DIO59119/A
30V/1.5A High Efficiency Single-cell Li-Ion Battery Charger with Integrated Power Path

Features

- Maximum 30V input
- Build in power path NFETs and Power Switches
- Independent internal two switches with external control
- 500kHz switching frequency operation
- Trickle Current / Constant Current / Constant Voltage Charge Mode with internal compensation
- Final Float Voltage: 4.35V
- Maximum 1.5A Charge Rate
- Up to 92% Efficiency in Buck Mode
- Independent 1A Boost output
- Up to 93% Efficiency in Boost Mode
- Low Quiescent Current: 1μA in Boost Mode
- +/-0.5% cell voltage accuracy
- Charge/discharge/fault status indicator
- Programmable charge current
- DIO59119A：Programmable output voltage
- DIO59119: 5V output boost
- Charge solutions for JEITA
- Bad battery output forbidden
- Dynamic Power Management
- Input Voltage UVLO and OVP
- Boost output Short Circuit Protection
- Available in QFN3*3-20

Descriptions

Both DIO59119A and DIO59119 require a single inductor to implement both buck or boost function. The DCDC converter operates at 500 kHz frequency and can support low cost inductors and capacitors. The DIO59119/A has integrated OVP protection function, tolerating 30V power surge, effectively improving the system reliability.

The DIO59119/A synchronous boost system supports maximum output current of 1A with efficiency of up to 93%. It also supports low quiescent power consumption, which can be as low as 1uA at no load condition.

The DIO59119/A has switch charging technology that supports adjustable charging current of 1.5A with efficiency up to 92%. And the VDPM function is integrated and the typical VDPM threshold is 4.5V. The DIO59119/A has also offered power path MOSFET handling up to 3A current. Both charging and boost function can work independently as needed. DIO59119/A is designed with QFN3*3-20 package.

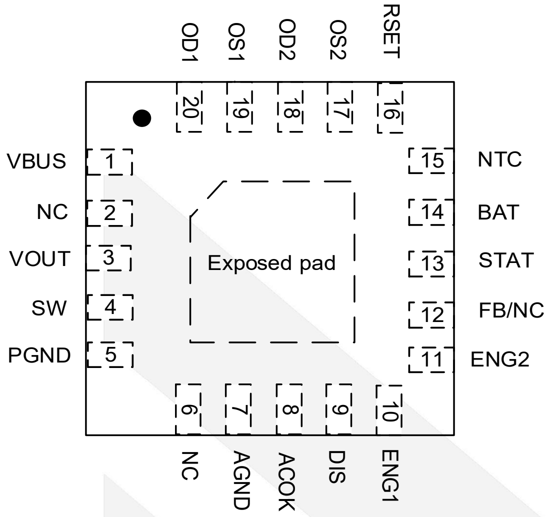
Applications

- True Wireless Stereo headphones
- Tablet, Portable Media Players
- Electronic cigarettes
- Smart video doorbell

Ordering Information

Order Part Number	Top Marking		T_A	Package	
DIO59119ACN20	EJL9A	Green	-40 to 85°C	QFN3*3-20	Tape & Reel, 5000
DIO59119CN20	DEJL9	Green	-40 to 85°C	QFN3*3-20	Tape & Reel, 5000

Pin Assignments



QFN3*3-20

Figure 1. Pin Assignment (Top View)

Pin Definitions

Name	Description
VBUS	Charger Input Voltage. Bypass with a 1μF capacitor to PGND.
NC	No connect.
VOUT	System output pin with two capacitors of 22uF to PGND.
SW	Switching Node. Connect to output inductor.
PGND	Power Ground.
AGND	Analog Ground.
ACOK	Open Drain output. When the Vbus voltage is within the range of ACOK (4.5-6.0V), the output is in high impedance.
DIS	Active LOW, boost mode pin
ENG1	Control signal input to internal NMOS gate, which will turn ON connecting OS1 and OD1 pins
ENG2	Control signal input to internal NMOS gate, which will turn ON connecting OS2 and OD2 pins
FB	Boost output Voltage Feedback Pin, just for DIO59119A
STAT	Open-drain output indicating charging status. The IC pulls this pin LOW when charging, and pulses STAT pin when fault.
BAT	Battery Voltage. Connect to the positive (+) terminal of the battery pack. Bypass with a 0.1μF capacitor to GND if the battery is connected through long leads.

NTC	QFN3*3-20	Temperature sensing pin. Pulling to logic HIGH or LOW will disable the charging function.
RSET	Charge current setting pin, and the chip will be shut down when RSET pin is floating.	
OS2	Output pin connected to internal NMOS Source terminal	
OD2	Output pin connected to internal NMOS Drain terminal	
OS1	Output pin connected to internal NMOS Source terminal	
OD1	Output pin connected to internal NMOS Drain terminal	

Block Diagram

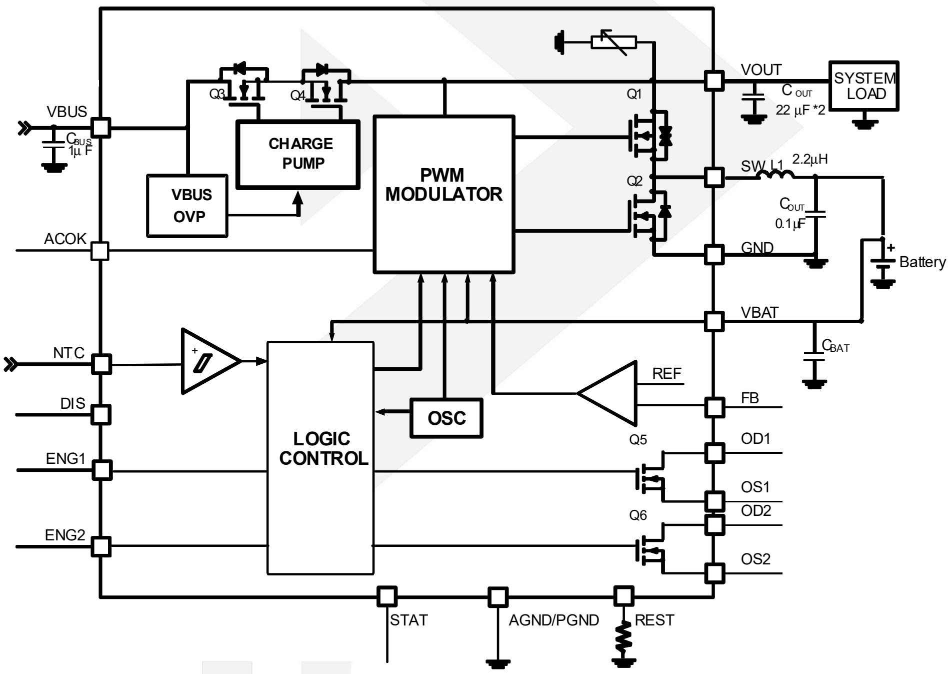


Figure 2. IC and System Block Diagram for V_{OUT} Adjustable

Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Rating” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Rating	Unit
VBUS	30	V
VOUT, SW, DIS, NTC, STAT, VBAT, RSET, ENG1/2, OS1/2, OD1/2, ACOK, FB	6	V
VBUS Pin Current Continuous	1.8	A
VOUT Pin Current Continuous	1.5	A
SW Pin Current Continuous	2.5	A
Junction Temperature	-40 to 150	°C
Storage Temperature	-65 to 150	°C
Lead Soldering Temperature, 10 Seconds	260	°C

Recommend Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended Operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not Recommend exceeding them or designing to Absolute Maximum Ratings.

Parameter	Rating	Unit
Supply Voltage	0 to 6.0	V
VOUT, SW, DIS, NTC, STAT, VBAT, RSET, ENG1/2, OS1/2, OD1/2, ACOK, FB	0 to 5.5	V
VBUS Pin Current Continuous	1.5	A
VOUT Pin Current Continuous	1.0	A
SW Pin Current Continuous	2.0	A
Ambient Temperature	-40 to 85	°C
Junction Temperature	-40 to 125	°C

Electrical Characteristics

V_{IN} = 5V, T_A = 25°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Bias Supply (VIN)						
V_{IN}	Supply voltage		4.5		5.5	V
V_{UVLO}	Adapter OK voltage	V_{IN} rising and measured from V_{IN} to GND		4.5		V
ΔV_{UVLO}	Adapter OK voltage hysteresis	Measured from V_{IN} to GND		200		mV
V_{OVP}	Input overvoltage protection	V_{IN} rising and measured from V_{IN} to GND	5.82	6.0	6.2	V
ΔV_{OVP}	Input overvoltage protection hysteresis	Measured from V_{IN} to GND		200		mV
Power Supplies						
I_{VBUS}	V_{BUS} Current	V_{BUS}> $V_{BUS(min)}$; PWM Enabled, Not Switching		0.2		mA
I_{LKG}	V_{BAT} to V_{BUS} Leakage Current	0°C<T_J<85°C, V_{BAT}=4.2V,V_{BUS}=0V		1.5		μA
I_{BAT}	Battery is charge Current in High- Impedance Mode	EN=low, 0°C<T_J<85°C, V_{BAT}=4.2V		5	15	μA
Charger Voltage Regulation						
V_{OREG}	Float Voltage	T_A=25°C		4.35		V
	Charge Voltage Accuracy	T_A=25°C	-0.5		0.5	%
		T_J=0 to 125°C	-1		1	
ΔV_{RCH}	Recharge Voltage			150		mV
	Deglitch Time	V_{BAT} Falling Below V_{RCH} Threshold		30		ms
Oscillator and PWM(TBD)						
F_{SW}	Switching frequency			500		kHz
Power MOSFET						
R_{MAINHS}	$R_{DS(ON)}$ of High side P-FET	Q1		85		mΩ
R_{MAINLS}	$R_{DS(ON)}$ of Low side N-FET	Q2		75		mΩ
R_{PP}	$R_{DS(ON)}$ of Power Path N-FET	Q3+Q4		100		mΩ
R_{OUT1}	$R_{DS(ON)}$ of Low side N-FET	Q5		500		mΩ
R_{OUT2}	$R_{DS(ON)}$ of Low side N-FET	Q6		500		mΩ
I_{CHG_MAX}	Peak current of switching FETs on Charge mode			1.8		A
I_{CC}	Charge current accuracy for Constant Current Mode	I_{CC}=1000mA	-10		10	%
I_{TC}	Charge current for Trickle Current Mode	I_{TC}=100mA		0.1		I_{CC}

I_{TERM}	Termination current			0.1		I_{CC}
Boost Mode Operation						
V_{BST}	Feedback voltage for adjustable output voltage (for DIO59119A)			1.11		V
	Boost Output Voltage at V_{OUT} (for DIO59119)	2.5V < V_{BAT}<4.5V, I_{LOAD} from 0 to 200mA	4.95	5.05	5.15	V
		3.0V < V_{BAT}<4.5V, I_{LOAD} from 0 to 500mA	4.9	5	5.25	V
$I_{BAT(BST)}$	Boost Mode Quiescent Current	PFM Mode, V_{BAT}=3.6V, I_{OUT}=0		1		uA
$I_{BAT(ALL)}$	Boost, NTC/KEY function and LED indicate total Quiescent Current	PFM Mode, V_{BAT}=3.6V, I_{OUT}=0		15		uA
$I_{SD(BST)}$	Boost Mode Shutdown Current			1		uA
$I_{LIMPK(BST)}$	Q2 Peak Current Limit			1800		mA
$UVLO_{BST}$	Minimum Battery Voltage for Boost Operation	While Boost Active		2.6		V
ΔV_{DPL}	UVLO hysteresis	Rising edge		200		mV
Logic Levels: DIS, ENG1, ENG2						
V_{IH}	High-Level Input Voltage		1.05			V
V_{IL}	Low-Level Input Voltage				0.4	V
STAT Output						
$V_{STAT(OL)}$	STAT Output Low	I_{STAT}=10mA			0.4	V
$I_{STAT(OH)}$	STAT High Leakage Current	V_{STAT}=5V			1	μA
Protection and Timers						
V_{BAT_LOWV}	Battery pre-charge threshold	Falling edge		2.5		V
ΔV_{BAT_LOWV}	Battery pre-charge hysteresis	Rising edge		100		mV
V_{BAT_SHORT}	Battery trickle charge threshold	Falling edge		1.9		V
ΔV_{BAT_SHORT}	Battery trickle charge hysteresis	Rising edge		100		mV
$T_{SHUTDWN}$	Thermal Shutdown Threshold	T_J Rising		150		°C
	Hysteresis	T_J Falling		30		
NTC						
V_{NTC_HOT}	High temperature detection voltage threshold	Battery temperature rise		31.25		$\%V_{BAT}$
	High temperature detection voltage hysteresis	Battery temperature drop		2		$\%V_{BAT}$
V_{NTC_COLD}	Low temperature detection voltage threshold	Battery temperature drop		69		$\%V_{BAT}$
	Low temperature detection voltage hysteresis	Battery temperature rise		2		$\%V_{BAT}$

Application Diagram

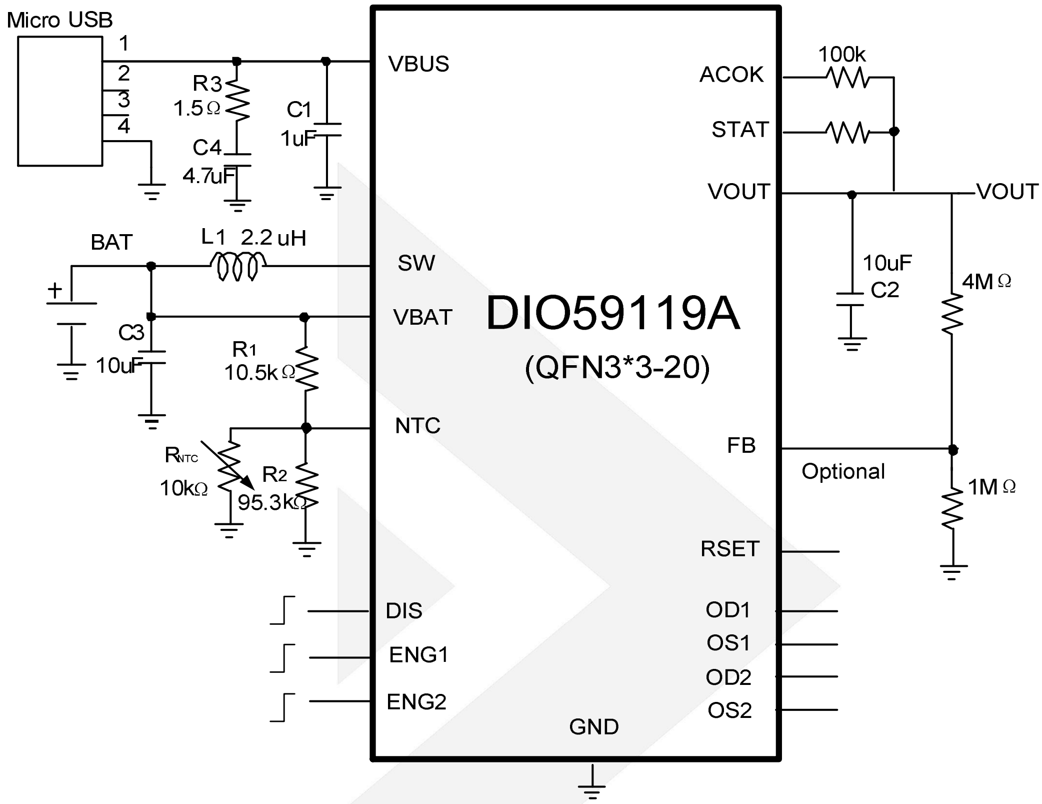


Figure 3. IC application Diagram for V_{OUT} Adjustable

Detailed Description

Overview

The DIO59119/A is an integrated solution with both cradle battery charger and headphone battery charger unit. It only needs one single inductor to realize both buck and boost function. DIO59119/A Integrated 2 independent controlled MOSFET to shut down the headphone charging loop to minimize the stand-by current when headphone is fully charged but still placed in the cradle. Please refer to the reference circuit for details.

The charger also comes with a full set of safety features: JEITA Temperature Standard, Over-Voltage Protection, VDPM, Safety Timers, Adaptor ACOK, and ISET short protection. All of these features and more are described in detail below.

Application Information

Dynamic Power Management

For the application of charging and discharging at the same time, Power-Path FET Q3 and Q4 can handle the current greater than 3A.

Power-Down or Under-voltage Lockout (UVLO)

The DIO59119/A is in power down mode when the Vbus is lower than UVLO threshold. The part is considered “dead” and all the terminals are high impedance, at the same time, the ACOK pin output will be pulled down to logic LOW.

Adaptive Input Current Limit Principle (VDPM)

DIO59119/A has adaptive input current limit function. When the input voltage drops to be lower than 4.5V, input current and I_{CHGREF} will be reduced until input voltage recovers back.

Overvoltage-Protection (OVP)

When the V_{BUS} exceeds $VBUS_{OVP}$, the IC, turns off Q3 and Q4, at the same time, the ACOK pin is pulled down. When V_{BUS} falls about 200mV below $VBUS_{OVP}$, the fault is cleared and ACOK pin (open drain) is in high impedance state. Under overvoltage protection, the maximum withstand voltage is up to more than 30V.

Charger Status/Fault Status

The STAT pin indicates the operating condition of the IC and provides a fault indicator for interrupt driven systems.

Table 1. STAT Pin Function

Charge State	STAT Pin
No Charging	High Z
Charging	LOW
Fault	2Hz Pulse

Table 2. Potential Fault Conditions Occurred in Charging Mode

Fault Description
VBUS OVP
Poor Input Source
Battery OVP
Thermal Shutdown
No Battery
NTC protection

ACOK indicator

The ACOK pin indicates the Vbus conditions. When Vbus is within the range of power-good condition, i.e. Vbus: 4.5<Vbus<6.0V, the ACOK output is in high impedance. When Vbus<4.5V or Vbus>6.0V, the output is pulled low. The ACOK pin is open drain configuration.

Charge Operation Mode

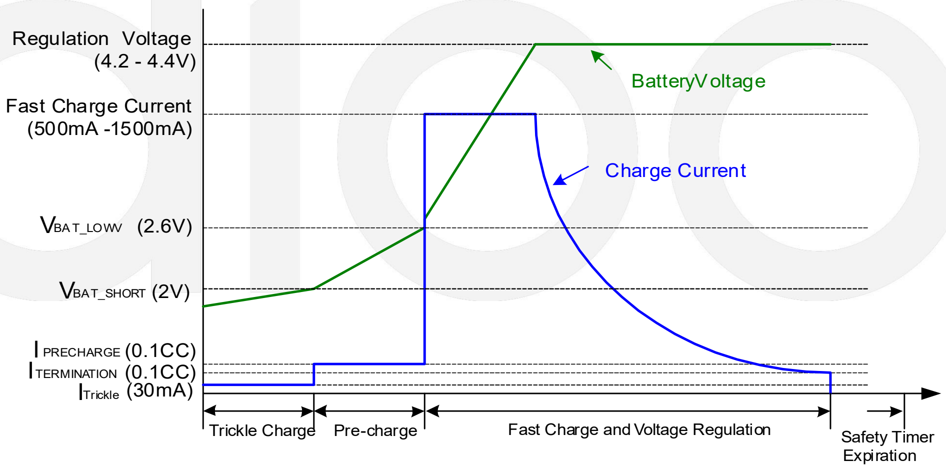


Figure 4. Battery Charging Profile

DIO59119 integrates a complete PWM charging module, shift the charging mode between the trickle charging, constant current charging and constant voltage charging mode with the internal power MOSFET, as shown in Figure 4. The charging current can be adjusted with external resistance, the maximum charging current up to 1.5A. In trickle mode, the chip works in linear charging with a charging current of 0.1 * I_{CC}. In the constant current mode, the chip charging current is I_{CC} by PWM modulation. In the constant voltage mode, the charging current gradually decreases. Once the charging current below to the charging termination current 0.1 * I_{CC}, the charging cycle is over. When the battery voltage drops below 4.05V again, the system automatically starts a recharge cycle.

ISET

An external resistor is used to Program the charging current (50 to 1500mA) based on below equation:

$$I_{BAT} = 62000/Rset \qquad (1)$$

Boost Mode

When pull DIS pin to low and Vbus is absent, the boost circuitry is active. The boost circuitry adopts special circuit to achieve ultra-high efficiency, the highest efficiency can reach more than 93%. Meanwhile, without load the device can draw as low as 1uA quiescent current.

Output Voltage Setting

Boost output voltage can be set by FB pin.

$$V_{OUT} = (R_{HIGH}+R_{LOW}) / R_{LOW}*1.11 \qquad (2)$$

Bad Battery Output Forbidden

When DIO59119/A stop providing output voltage to ear pods (such as battery is at UVLO condition or boost is disabled), a pull-down resistor exist at the output pin. The pull-down resistor is about 1KΩ and it always exists even when battery is zero.

Independent control MOSFET (Q5 and Q6)

It integrates two independent MOSFET Q5 and Q6, which can be independently controlled by ENG1 and ENG2 pins. In some design, customer wants to save stand-by current when ear pods are in cradle but Vbus is removed. Customer can use GPIO to control ENG1/ENG2 to turn off the ear pods grounding path to further reduce the stand-by current.

NTC protection

The NTC pin is used for monitoring ambient temperatures.

For example, with properly selected R1 and R2 (see next paragraph for selecting R1/R2), DIO59119 charges the battery within target range (($T_L < T < T_H$). For example, we can set the R1/R2 so that DIO59119 can charge with 100%*Iset between 10°C and 45°C. Between 0°C and 10°C the charge current level is 0.2*I_{SET} and if less than 0°C or more than 45°C, the charging is disabled. T_L and T_H can be adjusted with different R1/R2 combination.

Selecting R1 and R2

The values of R1 and R2 in the application circuit can be determined according to the assumed temperature monitor range and thermistor's values. The Follows is an example: Assume temperature monitor range is $T_L \sim T_H$, ($T_L < T_H$); the thermistor in battery has negative temperature coefficient (NTC), R_{TL} is thermistor's resistance at T_L, R_{TH} is the resistance at T_H, so $R_{TL} > R_{TH}$, then

At temperature TL, the voltage at TEMP pin is:

$$V_{TEMPL} = \frac{R_2 // R_{TL}}{R_1 + R_2 // R_{TL}} \times V_{CC}$$

At temperature TH, the voltage at TEMP pin is:

$$V_{TEMPH} = \frac{R_2 // R_{TH}}{R_1 + R_2 // R_{TH}} \times V_{CC}$$

Because:

$V_{TEMPL}=V_{HIGH}=K_2 \times V_{CC}$（$K_2=0.69$）

$V_{TEMPH}=V_{LOW}=K_1 \times V_{CC}$（$K_1=0.3125$）

Then we can have:

$$R_1 = \frac{R_{TL} \times R_{TH}(K_2 - K_1)}{(R_{TL} - R_{TH})K_1 \times K_2}$$

$$R_2 = \frac{R_{TL} \times R_{TH}(K_2 - K_1)}{R_{TL}(K_1 - K_1 \times K_2) - R_{TH}(K_2 - K_1 \times K_2)}$$

Likewise, for positive temperature coefficient thermistor in battery, we have $R_{TH}>R_{TL}$ and we can calculate:

$$R_1 = \frac{R_{TH} \times R_{TL}(K_2 - K_1)}{(R_{TH} - R_{TL})K_1 \times K_2}$$

$$R_2 = \frac{R_{TH} \times R_{TL}(K_2 - K_1)}{R_{TH}(K_1 - K_1 \times K_2) - R_{TL}(K_2 - K_1 \times K_2)}$$

We can conclude that temperature monitor range is independent of power supply voltage V_{CC} and it only depends on R1, R2, R_{TL} and R_{TH}: The values of R_{TH} and R_{TL} can be found in related battery handbook or deduced from testing data. In actual application, if only one terminal temperature is concerned (normally protecting overheating), there is no end to use R2 but R1. It becomes very simple to calculate R1 in this case.

Thermal Regulation and Protection

When the IC's junction temperature reaches the T_{CF} (about 120°C), the charger reduces its output current to 550mA to prevent overheating. If the temperature increases beyond $T_{SHUTDOWN}$; charging is suspended, and STAT is pulsed HIGH. In Suspend Mode, all timers stop and the state of the IC's logic is preserved. Charging resumes after the die cools to about 120°C.

CONTACT US

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