Charge Timer

Description

The monolithic integrated bipolar circuit U2403B is a time controlled constant current charger. Selection of charge current versus timing is according to external components at pins 2, 3 and 4. For high current requirement, an external transistor is recommended in series with the battery. To protect the IC against high power loss (typically > 140°C), the oscillator is shut down when the reference voltage is switched off (0 V). The same thing happens when there is a saturation of collector voltage at pin 1. When the overtemperature is reduced and the collector voltage is equal to supply voltage ($V_C = V_S$), charge time operation continues (see flow chart figure 4).

Features

- Easy to run autonomous dual rate charger
- Constant charge current
- 3 h – 24 h charge time programmable
- Integrated low cost dc regulator
- Integrated overtemperature protection
- Selectable charge mode indication
- Operation starts at the moment of battery insertion
- Final assembly test ability

Applications

- Cordless telephones
- Low cost battery charger-“timer”
- Entertainment

Block Diagram

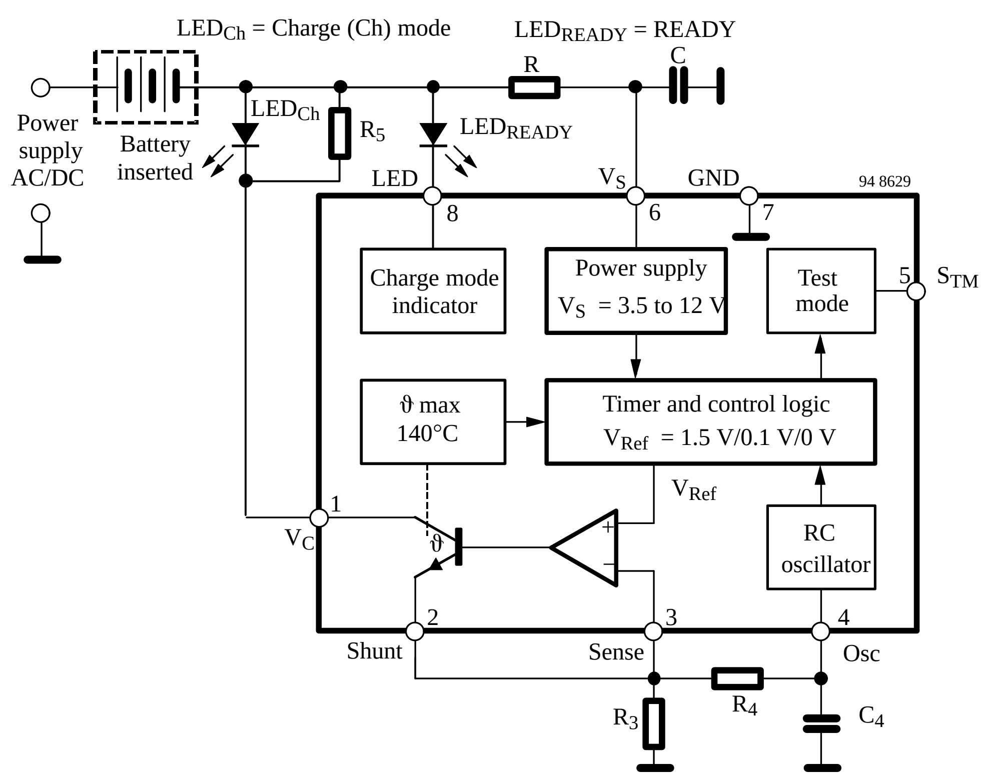
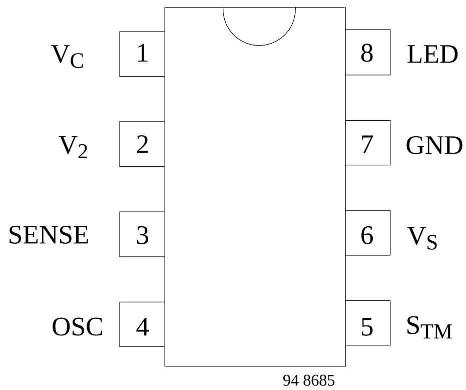


Figure 1 Block diagram with external circuit

Pin Description



Pin	Symbol	Function
1	V_C	Collector terminal
2	V_2	Emitter shunt terminal
3	SENSE	Amplifier SENSE input
4	OSC	Oscillator input
5	S_{TM}	Test mode switch
6	V_S	Supply voltage
7	GND	Ground
8	LED	Charge mode indicator

Pin 1, Collector Voltage V_C Terminal

Pin 1 is an open collector output. When $V_C \leq 3$ V, the charge cycle is switched off until it is above the supply voltage. The first eight divider stages can be tested directly. 256 input clocks at pin 4 create one clock at pin 5.

Pin 2, Emitter Shunt Terminal

The constant current source is supplied by the internal operational amplifier. The voltage across R_3 is determined via the internal reference source.

$I_{Ch} = V_3/R_3 \qquad (V_3 = V_{SENSE})$

Pin 3, Operational Amplifier "SENSE" Input (Inverted)

The voltage regulated current source has a closed loop with pin 2, pin 3, and resistor R_3.

Pin 4, Oscillator Terminal (R_4/C_4)

Selection of current charge versus timing is according to the external circuit at pins 2, 3, and 4. Typical values are given in figure 3 and table page 3.

Pin 5, Fast Test Mode for Charging Time

Charging time is given by the operation.

$$t_{ch} = \frac{1}{f_{OSC}} \cdot 2^n$$

where:

f_{osc} = oscillator frequency (see figure 3)
t_{ch} = charge time
n = frequency divider n = 2^{26}, if S_{TM} = OPEN
n = 2^{17}, if S_{TM} = GND
n = 2^8, if S_{TM} = VC

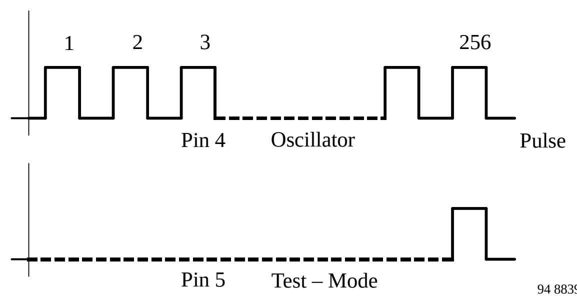


Figure 2 Quick test timer 1/3

Example

Assume a charge time of 6 h.
Select the values of R_4 and C_4 from the tables on page 3.

R_4 = 470 kΩ
C_4 = 680 pF

There is a frequency of about 3100 Hz at pin 4. It is possible to test the charge time of 6 h by running through the charge cycle for a very short time. By connecting pin 5 with GND the test time is 42 s. By connecting pin 5 with pin 1 (V_c) the test time is reduced to about 82.4 ms. R_5 is connected in parallel to the red LED and provides a protective bypass function for the LED (see figure 1).

Pin 6, Supply Voltage, V_S

$V_S \approx 3.1$ V power-on reset release (turn-on)
$V_S \approx 2.9$ V undervoltage reset
$V_S \approx 13$ V supply voltage limitation

Pin 7, Ground

Pin 8, Charge Mode Indicator

It is an open-collector output, which supplies constant current to LED after the active charge phase has been terminated. ϑ_{max} controls the function temperature to the final stage range, when the temperature is above 140°C, charge function is switched off.

Charge Characteristics

Charge Time U2403B

Charge tTme	OSC Components		Fre-quency	Short Test Cycle	
Test = OPEN	R_4 [KΩ]	C_4 [pF]	[Hz]	Test = VC [ms]	Test = GND [s]
1 h	430	100	187009	13.7	7
	270	180			
	220	220			
	180	270			
2 h	560	150	9320	27.4	14
	360	270			
	300	330			
3 h	510	270	6213	41.2	21
	430	330			
	300	470			
4 h	620	330	4660	54.9	28
	430	470			
	300	680			
5 h	510	470	3728	68.6	35
	390	680			
	300	1000			
6 h	620	470	3105	82.4	42
	470	680			
	360	1000			
7 h	560	680	2663	96.1	49
	430	1000			
	220	2200			
8 h	620	680	2330	109.8	56
	470	1000			
	200	2200			
9 h	750	680	2071	123.6	1 min 3
	510	1000			
	240	2200			
10 h	620	820	1864	137.3	1 min 10
	270	2200			
	130	4700			
12 h	390	2200	1553	164.8	1 min 24
	150	4700			
16 h	470	2200	1165	219.7	1 min 56
	200	4700			

Charge Time

Test Mode	Open	GND	V_C
f_{osc}	n = 26	n = 17	n = 8
1 KHz	18 h, 38 min	2 min, 11 s	256 ms
10 KHz	1 h, 51 min	13 s	25 ms
100 KHz	11 min, 11 s	1.3 s	2.5 ms

Trickle Charge

The trickle charge starts after the charge has been terminated. In this case the internal reference voltage is reduced from 1.5 V up to about 0.1 V. This means the charge current is decreased by the factor
K = 15 {K = 1.5 V/0.1 V}.

Trickle current = I_{Ch} / 15 + I_6 (supply current) + I_8

With resistor R_6 it is possible to reduce the trickle charge. See figure 7 and 8.

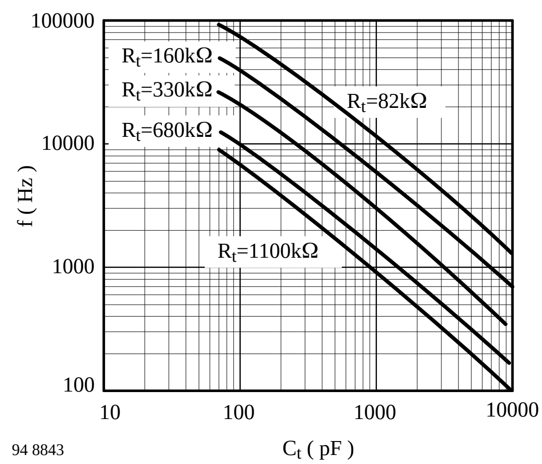


Figure 3 Oscillator

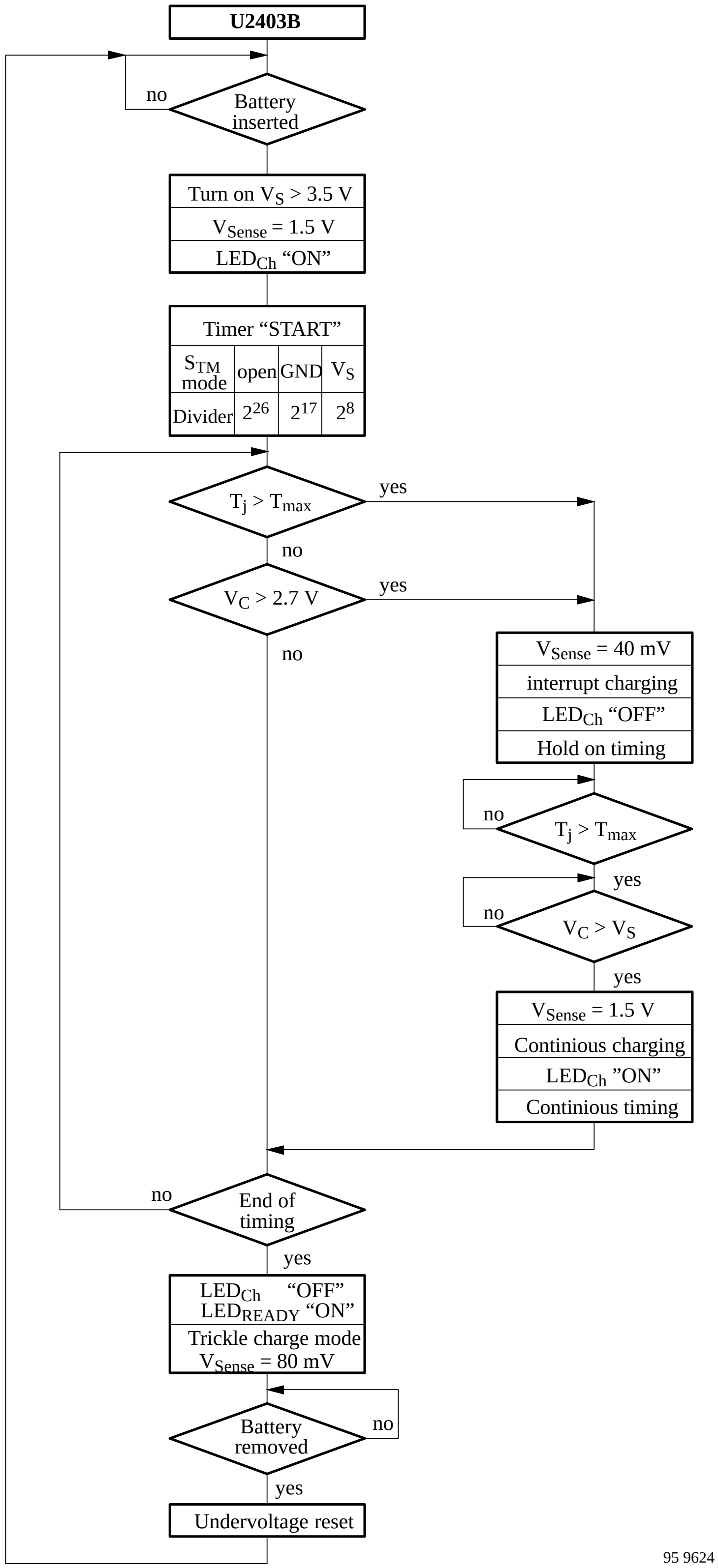


Figure 4 Flow chart

Absolute Maximum Ratings

Reference point Pin 7 (GND), unless otherwise specified.

Parameters		Symbol	Value	Unit
Supply current	Pin 6	I_S	20	mA
t ≤ 100 µs		i_s	100	mA
Currents	Pin 1	I_1	280	mA
	Pin 2	$-I_2$	+290	mA
	Pin 3	I_3	1	µA
	Pin 4	$I_{4(osc)}$	15	mA
	Pin 5	I_{TM}	–75 to +120	µA
	Pin 8	I_8	8	mA
Voltages	Pins 1, 3, 5, 6 and 8	V	13.5	V
	Pin 2	V_2	1.6	V
	Pin 4	V_4	1.5	V
Junction temperature		T_j	150	°C
Ambient temperature		T_{amb}	85	°C
Storage temperature range		T_{stg}	–50 to +150	°C

Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient	R_{thJA}		
DIP 8		120	K/W
SO 8 on PC-board		220	K/W
SO 8 on ceramic		140	K/W
SO 8 on ceramic with thermal compound		80	K/W

Electrical Characteristics

V_S = 6 V, T_{amb} = 25°C, reference point pin 7 (GND), unless otherwise specified.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply voltage limitation	Pin 6 I_S = 4 mA I_S = 20 mA	V_S	 12.5 12.6		 13.5 13.7	 V V
Supply current	V_S = 6 V	I_S	1.4		2.2	mA
Voltage monitoring	**Pin 6**					
Turn-on threshold		V_{TON}	2.8		3.5	V
Turn-off threshold		V_{TOFF}	2.5		3.2	V
Charge-mode indicator (LED)	**Pin 8**					
LED current		I_8	3.0		6.0	mA
LED saturation voltage	I_8 = 3.7 mA	V_8			960	mV
Leakage current		I_{lkg}	–0.35		1.1	µA
Collector terminal	**Pin 1**					
Open collector current		I_{CO}	15		55	µA
Saturation threshold		$V_{sat(ON)}$ $V_{sat(OFF)}$	2.55 5.00		3.35 6.40	V V
Shunt emitter current	R_3 = 5.6 Ω Pin 2	I_2	250		285	mA
Operational SENSE amplifier	**Pin 3**					
Input current	V_{SENSE} = 0 V	I_3	–0.6		0.08	µA
Input voltage	V_{Ref} = 1.5 V V_{Ref} = 100 mV V_{Ref} = 0 V	V_3 V_3 V_3	1.42 40 –0.4		1.58 100 27	V mV mV
Oscillator	**Pin 4**					
Leakage current	V_4 = 0 to 0.85 V	I_{lkg}	–0.5		0.1	µA
Threshold voltage	Upper	$V_{T(u)}$	875		985	mV
Frequency	R_4 = 160 kΩ, C_4 = 2.2 nF R_4 = 680 kΩ, C_4 = 4.7 nF	f_{osc}	2700 305		3050 345	Hz Hz
Test mode switch (S_{TM})	**Pin 5**					
Input current	V_5 = 6 V V_5 = 0 V	I_5	40 –75		120 –20	µA µA
Output voltage	High Low	V_H V_L	1.7 0.5		2.5 1.0	V V

Internal Temperature Switch

The internal temperature monitoring is active, if the chip temperature rises above 140°C. Above this temperature the voltage at pin 3 goes to zero. Similarly the charge current, I_{Ch}, reduces according to the relation:

$I_{Ch} = V_{SENSE} / R_3$

where I_{Ch} = 1 to 2 mA (IC supply current)

The oscillator is connected to GND via pin 3 (V_{SENSE}) which holds the present time status. When the chip temperature decreases below the transition value, all the functions are released and the charge time is continued. The process is reversible. If there is a higher power dissipation in the circuit (T_j > 140°C) the temperature monitoring remains permanently activated (ON). The total cycle time is prolonged according to the interrupt time duration, see figure 5.

Automatic Control Protection

To reduce the design costs, it is possible to select the transformer for the minimum of the power supply required.

The output stage of the control is selected so that it is switched off before saturation is attained (V_{CEsat} = 2.7 V). In this case the voltage at pin 3 is kept at a value of zero. The charge current is also zero, and the transformer is now an open circuit impedance. The system becomes active again if $V_c \geq V_S$.

The advantage of the system is that if sags of duration appear in the mains voltage or if the transformers used are too small, the charge duration is increased while the charge capability remains the same (see figure 6).

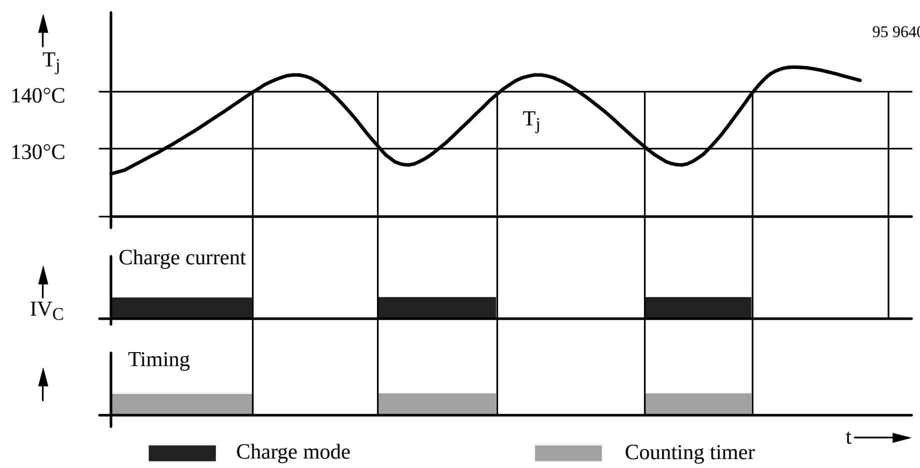


Figure 5 Charge duration in case of overtemperature

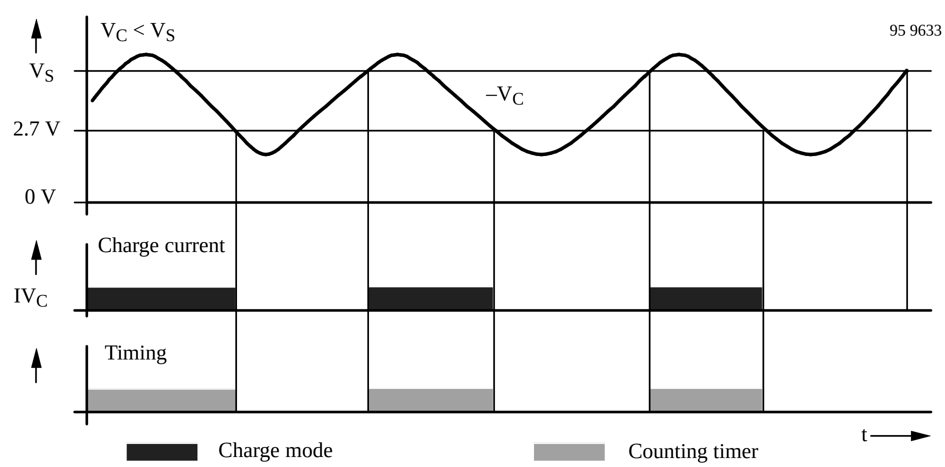


Figure 6 Charge duration in case of V_C

Application Notes

U2403B Minimal Configuration

Basic Example

NiCd battery 750 mAh	R = 510 Ω, 1/8 W
Charging time: 3 h	C = 47 μF, 16 V
Charge current: 240 mA, 1/3 C	R_3 = 6.2 Ω, 1/2 W
	R_4 = 300 kΩ
Trickle charge: 19 mA < 1/40 C	C_4 = 470 pF
	R_5 = 8.2 Ω, 1/2 W

Minimum Supply Voltage

No of Cells	DC Supply Minimum
1	6.8 V
2	8.3 V
3	9.8 V
4	11.3 V
5	12.8 V

Special Requirements of Different Charge Times

	2 h	4 h	6 h	7 h	12 h
R_4	300 kΩ	430 kΩ	470 kΩ	470 kΩ	390 kΩ
C_4	330 pF	470 pF	680 pF	1 nF	2.2 nF

Special Requirements for Different Charge Current

	240 mA	150 mA	100 mA	50 mA
R_3	6.2 Ω	10 Ω	15 Ω	30 Ω
R_5	8.2 Ω	15 Ω	22 Ω	68 Ω

Basic Equations

R = 0.5 V / IS IS = 1.8 mA, typically

$R_5 = V\_LED_{Ch} / (I_{Ch} – 20\ mA)$

Charge Current (I_{Ch}):

$I_{Ch} = V_{SENSE}/R_3$

V_{SENSE} = 1.48 V, typically

Trickle Current (IT):

$I_{Ch} = V_{SENSE}/R_3 + ILED + IS$

V_{SENSE} = 80 mV, typically

ILED = 4.5 mA, typically

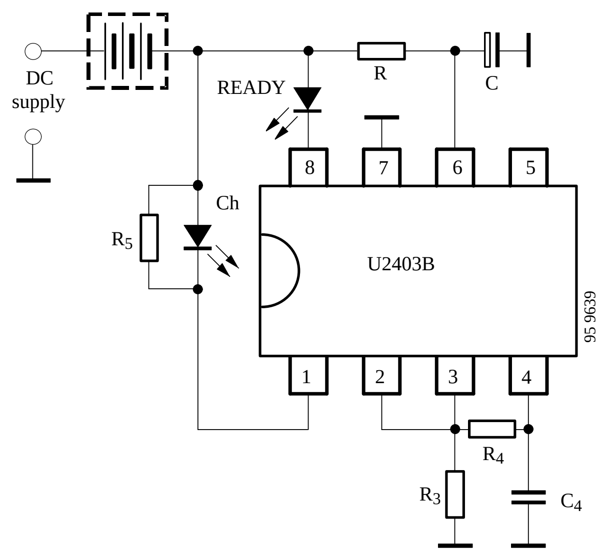


Figure 7 Standard application

U2403B with Booster and Trickle Charge Reduction

Basic Example

NiCd battery 1000 mAh	R = 510 Ω, 1/8 W
Charging time: 2 h	C = 100 µF, 16 V
Charge current: 500 mA	R_3 = 3 Ω, 1 W
Trickle charge: 22 mA < 1/22 C	R_4 = 300 kΩ
	C_4 = 330 pF
	R_5 = 3.9 Ω, 1 W
	C_1 = 1 µF

Minimum Supply Voltage

No of Cells	DC Supply Minimum
1	6.5 V
2	8.0 V
3	9.5 V
4	11.0 V
5	12.5 V

Special Requirements for Different Charge Times

	2 h	4 h	6 h	7 h	12 h
R_4	300 kΩ	430 kΩ	470 kΩ	470 kΩ	390 kΩ
C_4	330 pF	470 pF	680 pF	1 nF	2.2 nF

Special Requirements for Different Charge Current

	616 mA	493 mA	411 mA	296 mA
R_3	2.4 Ω	3 Ω	3.6 Ω	5 Ω
R_5	3 Ω	3.9 Ω	4.7 Ω	6.8 Ω

R_6 = 560 Ω, reduce trickle charge

Basic Equations

R = 0.5 V / IS
$R_5 = V\_LED_{Ch} / (I_{Ch} - 20\text{ mA})$

Charge Current (I_{Ch})
$I_{Ch} = V_{SENSE} / R_3$
V_{SENSE} = 1.48 V, typically

Trickle Current (IT)
$I_{Ch} = V_{SENSE}/R_3 + ILED + IS - I6$
V_{SENSE} = 80 mV, typically
ILED = 4.5 mA, typically
IS = 1.8 mA, typically

Trickle Charge Reduction (I6)
$I6 = (V_{battery} + V_{D1})/R6$ $V_{D1} = 0.75$ V

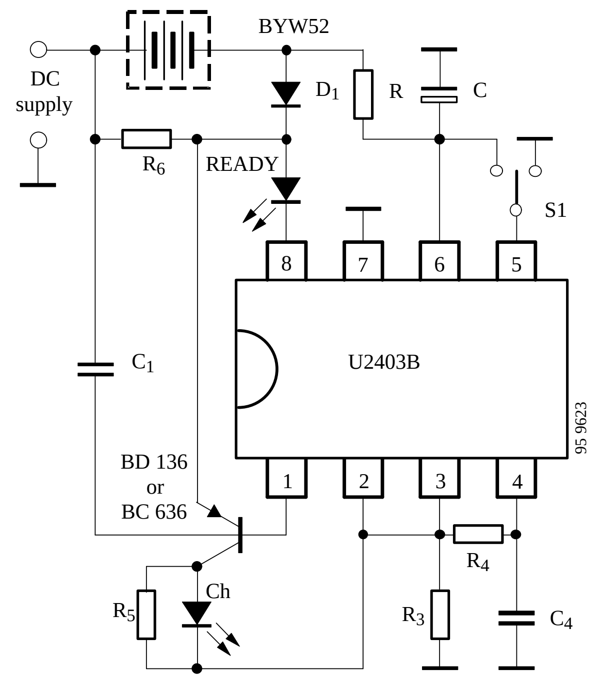
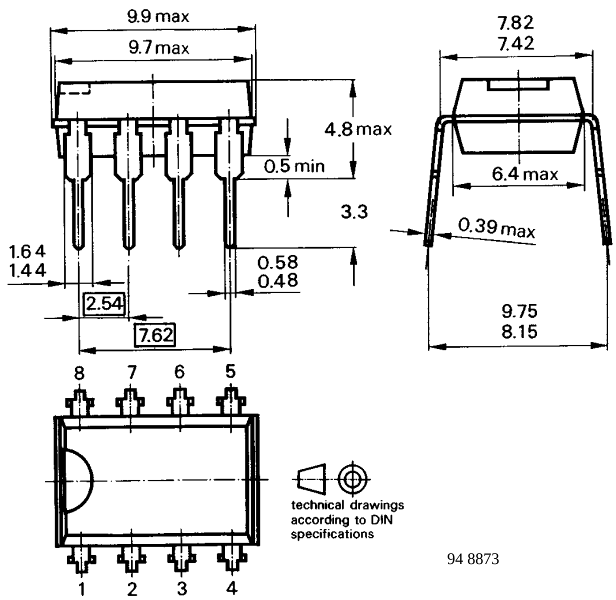


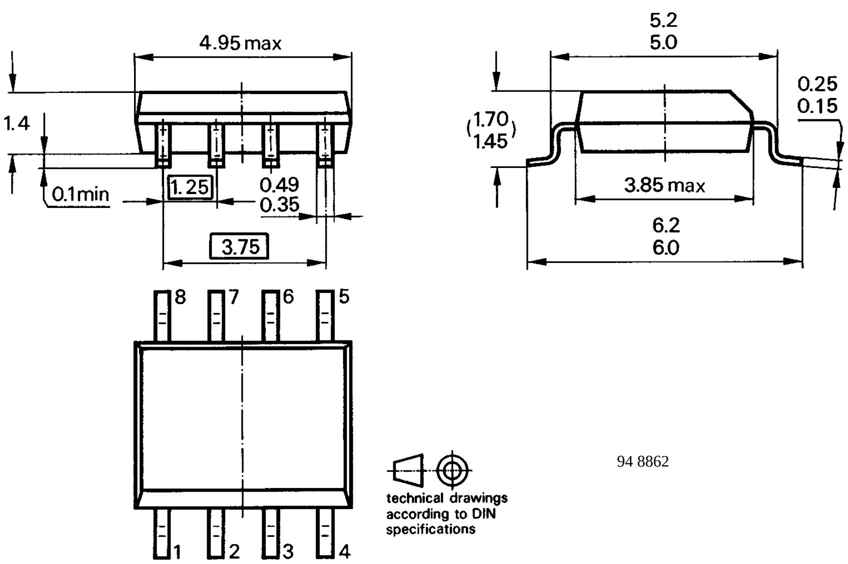
Figure 8 Application for charge current > 250 mA

Dimensions in mm

Package: DIP 8



Package: SO 8



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2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

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1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively

2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA

3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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