CHARGE CONTROLLER

C C S 9 3 1 0 B 2

D a t a s h e e t

Applications for the *Computer-Charging-System*:

Alarm Systems, Cellular Phones, Computer, Electric Vehicles, HiFi, Hobby, Instruments, Lamps, Medical Electronics, Pager, Portables, Radio, Solar Systems, Telephone, Tools, Toys, UPS, Video..

CCS Basic Features:

☺ Microcomputer controlled quickcharge up to 100% exactly
☺ CCS charge termination
☺ No overcharge, no memory effect
☺ Extended battery life
☺ Independent of battery type: NiCd, NiMH, Lead Acid, etc.
☺ Number of cells unlimited
☺ Automatic recharge, MC controlled
☺ Standby operation
☺ Independent of precharging state, no discharge needed
☺ Reliable function also with protection diodes in the battery pack
☺ Simple handling, fail-safe by watchdog control
☺ Independent of external influences (e.g. temperature)
☺ Improved start up characteristic on empty cells
☺ Battery fault detection (LED & buzzer signal)

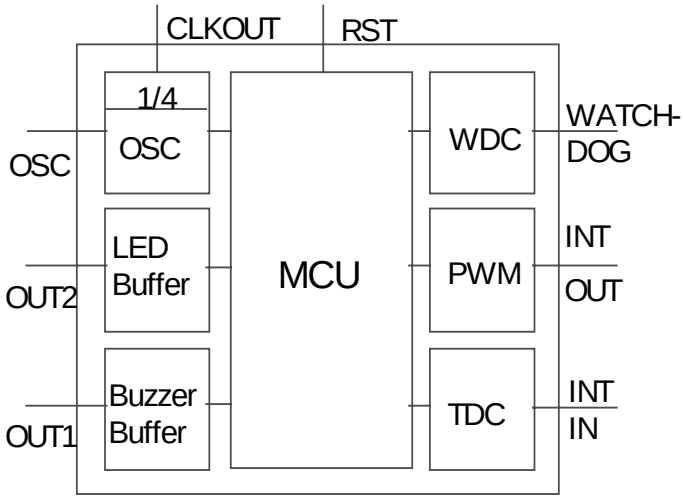
Characteristics:

Input voltage: 3.0V to 5.5V
Low power: < 2 mA
Package: PDIP 18, SOIC 18, SSOP 20

Operating temperature:
Commercial: 0 to +70 °C
Industrial: -40 to +85 °C

Storage temperature: -65 to +150 °C

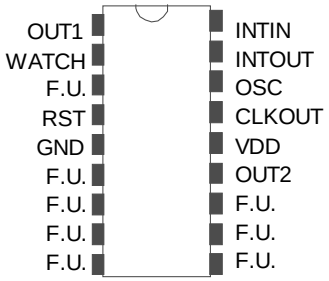
Block Diagram:



Pin Configuration:

1	OUT 1 (Buzzer)	13	OUT 2 (LED)
2	WATCH	14	VDD
3	F.U.	15	CLKOUT
4	RST	16	OSC
5	GND	17	INTOUT, Integrator
6-12	F.U.	18	INTIN, Integrator

(F.U. Factory Use)



Absolute Maximum Ratings:	**min.**	**max.**	**units**
V_{DD}	0	5.5	V
Operating current I_{DD}	-	50	mA
I/O pins	-0.6	V_{DD}+0.6	V
INPUT-port pin-No. 4,18	-	+/- 500	µA
OUTPUT-port pin-No. 1,2,6-13,15,17	-	+/- 20	mA
Total power dissipation	-	800	mW

Supply: at 25°C	**min.**	**typ.**	**max.**	**units**
V_{DD}	3.0	5.0	5.5	V
Standby current (OUT1/2 n.c.)	-	1.8	3.3	mA
Characteristics: at 25°C	**min.**	**typ.**	**max.**	**units**
Input low-value	V_{SS}	-	$0.2V_{DD}$	V
Input high-value	$0.2V_{DD}$+1	-	V_{DD}	V
Input leakage current	-1	0.5	+1	µA
Output low-value (I_{OL}=8.7mA, V_{DD}=4.5V)	-	-	0.6	V
Output high-value (I_{OH}=-5.4mA, V_{DD}=4.5V)	V_{DD}-0.7	-	-	V
RESET low-timing (pulse width)	100	-	-	ns
RC-oscillator (3k6@330pF or 10k@120pF)	530	625	737	kHz

Functional Description

The CCS controller with appropriate circuitry controls the charging of a rechargeable battery up to 100% of the available capacity. The inner impedance between electrode and electrolyte is used for the determination of the 100% full charge state (patented worldwide). In addition the CCS controller features a battery fault detection and an intelligent recharging procedure for maintaining charge in standby operation without derating the performance of the battery by memory effect. Automatic on/off switching of the charging current is controlled by a fail-safe Watch Dog Circuit (WDC).

Power Source:
For the calculation of the inner impedance (according to the new process) it is essential, that the power is supplied with the sinusoidal 100/120Hz pulsation of the rectified line current. Although the battery is charged correctly in many cases, the use of a DC current may not prevent in every condition from uncertain calculations which may lead to premature shut off, overloading, excessive heating and damage of the battery and surrounding material. Therefore the use of a smoothing capacitor as well as the operation from a DC supply (battery) is strictly forbidden.

Battery Voltage:
In principle the controller is independent of cell voltage and number of cells. In every case the battery voltage is reduced by a voltage devider to normalized 1,26V at battery nominal voltage.

Charge Current:
To ensure best results it is necessary that the parameters remain inside their computational limits. Therefore the mean charging current should be stabilized around $1C_A$ (0.5-2).

Process Timing:
The moment, the power supply is switched on (t0), the controller is in standby operation until the duty cycle on pin 17 (integrator out) is lower than 37% (battery is connected). When a battery connection is detected (t1), the controller starts the measurement of the inner impedance and switches on a pulsating charging current (t2). When the measurement of the inner impedance of the battery points to a 100% full charge, the processor switches off the charging current (t3).

Battery Fault Detection:

a) Over voltage (open circuit): If the battery voltage exceeds the upper „limit S2“, the charging process stops immediately. The charging cycle will be restarted for a maximum of two times. If then the voltage is below that limit the charge process will continue, when it is still above the limit the charge process is interrupted and the controller signals „Battery defective“.
S2: e.g. for NiCd $V_{nom.} = 1.2V$ 166% of $V_{nom} = 1.99V$ / cell

b) Under voltage (shorted cell): If, at moment t4, which is 30 sec after charge termination t3, the battery voltage is below a defined lower „limit S1“, the charging cycle will be restarted for a maximum of two times. If the voltage is still out of that range, the controller signals "Battery defective" (LED flashing). If the battery is not disconnected, recharge will follow in every case.
S1: e.g. for NiCd $V_{nom.} = 1.2V$ 105% of $V_{nom} = 1.26V$ / cell

Recharge:

The first recharge starts at moment t5. The shut off is detected by measurement of the inner impedance of the battery as mentioned before (t7). The time distance to the next recharge is determined by the processor.

Standby:

Because of the intelligent recharge, even for the battery with load ($I_{Standby}<0.2C_A$) a residual capacity of approx. 80% of the nominal capacity can be achieved any time ($I_{Charge} = 1C_A$).

Operating Instructions:

1) Power supply on: 1 beep (standby), LED 1 on.
2) Battery connected: Beep 2 times and LED 2 on.
3) Battery fully charged: 1 beep and LED 2 off.
4) Battery fault: 5 short beep and LED 2 flashing.
5) Interrupt: 3 times 2 short beep.
6) Battery disconnected: Last signal repeated (full or fault).
7) During charging: Click with 1 sec - period and LED 2 on.

CCS-Options

CCS-Evaluation Board, Kit:

Universal-Charging Kit or Board: 1-10 cells in series, 100mA-2A

Extension: AN009

Circuit description to charge 1-36 cells in series

DC-Interface Schematic:

Schematic for additional module for to
- Reduce the power loss at the linear transistor; smaller heat sink
- Charge the battery also from a DC-supply (e.g. car battery)

BTI-Adapter:

Microcomputer controlled adapter as an interface between PC and charging circuit.
Indicates the charging curve (graphical presentation) and the amount of charge at the PC
Records the charging process without additional measurement

4-fold and 8-fold Multiplexer Schematic:

With the BTI multiplexer circuitry it is possible to charge 4 or up to 8 independent battery packs automatically and in series.
The batterypacks can differ in chemistry, capacity (0,5 - 2 C) and type but they must have the identical battery voltage (number of cells).

Pin Descriptions

Pin 5	GND	Ground
Pin 14	V_{DD}	Positive input voltage
Pin 4	RST	GND = RESET / V_{DD} (Pull-up) = program start Rising edge to V_{DD}, RESET-TIME = 18 msec
Pin 16	OSC	R/C oscillator input
Pin 15	CLKOUT	Oscillator output (1/4 f_{OSC})
Pin 17	INTOUT	Integrator output: pulse, period T approx. 52 msec $\pm$ 18% Duty cycle (H/T) < 37%...battery connected, limit S2 (Vnom = 1,99V) Duty cycle (H/T) up to approx. 37%... measurement, battery full Duty cycle (H/T) < 23%...battery fault , limit S1 (Vnom = 1,26V) Duty cycle (H/T) over 37%...battery fault limit S2, no battery
Pin 18	INTIN	Integrator input
Pin 2	WATCH	Control input for charging current (off = 0V, on = 5V approx. 16 kHz)
Pin 1	OUT 1 (Buzzer)	Status indicator 1 (square wave 0V-5V) Supply "ON": approx. 1 sec. 550 Hz Battery connected: approx. 2x0,5 sec. 550 Hz Charging cycle: pulses approx. 0,3 msec./sec. Battery full: approx. 1 sec. 550 Hz Interrupt of charging: approx. 3x(2x0,5) sec. 550 Hz Battery fault: approx. 5x0,5 sec. 550 Hz Battery disconnected: repetition of the last signal
Pin 13	OUT 2 (LED)	Status indicator 2 (level 0V-5V) Battery connected: output HIGH Charging cycle: output stays HIGH Battery full: output LOW Battery fault: 1 Hz until next recharge

Pin 16: For a new design use R6=3k6 and C6=330pF, oscillator is more stable!

Do not connect F.U. Pins!

Process-Timing

t0-t1	Delay	Until battery is connected.
t1-t2	1st Measurement	Approx. 20 sec.
t2-t3	Charging	Until 100% fullcharge of the battery Time depends on precharge and charging current, from 1 min. to approx. 30 min. at $2C_A$ (60 min. at 1 C_A, 120 min. at $0{,}5C_A$)
t3-t4	Measurement	Approx. 30 sec.
t4-t5	Delay	Until next recharge, MC-controlled
t5-t7	Charging	Recharge (similar to t1-t3)
t7-t8		Similar to t3-t4

CHARGE-DIAGRAM: FULLCHARGE OF A BATTERYPACK

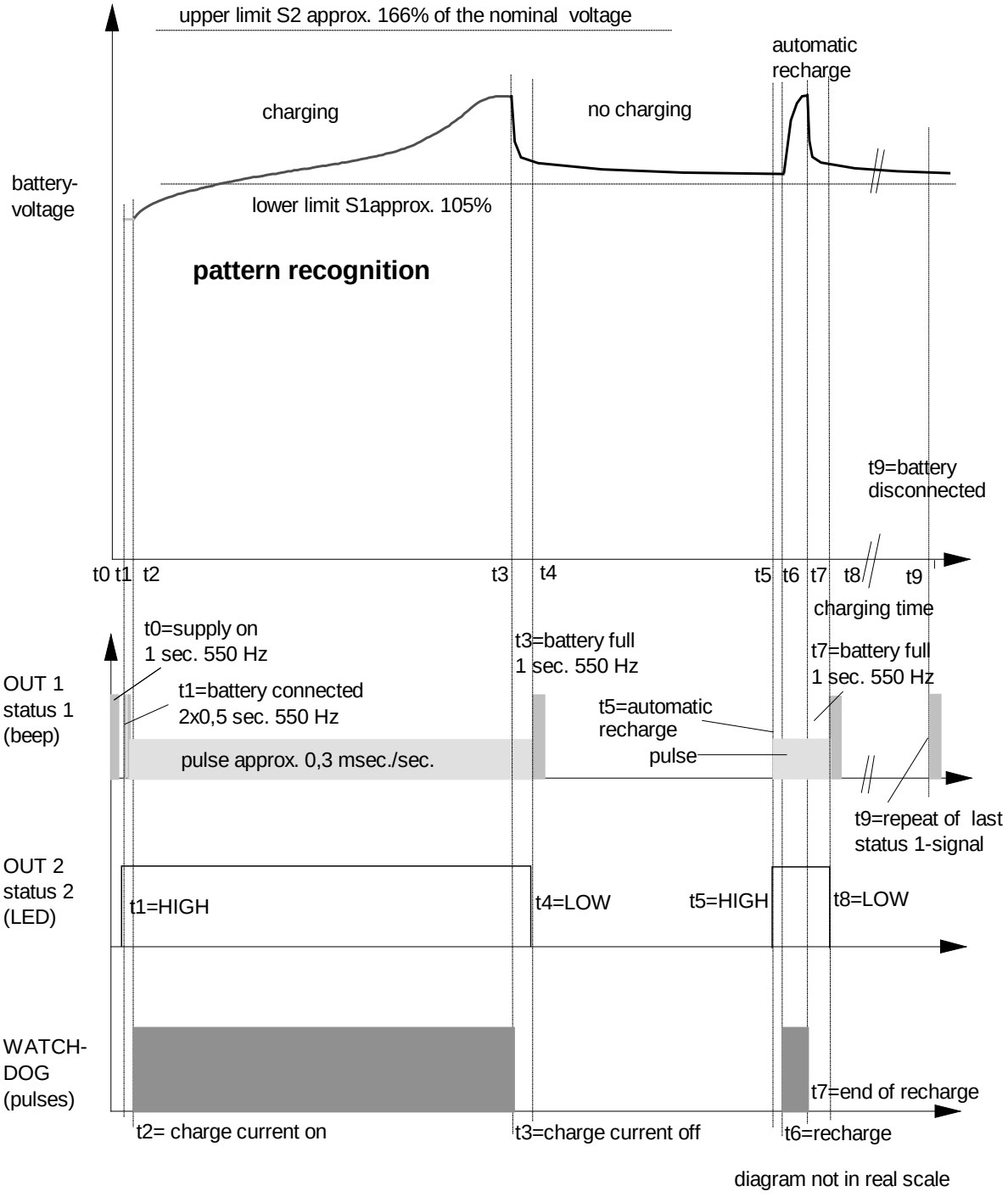
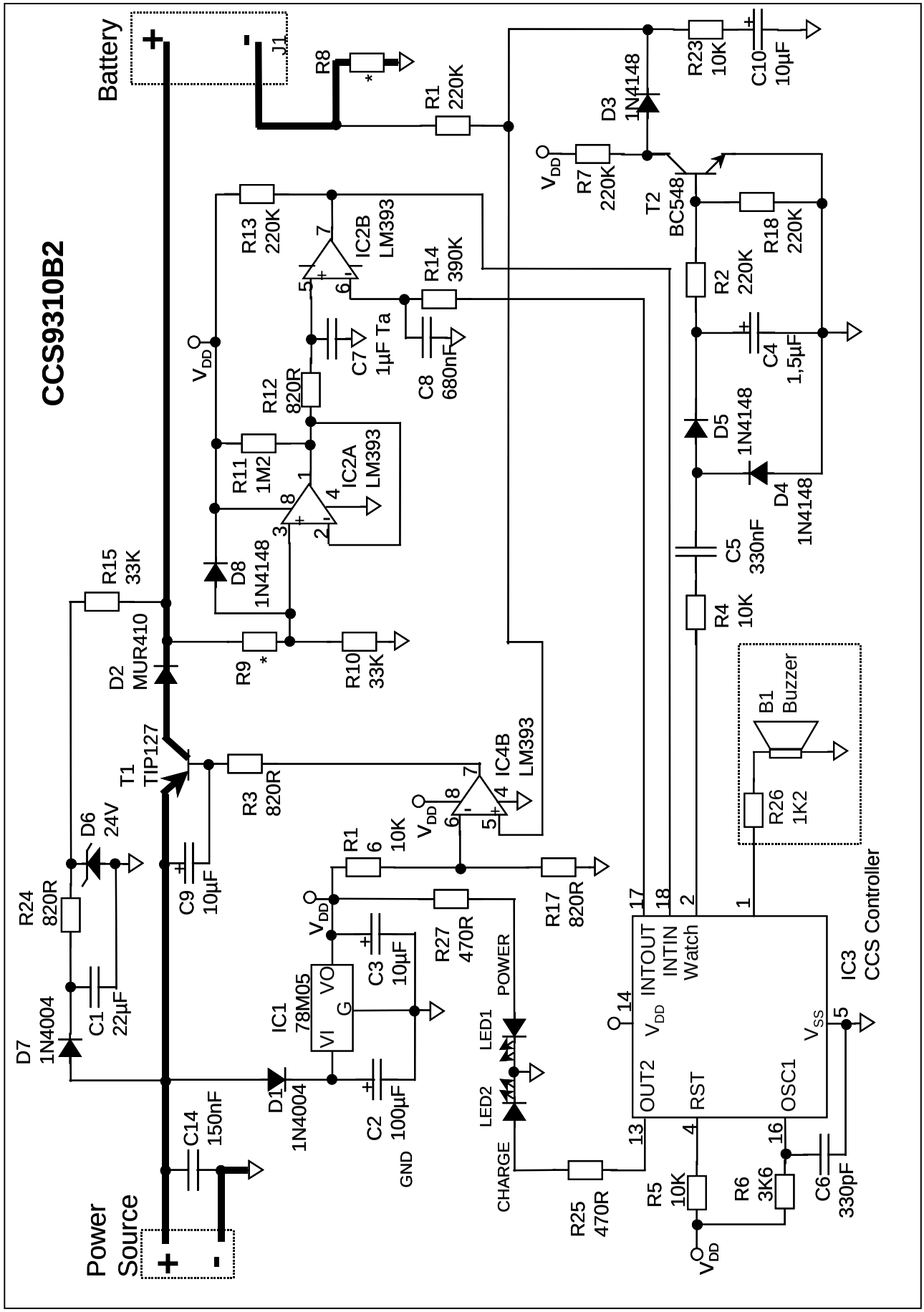


diagram not in real scale

Event t0 : supply on.
Event t1 : battery connected, measurement of the inner impedance of the battery for approx. 20 sec.
Event t2 : start with battery charging
Event t3 : end of charge, automatic cut off controlled by the processor, battery must not be disconnected
Event t4 : end of measurement approx. 30 sec after fullcharge recognition
Event t5: automatic recharge, controlled by the processor
Event t6 : battery recharging
Event t7 : end of recharge
Event t8: end of measurement approx. 30 sec after full charge recognition
Event t9 : battery disconnected

Electronic Circuit: typical charger circuit



Application:

Power Source:
The circuit must be supplied with a full-bridge rectifier - **no smoothing capacitor**!
As supply voltage V_{in} use a rectified 50/60 Hz AC voltage pulsating with a 100/120 Hz frequency.

V_{in} = approx. 1.9V x nominal battery voltage

Battery nominal-voltage	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	V=
Number of cells	1	2	3	4	5	6	7	8	9	10	
V_{in} typ.	7	7	9	10	12	14	16	18	20	22	V_{eff}

R8 Charge Current:
The charging current should come up to approx. $1C_A$ (limits $0.5\text{-}2C_A$):

$I_{Charge}=U_{ref}$ / Resistor R8 with $U_{Ref}=0.38V$.

Examples:

Icharge	100	500	1,000	2,000	3,000	mA
Resistor R8	3.9	0.76	0.38	0.19	0.13	Ohm

R9 Number of Cells: unlimited

$$R9 = R10 \times [(V_{Battery} / 1.2) -1]$$

$$V_{Battery} = 1.2 \times [1 + (R9 / R10)]$$

Exception: $V_{Battery}$ = 1.2 (R9 = 1K)

R9 @ R10 = 33K

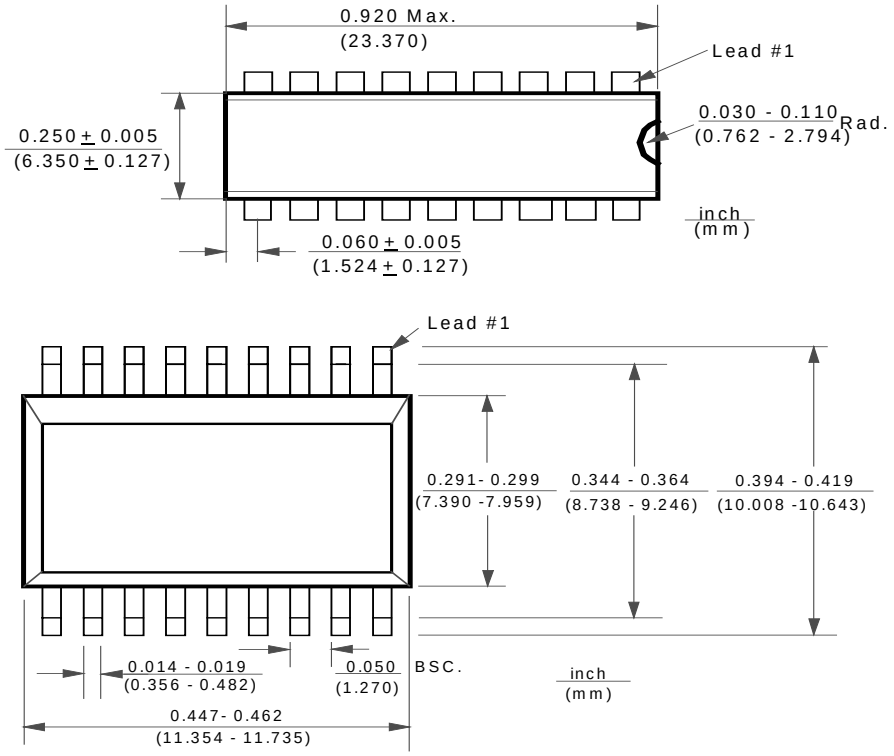
Battery nominal-voltage	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	V=
Number of cells	1	2	3	4	5	6	7	8	9	10	
Resistor R9	1	33	66	100	133	166	199	232	265	298	KOhm

Final Check:
1) Without battery:
Power supply on (1 beep and Power LED on).
Standby current: approx. 15-25 mA (with LED)
VDD: 5 V +/- 0.2 V
Pin 15 of IC1 (CCS 9310): square wave - period approx. 6 µsec 5V level.
Pin 17 - " - : - " - approx. 53 msec 5V Level

2) With battery
Connect battery (2 short beep, Charge LED on), 18-20 sec later charging current on.
Check of charging current with Amperemeter (low inner resistance). After check disconnect measurement device!

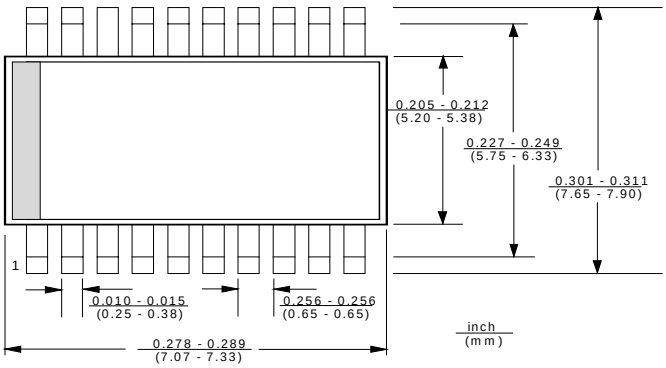
Package:

18 - Lead Plastic Dual In-line **DIP 18**



18 - Lead Plastic Surface Mount SOIC -Wide **SMD**

20 - Lead Plastic Surface Mount **SSOP**



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