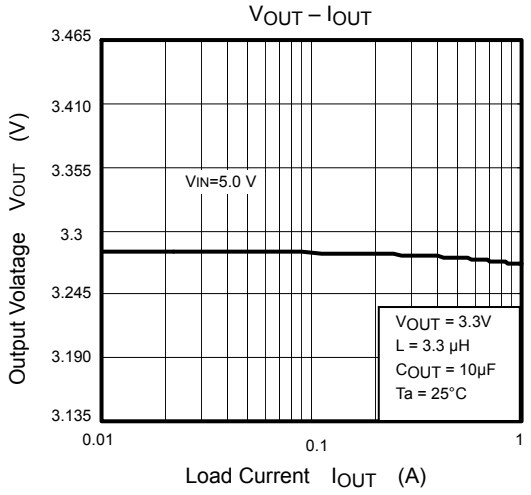
$V_{OUT} - I_{OUT}$



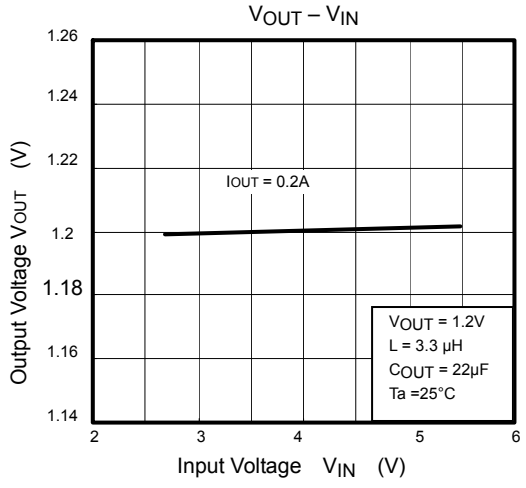
$V_{OUT} - I_{OUT}$



$V_{OUT} - I_{OUT}$



$V_{OUT} - V_{IN}$



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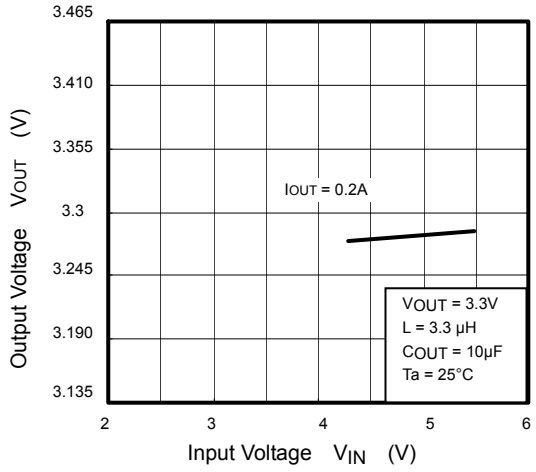
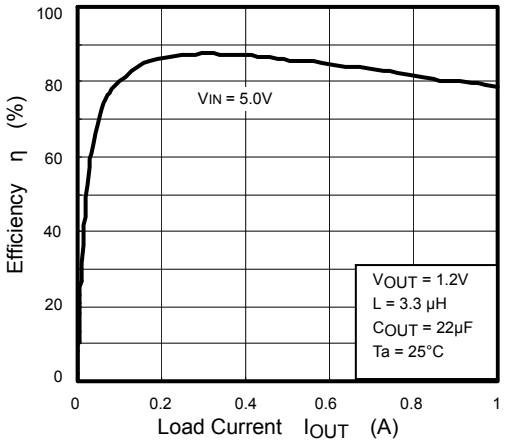


$\eta - I_{OUT}$



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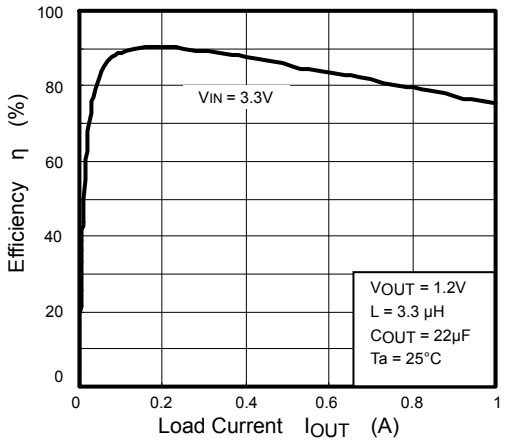

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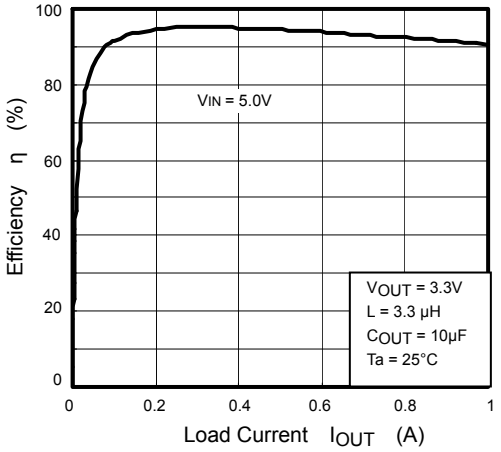
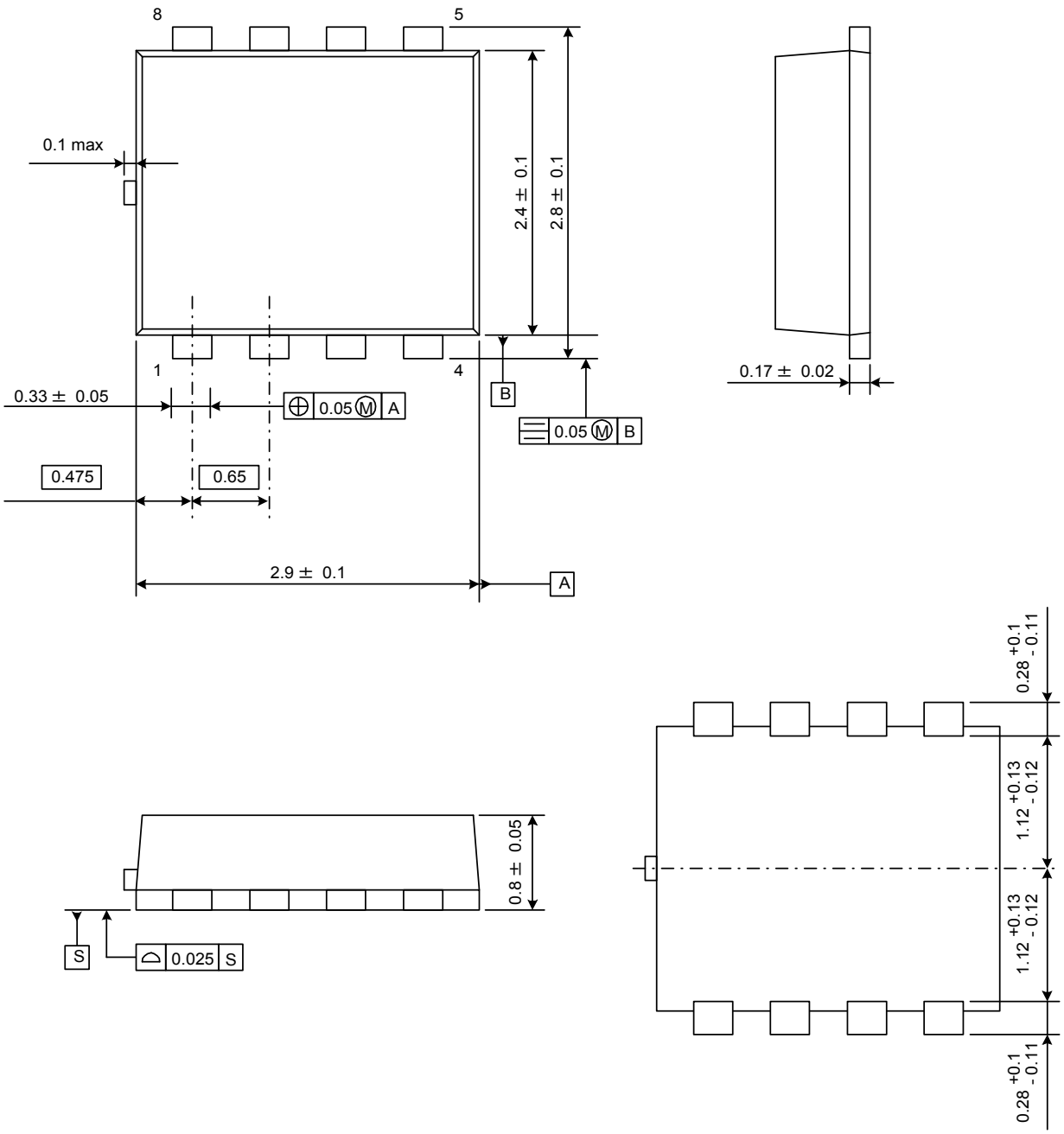


Package dimensions

SON8-P-0303-0.65A

Unit: mm



Weight: 0.017 g (Typ.)

RESTRICTIONS ON PRODUCT USE

20070701-EN

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