



**ON Semiconductor®**

<http://onsemi.com>

# LV52204MT

Bi-CMOS IC

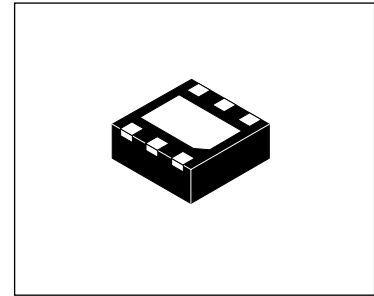
## LED Boost Driver with PWM and 1-Wire Dimming

### Overview

The LV52204MT is a high voltage boost driver for LED drive. LED current is set by the external resistor R1 and LED dimming can be done by changing FB voltage with PWM or 1-Wire.

### Features

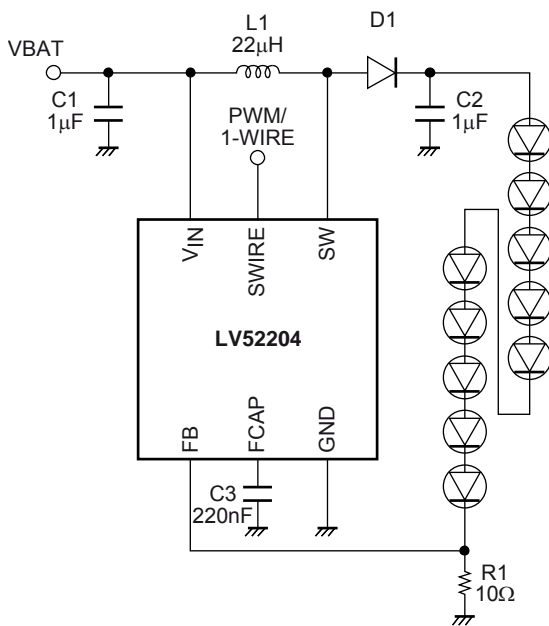
- Operating Voltage from 2.7V to 5.5V
- 1-Wire 32 level digital and PWM dimming
- Integrated 40V MOSFET
- 600kHz Switching Frequency



WDFN6 2x2, 0.65P

### Typical Applications

- LED Display Backlight Control



### ORDERING INFORMATION

See detailed ordering and shipping information on page 16 of this data sheet.

# LV52204MT

## Specifications

### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{CC\text{ max}}$	$V_{CC}$	6.0	V
Maximum pin voltage1	$V1\text{ max}$	SW	40	V
Maximum pin voltage2	$V2\text{ max}$	Other pin	5.5	V
Allowable power dissipation	$Pd\text{ max}$	$T_a = 25^\circ\text{C}^*1$	2.05	W
Operating temperature	$T_{opr}$		-30 to +85	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +125	$^\circ\text{C}$

\*1 Mounted on a specified board: 70mm×50mm×1.2mm (4 layer glass epoxy)

Caution 1) Absolute maximum ratings represent the values which cannot be exceeded for any length of time.

Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### Recommendation Operating Condition at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range1	$V_{CC\text{ op}}$	$V_{CC}$	2.7 to 5.5	V
PWM frequency	$F_{pwm}$	PWM MODE	300 to 100k	Hz
PWM minimum duty	$F_{duty}$	10kHz, $V_{IN} \geq 3.3\text{V}$ , $-30^\circ\text{C}$ to $85^\circ\text{C}^*2$	2	%
		20kHz, $V_{IN} \geq 3.3\text{V}$ , $-30^\circ\text{C}$ to $85^\circ\text{C}^*2$	4	%
		30kHz, $V_{IN} \geq 3.3\text{V}$ , $-30^\circ\text{C}$ to $85^\circ\text{C}^*2$	6	%

\*2 Guaranteed by design

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

### Electrical Characteristics Analog block at $T_a = 25^\circ\text{C}$ , $V_{CC} = 3.6\text{V}$ , unless otherwise specified

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby current dissipation	$I_{CC1}$	SHUTDOWN		0	5	$\mu\text{A}$
DC/DC current dissipation	$I_{CC2}$	$V_{OUT} = 30\text{V}$ , $I_{LED} = 20\text{mA}$			1	$\text{mA}$
FB voltage	$V_{fb}$	PWM duty 100%	0.19	0.2	0.21	V
FB pin leak current	$I_{fb}$				1	$\mu\text{A}$
OVP voltage	$V_{ovp}$	SW	37	38	39	V
SWOUT ON resistance	$R_{on}$	$I_L = 100\text{mA}$		700		$\text{m}\Omega$
NMOS switch current limit	$I_{LIM}$	$V_{fb} = 200\text{mV}$		0.7		A
OSC frequency	$F_{osc}$			600		kHz
High level input voltage	$V_{INH}$	SWIRE	1.5		$V_{CC}$	V
Low level input voltage	$V_{INL}$	SWIRE	0		0.4	V
Under voltage lockout	$V_{uvlo}$	$V_{IN}$ falling		2.2		V
SWIRE output voltage for Acknowledge	$V_{ack}$	$R_{pullup} = 15\text{k}\Omega$			0.4	V

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

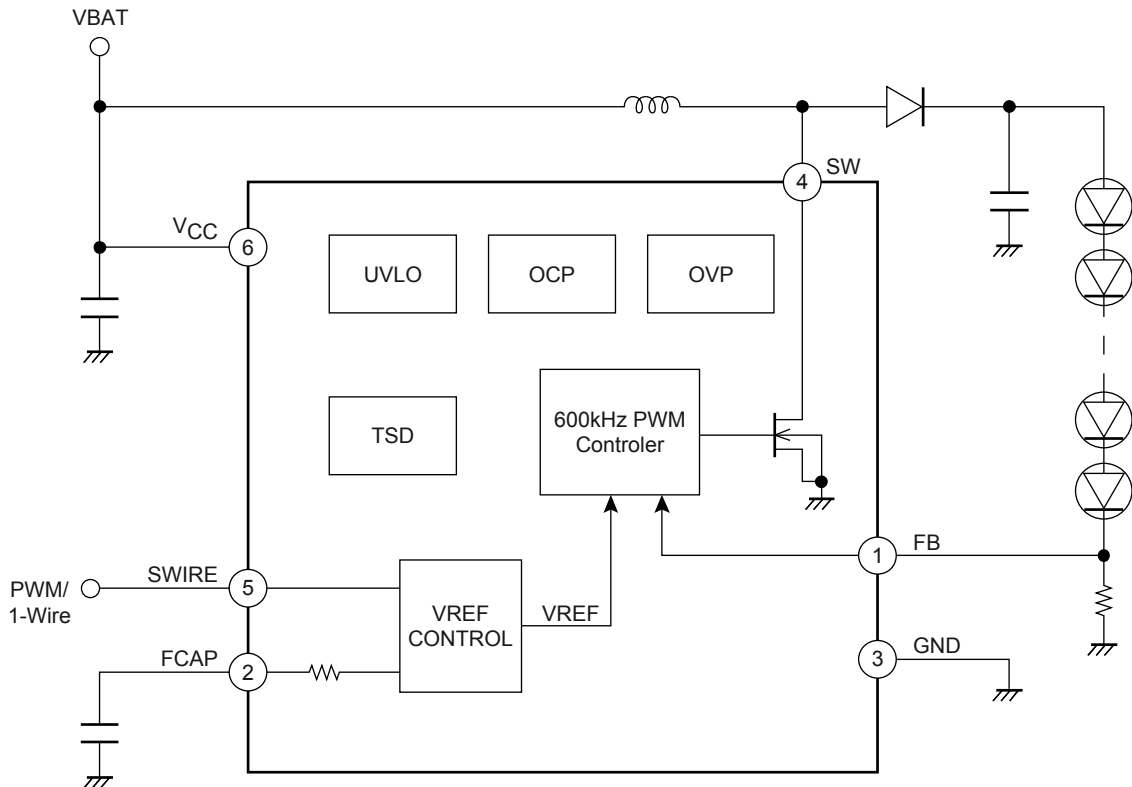
# LV52204MT

**Recommended SWIRE Timing** at  $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 3.6\text{V}$ , unless otherwise specified

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
SWIRE setup time1 from shutdown	Ton1	PWM duty more than 2%, $V_{IN} \geq 3.3\text{V}$ , $-30^\circ\text{C}$ to $85^\circ\text{C}$ *3	2			$\mu\text{s}$
SWIRE setup time2 from shutdown	Ton2		20			$\mu\text{s}$
SWIRE mode selectable time	Tsel		1		2.2	ms
SWIRE delay time to start digital mode detection	Tw0		100			$\mu\text{s}$
SWIRE low time to switch to digital mode	Tw1		260			$\mu\text{s}$
SWIRE low time to shutdown	Toff		8.9			ms
SWIRE start time for digital mode programming	Tstart		2			$\mu\text{s}$
SWIRE end time for digital mode programming	Tend		2		360	$\mu\text{s}$
SWIRE High time of bit 0	Th0	Bit detection = 0	2		180	$\mu\text{s}$
SWIRE Low time of bit 0	TI0	Bit detection = 0	$\text{Th0} \times 2$		360	$\mu\text{s}$
SWIRE High time of bit 1	Th1	Bit detection = 1	$\text{TI1} \times 2$		360	$\mu\text{s}$
SWIRE Low time of bit1	TI1	Bit detection = 1	2		180	$\mu\text{s}$
DCDC startup delay	Tdel			2		ms
Delay time of Acknowledge	Tackd				2	$\mu\text{s}$
Duration of Acknowledge	Tack				512	$\mu\text{s}$

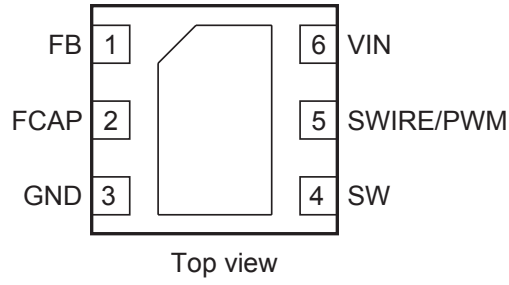
\*3 Guaranteed by design

## Block Diagram



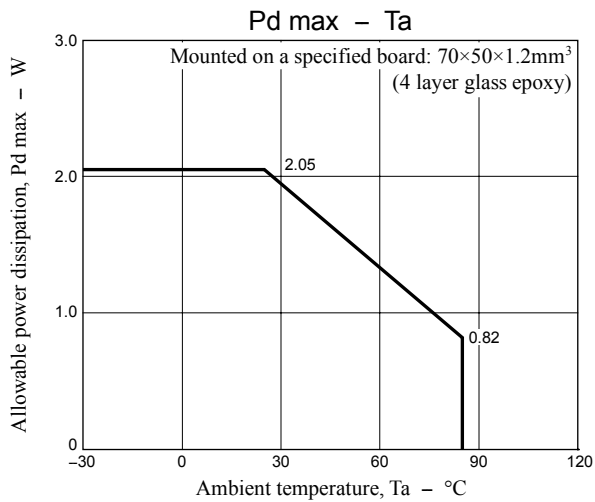
# LV52204MT

## Pin Connections



## Pin Function

PIN #	Pin Name	Description
1	FB	Feedback pin.
2	FCAP	Filtering capacitor terminal for PWM mode.
3	GND	Ground
4	SW	Switch pin. Drain of the internal power FET.
5	SWIRE	1-wire dimming control and PWM dimming input (active High).
6	V <sub>CC</sub>	Supply voltage.
	Expose-pad	Connect to GND on PCB.



## LED Current Setting

LED current is set by an external resistor connected between the FB pin and ground.

$$I_{LED} = V_{FB}/R_{FB}.$$

The  $V_{FB}$  can be controlled by two dimming modes, PWM Mode or Digital Mode. In PWM mode, PWM input is converted into a near DC current by the internal resistor  $R$  that was equivalent to  $60k\Omega (\pm 10\%)$  and the external capacitor  $C_{FCAP}$  as a low pass filter with a cut-off frequency  $f_c = 1/2\pi R_{FCAP}$ . The  $V_{FB}$  can be adjusted by altering the duty cycle of the PWM signal (See Fig.1).

$$V_{FB} = 200 \text{ (mV)} \times \text{PWM Duty (\%)}$$

On the other hand,  $V_{FB}$  can be selected one from among 32 steps in Digital Mode (See Fig.2).

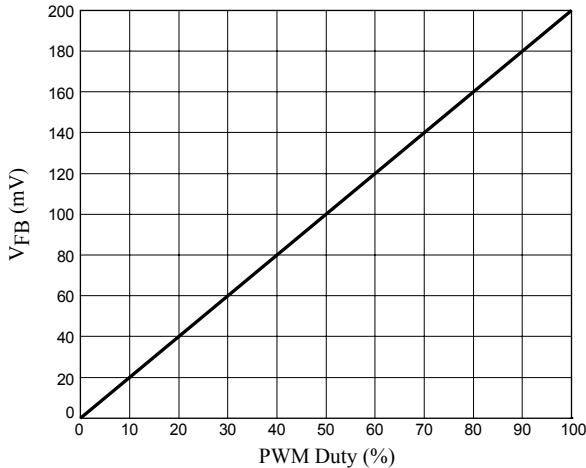


Fig1.  $V_{FB}$  vs. PWM Duty (PWM mode)

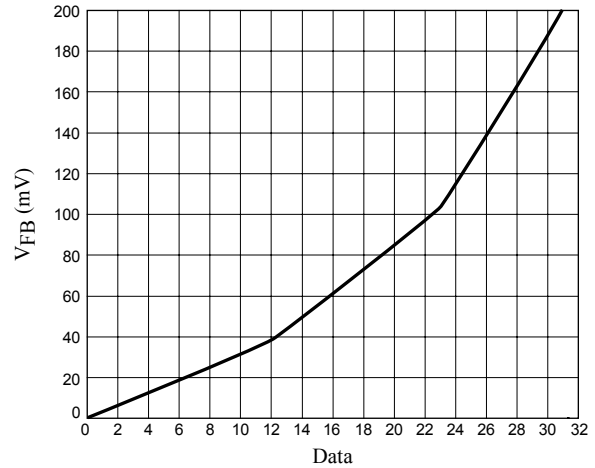


Fig2.  $V_{FB}$  vs. Data Register Value (Digital mode)

## Dimming Mode Selection

Dimming Mode is selected by a specific pattern of the SWIRE within  $T_{sel}$  (1ms) from the startup of the device every time. In order to startup the device, the SWIRE must keep high for longer than  $T_{on}$ .

### PWM Mode

The dimming mode is set to PWM mode when it is not recognized as a digital mode within  $T_{sel}$ . To enter Digital Mode, the SWIRE is required keeping in low state for  $T_{w1}$  (See Fig.4). If the PWM frequency is used faster than 6.6kHz, the dimming mode is set to PWM mode only. But slower than 6.6kHz, it is necessary to avoid entering the digital mode condition, such as SWIRE keeps high for longer than  $T_{sel}$ . PWM is enabled after  $T_{del}$  from  $T_{sel}$ .

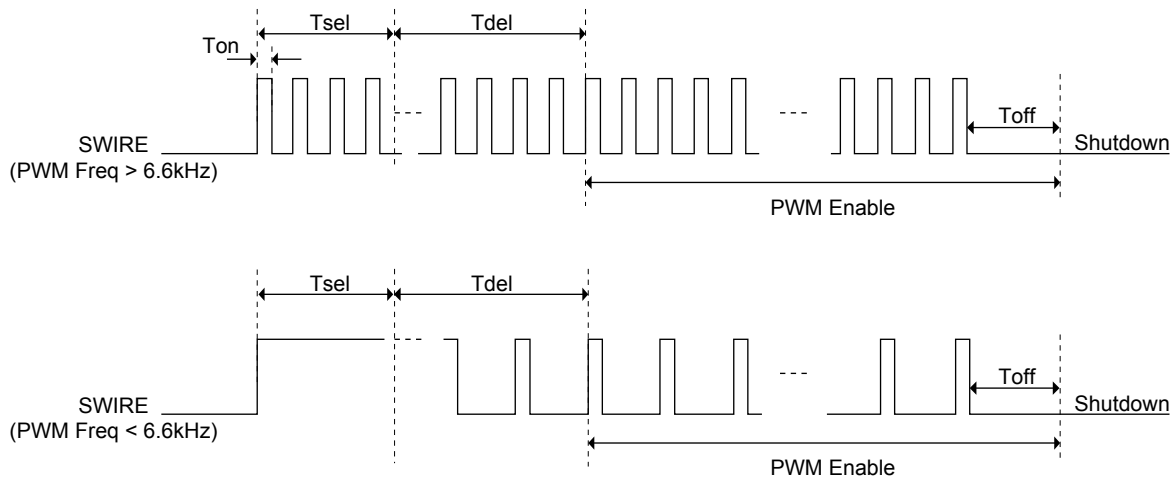


Fig3. SWIRE Timing Diagram in PWM mode

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## Digital Mode

To enter Digital Mode, SWIRE should be taken high for more than  $T_{w0}$  (100 $\mu$ s) from the first rising edge and keep low state for  $T_{w1}$ (260 $\mu$ s) before  $T_{sel}$ (1ms).

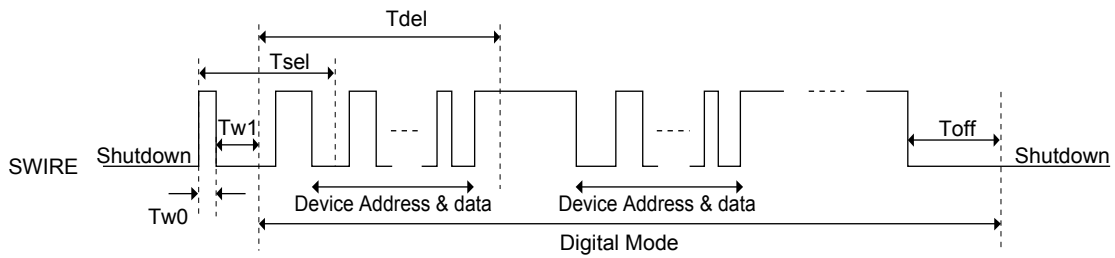


Fig4. SWIRE Timing Diagram in Digital mode

It is required sending the device address byte and the data byte to select  $V_{FB}$ . The bit detection is determined by the ratio of  $T_h$  and  $T_l$  (See Fig6). The start condition for the bit transmission required SWIRE high for at least  $T_{start}$ . The end condition is required SWIRE low for at least  $T_{end}$ . When data is not being transferred, SWIRE is set in the “H” state. These registers are initialized with POR (Power On Reset).

In the LV52204MT, the device address (DA7 to DA0) is specified as “01110010”. D7 is setting for the acknowledge response. If the device address and the data byte are transferred on  $D7 = 1$ , the ACK signal is sent from the receive side to the send side. The acknowledge signal is issued when SWIRE on the send side is released and SWIRE on the receive side is set to low state. D6 and D5 need to send 0. D4 to D0 allow to changing the FB voltage.

	Register	BIT	Description
Device Address	DA7	7	0
	DA6	6	1
	DA5	5	1
	DA4	4	1
	DA3	3	0
	DA2	2	0
	DA1	1	1
	DA0	0	0

Table1. Device Address Description

	Register	BIT	Description
Data	D7	7	0 = Acknowledge disabled 1 = Acknowledge enabled
	D6	6	0
	D5	5	0
	D4	4	Data bit 4
	D3	3	Data bit 3
	D2	2	Data bit 2
	D1	1	Data bit 1
	D0	0	Data bit 0

Table2. Data Description

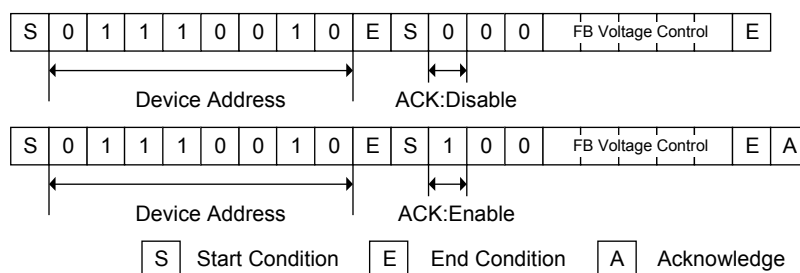
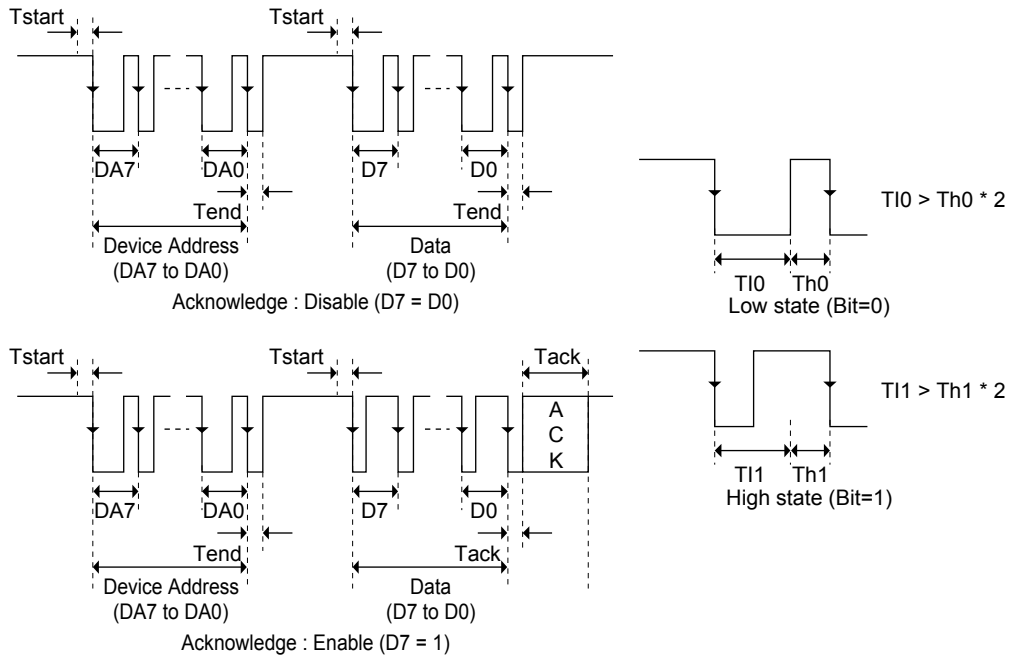


Fig5. Example of writing data

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**Fig6.Bit detection Diagram**

	D7	D6	D5	D4	D3	D2	D1	D0	FB voltage (mV)
0	1/0	0	0	0	0	0	0	0	0
1	1/0	0	0	0	0	0	0	1	5
2	1/0	0	0	0	0	0	1	0	8
3	1/0	0	0	0	0	0	1	1	11
4	1/0	0	0	0	0	1	0	0	14
5	1/0	0	0	0	0	1	0	1	17
6	1/0	0	0	0	0	1	1	0	20
7	1/0	0	0	0	0	1	1	1	23
8	1/0	0	0	0	1	0	0	0	26
9	1/0	0	0	0	1	0	0	1	29
10	1/0	0	0	0	1	0	1	0	32
11	1/0	0	0	0	1	0	1	1	35
12	1/0	0	0	0	1	1	0	0	38
13	1/0	0	0	0	1	1	0	1	44
14	1/0	0	0	0	1	1	1	0	50
15	1/0	0	0	0	1	1	1	1	56
16	1/0	0	0	1	0	0	0	0	62
17	1/0	0	0	1	0	0	0	1	68
18	1/0	0	0	1	0	0	1	0	74
19	1/0	0	0	1	0	0	1	1	80
20	1/0	0	0	1	0	1	0	0	86
21	1/0	0	0	1	0	1	0	1	92
22	1/0	0	0	1	0	1	1	0	98
23	1/0	0	0	1	0	1	1	1	104
24	1/0	0	0	1	1	0	0	0	116
25	1/0	0	0	1	1	0	0	1	128
26	1/0	0	0	1	1	0	1	0	140
27	1/0	0	0	1	1	0	1	1	152
28	1/0	0	0	1	1	1	0	0	164
29	1/0	0	0	1	1	1	0	1	176
30	1/0	0	0	1	1	1	1	0	188
31	1/0	0	0	1	1	1	1	1	*200

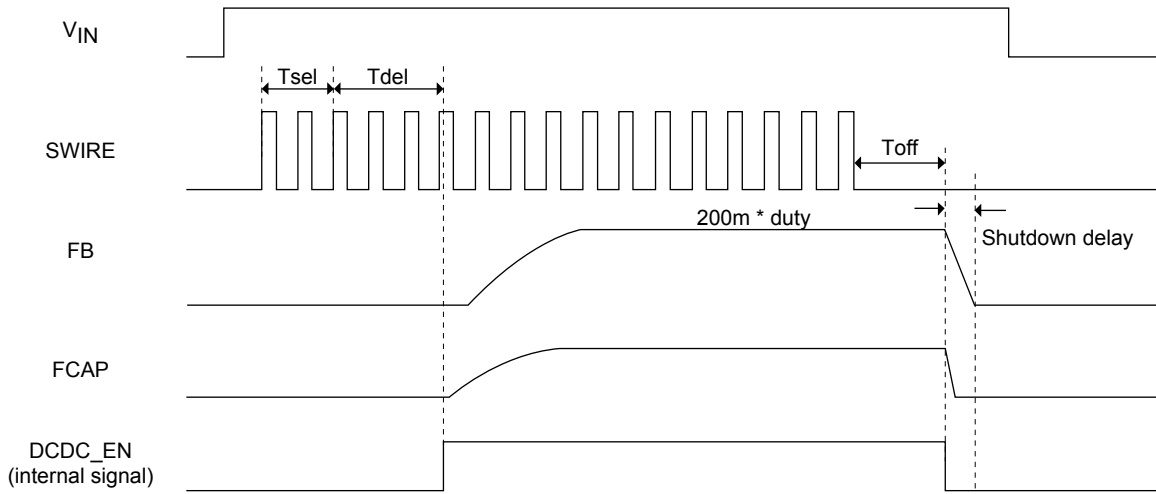
(\*Default)

**Table3. Data Register vs. FB Voltage**

**Start up and Shutdown**

The device becomes enabled when SWIRE is initially taken high. The dimming mode is determined within  $T_{sel}$  and the boost converter start up after  $T_{del}$ . To place the device into shutdown mode, the SWIRE must be held low for  $T_{off}$ .

PWM MODE



Digital MODE

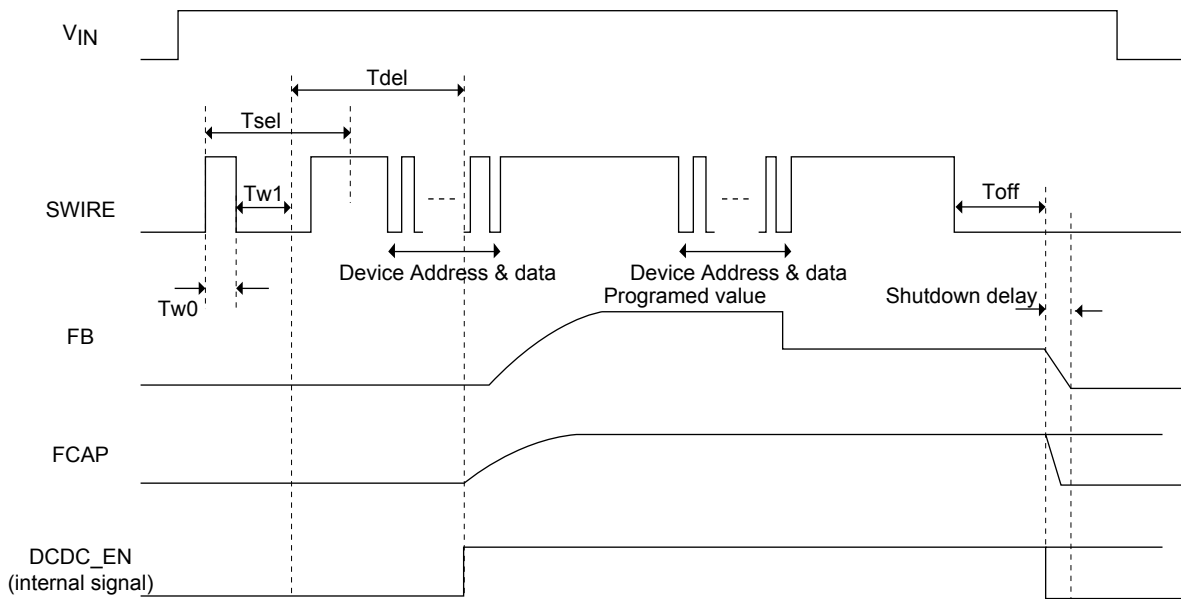


Fig7. Start up and shutdown diagram



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## Open LED Protection

If SW terminal voltage exceeds a threshold  $V_{ovp}$  (38V typ) for 8 cycles, boost converter enters shutdown mode. In order to restart the IC, SWIRE signal is required again.

## Over Current Protection

Current limit value for built-in power MOS is around 0.7A. The power MOS is turned off for each switching cycle when peak current through it exceeds the limit value.

## Under Voltage Lock Out (UVLO)

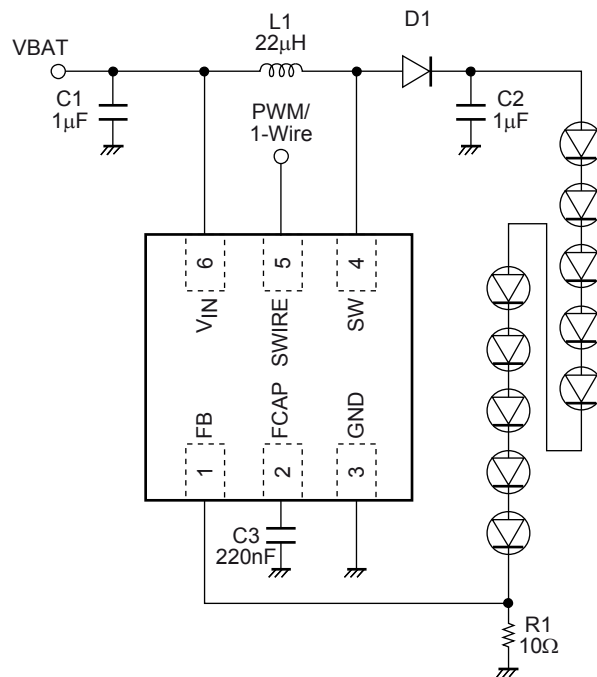
UVLO operation works when  $V_{IN}$  terminal voltage is below 2.2V.

## Thermal Shutdown

When chip temperature is too high, boost converter is stopped.

## Application Circuit Diagram

### 10LEDs



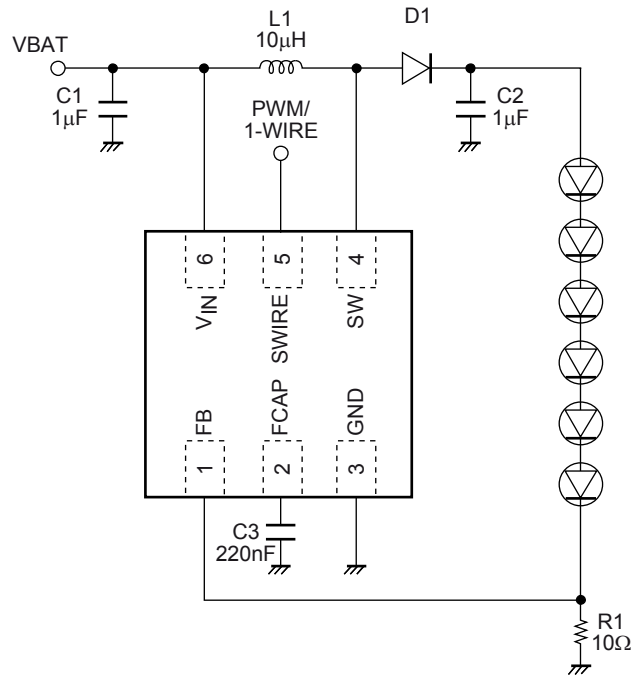
L1: VLS3012T-220M49 (TDK), VLF504015MT-220M (TDK)

D1: MBR0540T1 (ON semi), NSR05F40 (ONsemi)

C2: GRM21BR71H105K (Murata), C1608X5R1H105K (TDK)

# LV52204MT

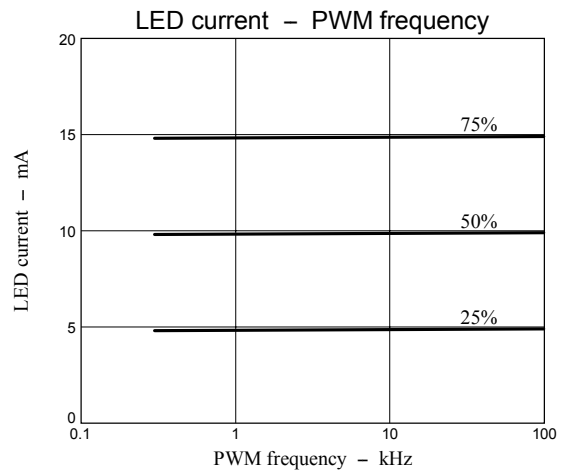
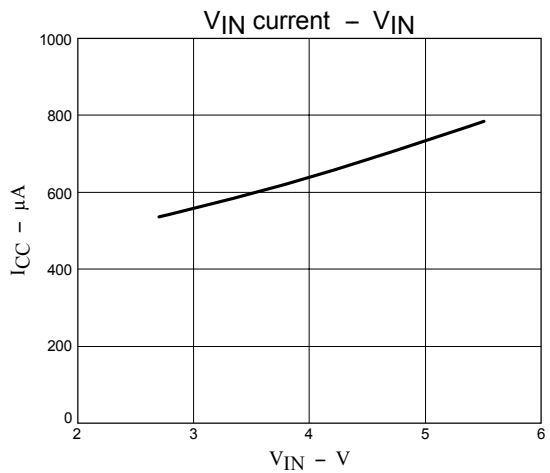
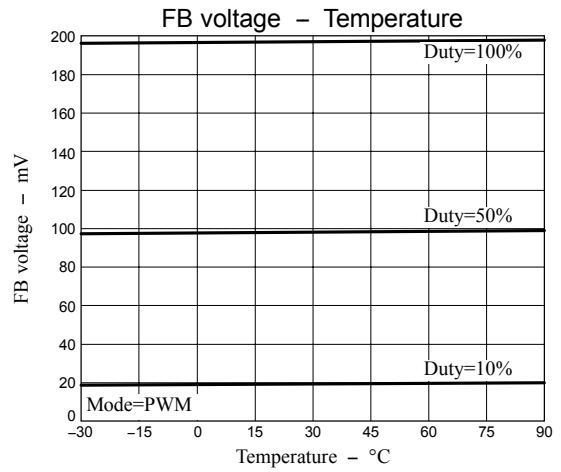
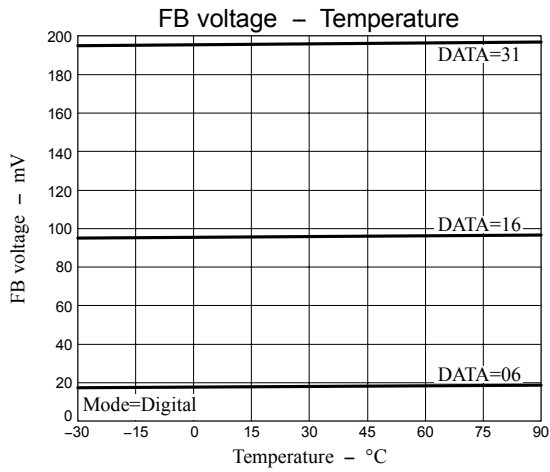
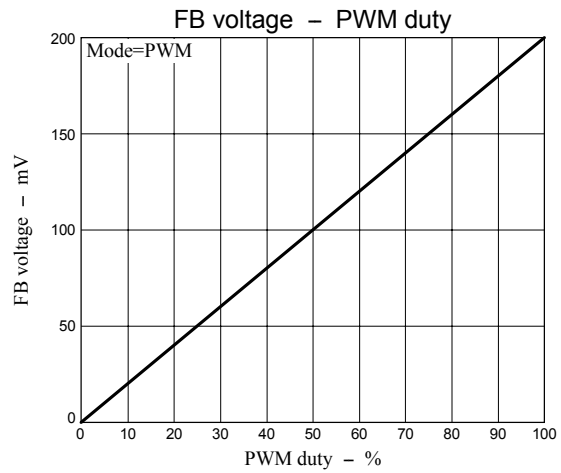
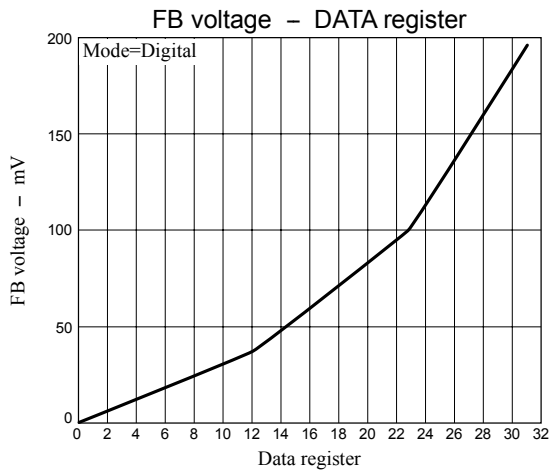
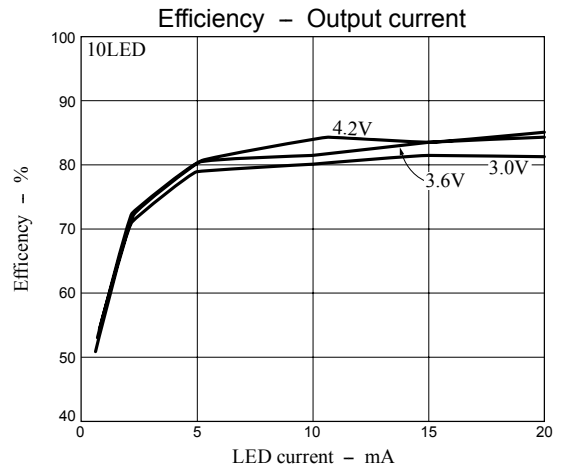
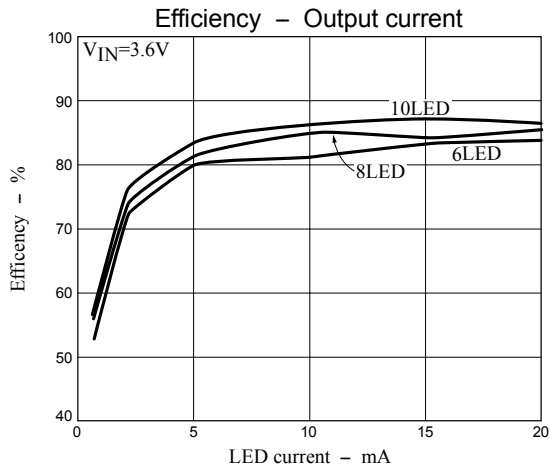
## 6LEDs



- L1: VLS3012T-100M72 (TDK), VLF302512M-100M (TDK)  
D1: MBR0540T1 (ON semi), NSR05F40 (ONsemi)  
C2: GRM21BR71H105K (Murata), C1608X5R1H105K (TDK)

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Typical Characteristics ( $V_{IN} = 3.6V$ ,  $L = 22\mu H$ ,  $T = 25^\circ C$ , unless otherwise specified)



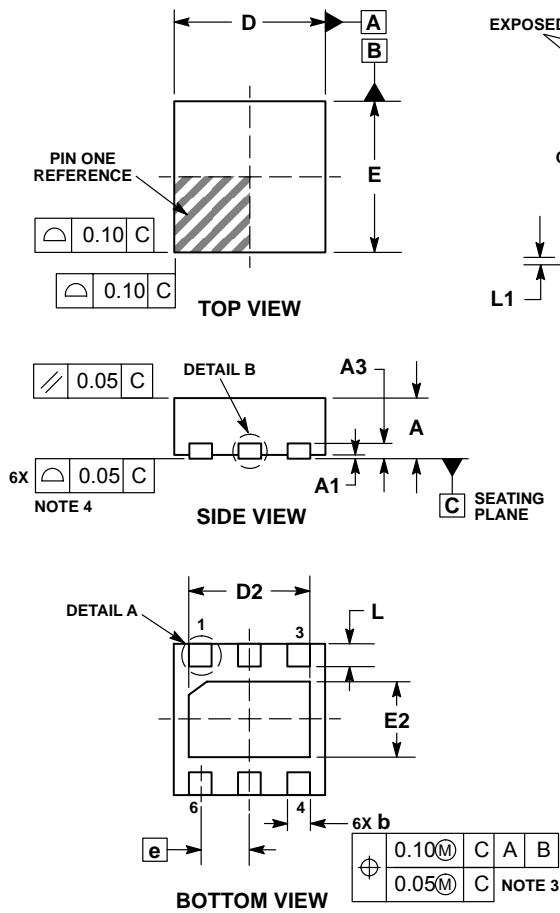
# LV52204MT

## PACKAGE DIMENSIONS

WDFN6 2x2, 0.65P

CASE 511BR-01

ISSUE 0



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.25 mm FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A3	0.20 REF	
b	0.25	0.35
D	2.00 BSC	
D2	1.50	1.70
E	2.00 BSC	
E2	0.90	1.10
e	0.65 BSC	
L	0.20	0.40
L1	---	0.15

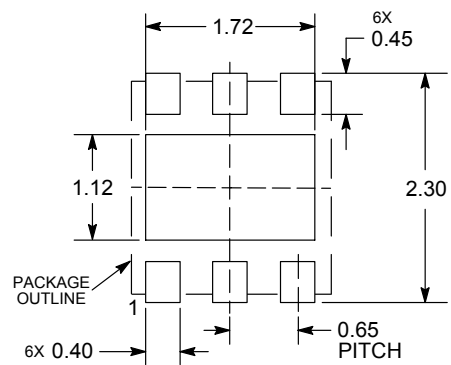
### GENERIC MARKING DIAGRAM\*



XX = Specific Device Code  
M = Date Code

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, G or microdot ■, may or may not be present.

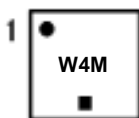
### RECOMMENDED MOUNTING FOOTPRINT



DIMENSIONS: MILLIMETERS

LV52204MT is as follows.

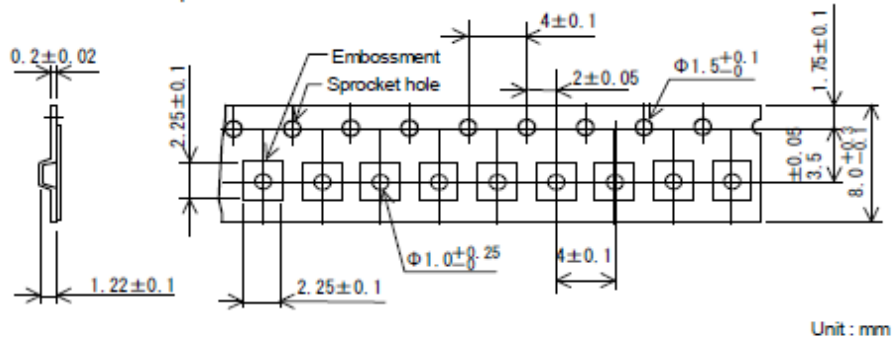
### MARKING DIAGRAM



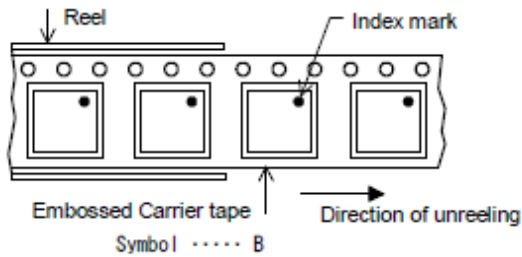
W4 = Device Code  
M = Date Code  
■ = Pb-Free Package

1.EMBOSSED CARRIER TAPING

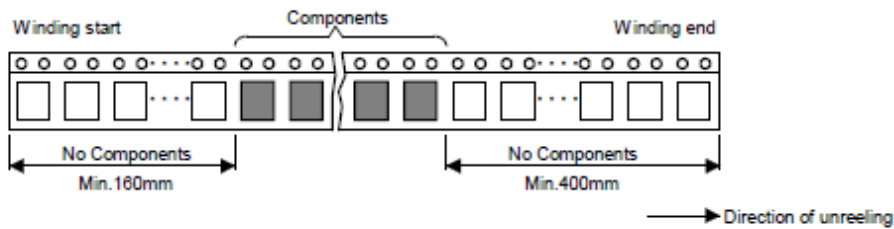
1-1 .Embossed carrier tape dimensions



1-2 .Tape mounting direction



1-3 .Reel winding start and reel winding end



2.TAPE STRENGTH

2 - 1 .Tensile strength of the carrier tape : Min.10N

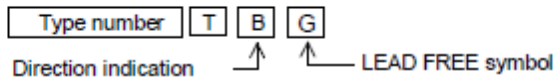
2 - 2 .Peel strength of the top cover tape

( a )Peel angle : 165° to 180° relative to the tape adhesive surface

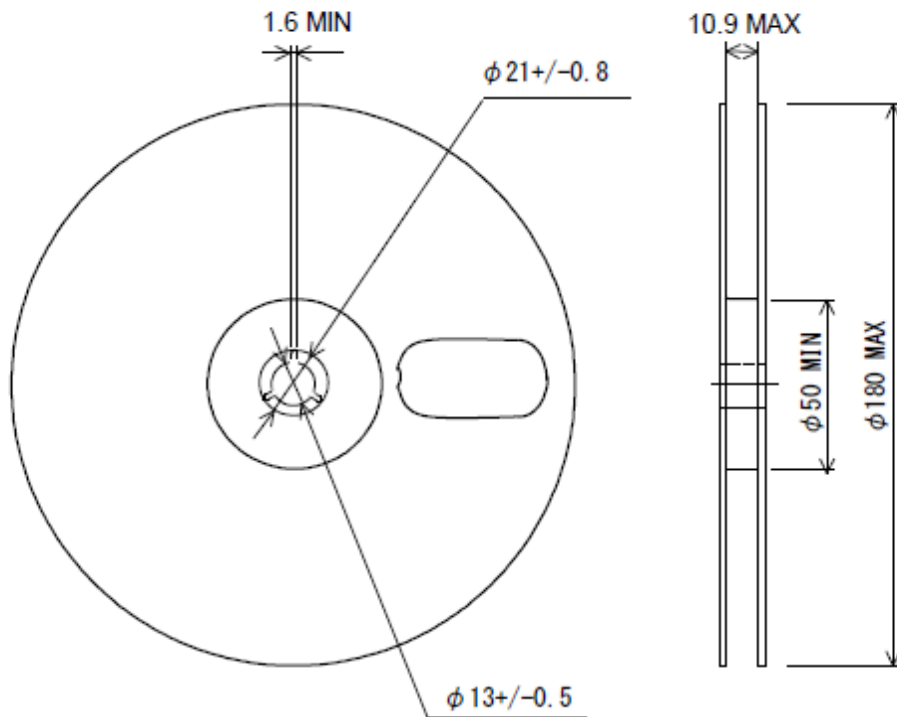
( b )Peel rate : 300mm / minute

( c )Peel of strength : 0.1N to 1.0N

3.PARTS No. ON BAR CODE LABEL



4 .REEL DIMENSIONS



TYPE:P-RRM-08B  
UNIT:mm

Packing Specification of Embossed Carrier Taping

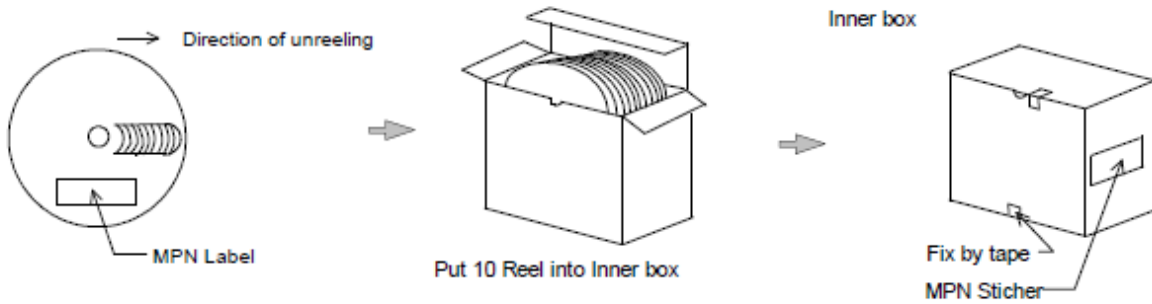
WDFN6(2.0\*2.0) 3,000 pcs/reel

Carrier tape type number	Package code	Maximum number of ICs contained (pcs.)		Packing form
		Reel	Inner box	Inner box: B50766P001
N16402D001	WDFN6(2.0*2.0)	3,000	30,000	10 Reels contained Dimensions:mm 190 × 136 × 186

**MPN Label**



**Packing Method**



# LV52204MT

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## ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
LV52204MTTBG	WDFN6 (2x2) (Pb-Free)	3000 / Tape & Reel

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