One Cell Lithium-ion/Polymer Battery Protection IC

1 Features

- Integrate Advanced Power MOSFET with Equivalent of 16mΩ $R_{SS(ON)}$
- Low Current Consumption

  Operation Mode: 3.0μA typ.

  Power-down Mode: 2.0μA typ.
- Charge over voltage protection and release
- Discharge under voltage protection and release
- Two-step Overcurrent Detection:

  Over discharge Current

  Load Short Circuiting
- Over-temperature Protection
- Support 0V battery charging function
- Ultra-small CPC5 Package

2 Applications

- One-Cell Lithium-ion Battery Pack
- Lithium-Polymer Battery Pack
- Wearable device
- Power Bank

3 Description

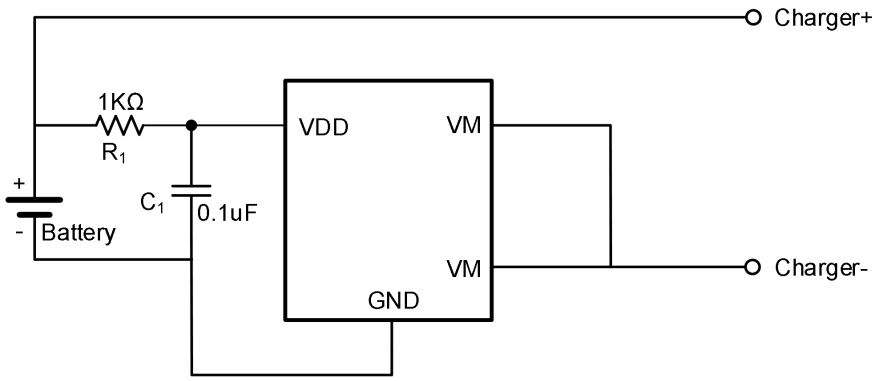
The MX4191 is a single chip protection solution specially designed for 1-cell Li+ rechargeable battery pack application. Also it integrates highly accurate detection circuits and detection delay circuits to prevent batteries from over-charging, over-discharging, over-current discharging and over-current charging. The MX4191 consumes very low standby current for cell longtime storing. The integrated low-Rdson MOSFET ensures that battery delivers the maximum power. The device is not only targeted for digital cellular phones, but also for any other Li-Ion and Li-Poly battery-powered information appliances requiring longterm battery. The MX4191 is available in CPC5 package.

ORDERABLE DEVICE	PACKAGE TYPE	PACKAGE SIZE(mm)	DEVICE MARKING (1)
MX4191	CPC5	2.6 x 2.6x 0.95	LSxyz

Device Information

(1) "LS" is Device code, "x" is year code ,"y" is Month code, "z" is lot number code.

Simplified Schematic



4 Pin Configuration and Functions

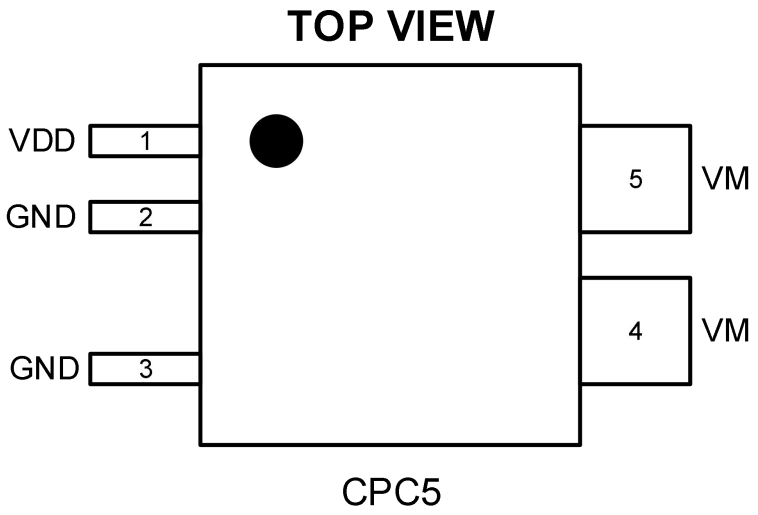


Figure 1.Pin Configuration

PIN NO.	NAME	DESCRIPTION
1	VDD	Internal power supply pin. Connect a 0.1uF~1uF ceramic capacitor between VDD and GND.
2	GND	Ground pin, connected with the negative terminal of the battery.
3	GND	Ground pin, connected with the negative terminal of the battery.
4	VM	The negative terminal of the battery pack. Connected with charger negative port.
5	VM	The negative terminal of the battery pack. Connected with charger negative port.

5 Specifications

5.1 Absolute Maximum Ratings

Over operating temperature range(25℃) (unless otherwise noted)(1)

ITEM		MIN	MAX	UNIT
Voltage (2)	VDD	–0.3	6	V
	VM	-6	10	V
	TM	–0.3	6	V
Operating junction temperature, T_J		–40	150	℃
Storage temperature, T_{stg}		-55	150	℃
ESD (Human Body Made) HMB			4000	V

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only and the device is not switching. Functional operation of the device at these or any other conditions beyond those indicated under recommended perating conditions is not implied. Exposure to absolute– maximum– rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal .

5.2 Recommended Operating Conditions

ITEM	MIN	Typ.	MAX	UNIT
Operating junction temperature (1)	-40		125	°C/W
Operating ambient temperature	-40		85	°C/W

(1) All limits specified at room temperature (TA = 25°C) unless otherwise specified. All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

5.3 Thermal Information

Fun	DESCRIPTION	VALUE	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	250	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	130	°C/W

5.4 Electrical Characteristics

T_A=25°C, unless otherwise specified.

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DETECTION VOLTAGE						
V_{OCV}	Over-charge detection voltage		4.25	4.3	4.35	V
V_{OCR}	Over-charge release voltage		4.05	4.1	4.15	V
V_{ODV}	Over-discharge detection voltage		2.3	2.4	2.5	V
V_{ODR}	Over-discharge release voltage		2.9	3.0	3.1	V
V_{CHA}	Charge detection voltage			-0.12		V
DETECTION CURRENT						
*I_{ODC}	Discharge over-current detection current	V_{DD}=3.6V	6	9	12	A
*I_{OCC}	Charge over-current detection current	V_{DD}=3.6V	4	6	8	A
*I_{SHORT}	Load Short-Circuiting Detection	V_{DD}=3.6V	18	35	52	A
CURRENT CONSUMPTION						
I_{OPE}	Current Consumption in Operation	V_{DD}=3.6V VM=0V		3	6	μA
I_{PDN}	Current Consumption in power Down	V_{DD}=2.0V VM floating		2	4	μA
VM INTERNAL RESISTANCE						
*R_{VMD}	Resistance between VM and VDD	VDD=3.6V VM=1.0V	200	300	400	kΩ
*R_{VMS}	Resistance between VM and GND	VDD=2.0V VM=1.0V	15	25	35	kΩ
FET ON RESISTANCE						
*$R_{SS(ON)}$	Equivalent FET on Resistance	VDD=3.6V VM=1.0A		16	21	mΩ
OVER TEMPERATURE PROTECTION						
*T_{SHD+}	Over Temperature Protection			150		℃
*T_{SHD-}	Over Temperature Recovery Degree			110		℃
DETECTION DELAY TIME						
t_{OCV}	Over-charge Voltage Detection Delay Time		80	130	180	mS
t_{ODV}	Over-discharge Voltage Detection Delay Time		20	40	60	mS
*t_{ODC}	Over-discharge Current Detection Delay Time	VDD=3.6V	5	10	20	mS
*t_{SHORT}	Load Short-Circuiting Detection Delay Time	VDD=3.6V	50	200	600	μS

Note1: *---The parameter is guaranteed by design.

6 Function Description

6.1 Functional Block Diagram

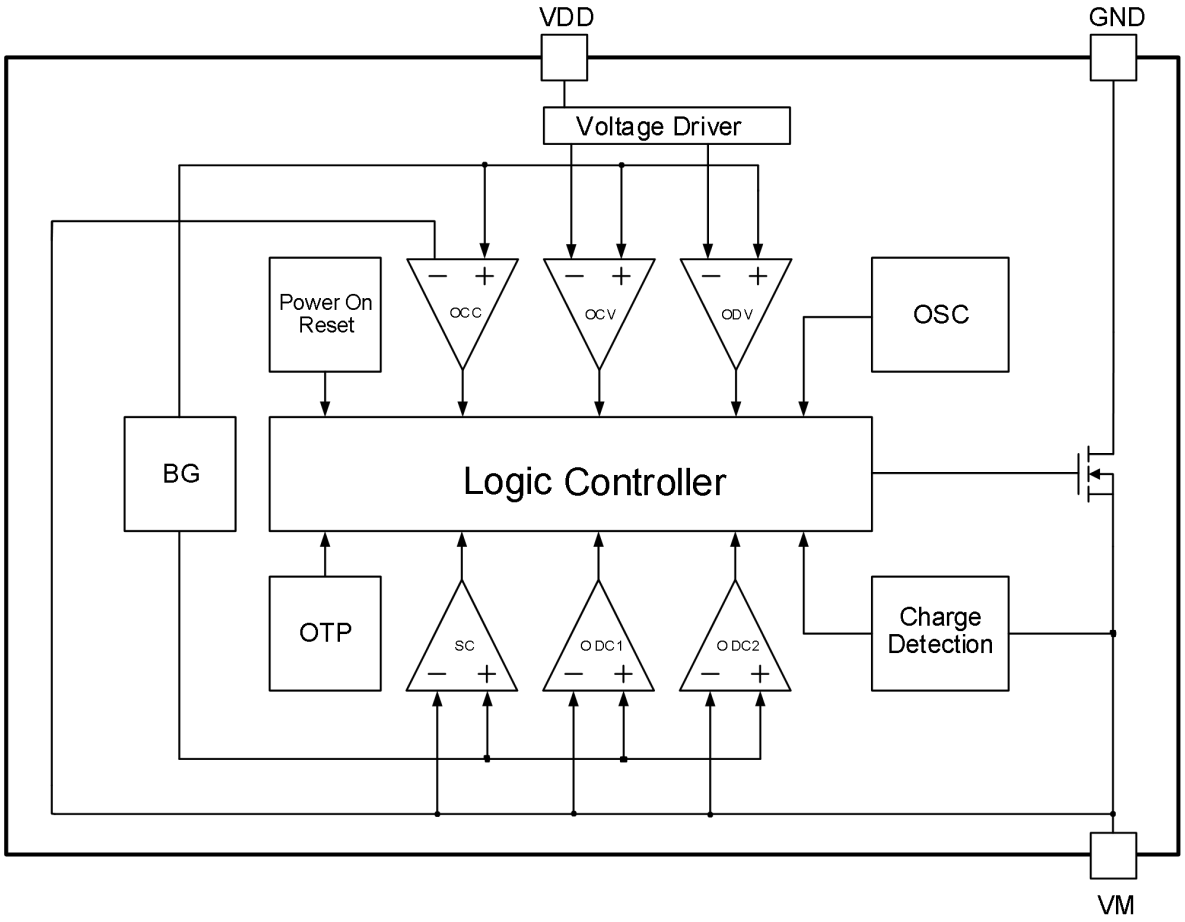


Figure 2. MX4191 Functional Block Diagram

6.2 Overview

The MX4191 monitors the voltage and current of a battery and protects it from being damaged due to overcharge voltage, overdischarge voltage, overdischarge current, and short circuit conditions by disconnecting the battery from the load or charger.The device requires only one external capacitor.The MOSFET is built-in and the equivalent resistance is typically 16mΩ.

6.3 Normal Mode

When battery voltage VDD rises above V_{ODV} (over discharge voltage), and not exceeds V_{OCV} (over charge voltage), the IC works in normal mode. In normal mode, the internal low-Rdson MOSFET is fully turned on to ensure the maximum power efficiency. The IC keeps detecting cell voltage by internal resistor divider, and monitoring charging/discharging current by internal sense resistor in the normal mode.

6.4 Over Charge Voltage Protection

When IC detects the battery voltage $V_{DD} > V_{OCV}$ (OCV, over charge voltage) and lasting time is longer than T_{OCV}, the IC enters over charge voltage protection mode. Charging path is turned off, but discharging path is allowed in OCV mode.

The recovery from over-charging will be made after the following two conditions are satisfied.

- Charger is removed from IC.
- Cell voltage decreases under over-charge release voltage (VOVR) over the delay time of over-charging releasing (TOVR) due to discharging through a load.

6.5 Over Discharge Voltage Protection

When IC detects the battery voltage VDD < V_{ODV} (ODV, over discharge voltage) and lasting time is longer than T_{ODV} (over discharge voltage delay time), the IC enters ODV protection mode. After detecting over-discharging, VM pin will be pulled up to V_{DD} by an internal resistor R_{CSU} and the bias of internal circuits will be shut off. (Shut-down mode) In shut-down mode, operating current is suppressed under 0.1uA (max).

The power-down condition is released when a charger is connected and the potential difference between VM and VDD becomes 1.3V (Typ.) or higher (load short circuiting detection voltage). At this time, the FET is still off. When the battery voltage becomes the over-discharge detection voltage (V_{ODV}) or higher (see note), the MX4191 turns the FET on and changes to the normal condition from the over-discharge condition.

6.6 Over Charge Current Protection

When the discharging current becomes equal to or higher than a specified value (the VM pin voltage is equal to or higher than the over-current detection voltage) during discharging under normal condition and the state continues for the over-current detection delay time or longer, the MX4191 turns off the discharging control FET to stop discharging. This condition is called over-current condition. (The over-current includes over-current, or load short circuiting.) The VM and GND pins are shorted internally by the R_{VMS} resistor under the over-current condition. When a load is connected, the VM pin voltage equals the VDD voltage due to the load. Because of the connection between the VM and the GND by the R_{VMS} resistor，when the load is removed, the VM pin goes back to the GND potential since the VM pin is shorted the GND pin with the R_{VMS} resistor. Detecting that the VM pin potential is lower than the over-current detection voltage (V_{OCV}), the IC returns to the normal condition.

6.7 Abnormal Charge Current Detection

If the VM pin voltage drops below the charger detection voltage (V_{CHA}) during charging under the normal condition and it continues for the overcharge detection delay time (T_{ODV}) or longer, the MX4191 turns the charging control FET off and stops charging. This action is called abnormal charge current detection.

Abnormal charge current detection is released when the voltage difference between VM pin and GND pin becomes higher than the charger detection voltage (V_{CHA}) by separating the charger. Since the 0V battery charging function has higher priority than the abnormal charge current detection function, abnormal charge current may not be detected by the product with the 0V battery charging function while the battery voltage is low.

6.8 0V Battery Charging Function

This function enables the charging of a connected battery whose voltage is 0V by self-discharge. When connectes to a charger , the discharging control FET is off and the charging current flows through the internal parasitic diode in the discharging control FET. If the battery voltage becomes equal to or higher than the over-discharge release voltage (V_{ODR}), the normal condition returns.

Notes：

(1) Some battery providers do not recommend charging of completely discharged batteries. Please refer to battery providers before the selection of 0 V battery charging function.

(2) The 0V battery charging function has higher priority than the abnormal charge current detection function. Consequently, a product with the 0 V battery charging function charges a battery and abnormal charge current cannot be detected during the battery voltage is low.

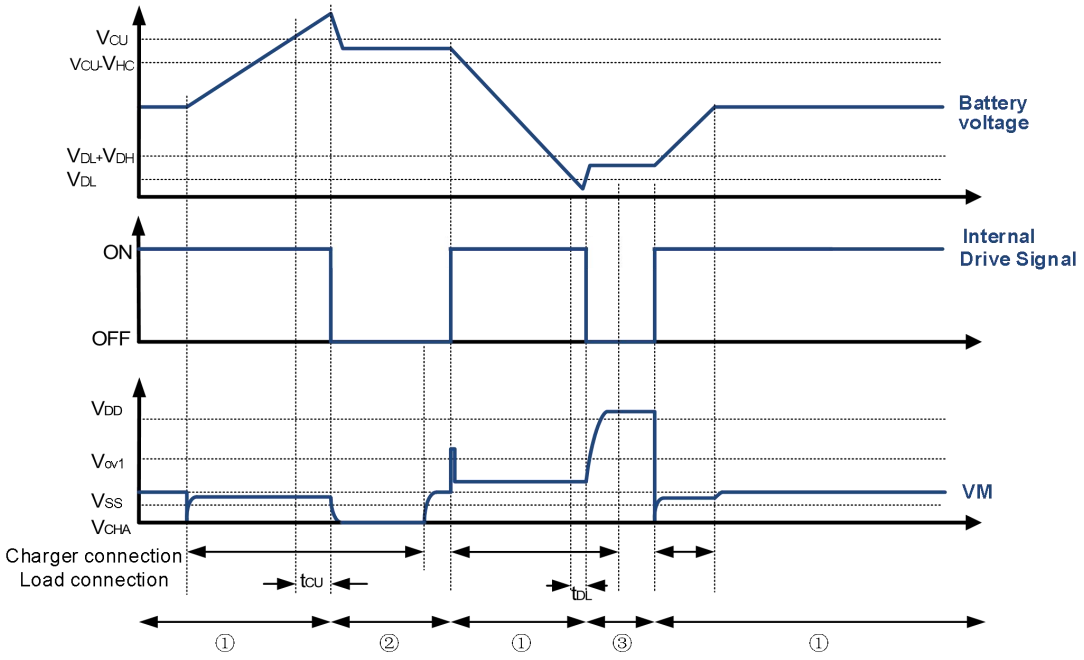
(3) When a battery is connected to the IC for the first time, the IC may not enter the normal condition in which discharging is possible. In this case, set the VM pin voltage equal to the GND voltage (short the VM and GND pins or connect a charger) to enter the normal condition.

6.9 Load Short-circuiting Condition

If voltage of VM pin is equal or below short circuiting protection voltage (V_{SHORT}),the MX4191 will stop discharging and battery is disconnected from load. The maximum delay time to switch current off is t_{SHORT}. This status is released when voltage of VM pin is higher than short protection voltage (V_{SHORT}), such as when disconnecting the load.

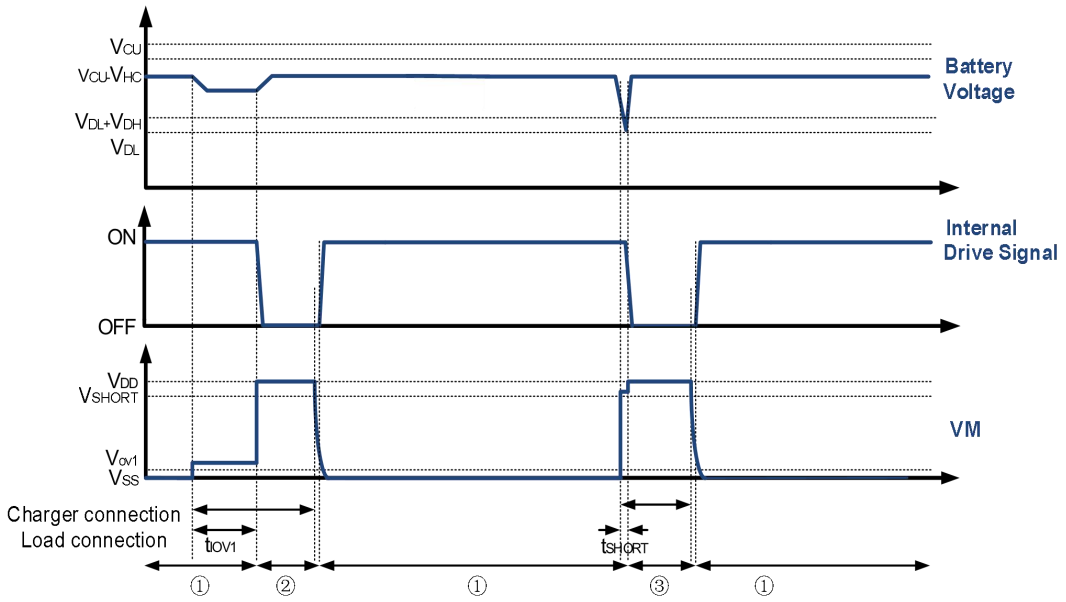
7 Timing Chart

7.1 Overcharge and Overdischarge voltage detection



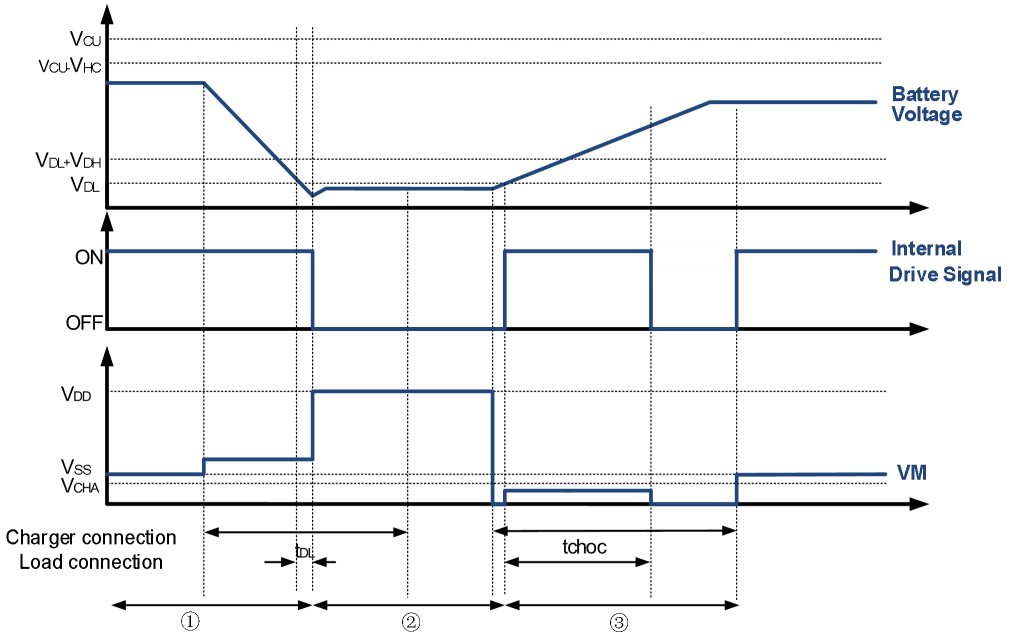
Remark: ①Normal condition ②Overcharge voltage condition ③Overdischarge voltage condition

7.2 Overdischarge Current and Load Short detection



Remark: ①Normal condition ②Overcharge voltage condition ③Overdischarge voltage condition

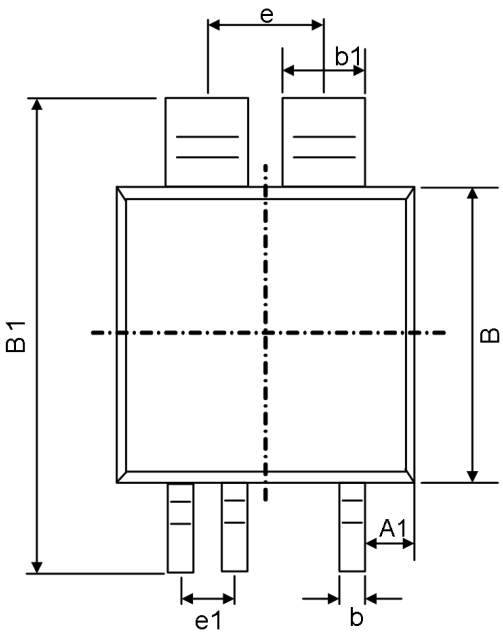
7.3 Abnormal Charger Detection

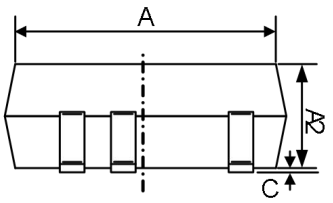


Remark: ①Normal condition ②Overcharge voltage condition ③Overdischarge voltage condition

8 Package Outline

CPC5





Symbol	Dimensions In Millimetres	
	Min	Max
A	2.50	2.70
A1	0.35	0.45
B	2.50	2.70
B1	3.85	4.15
b	0.16	0.26
b1	0.69	0.79
C	0.85	1.05
C1	0.00	0.15
C2	0.15	0.18
L	0.40	0.60
e	1.06 BSC	
e1	0.53 BSC	
θ	0°	8°