Charge Controller

C C S 9 6 2 0 L T

D a t a s h e e t

Applications for the *CCS-System*:

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

Special Features

- ☺ **Power source - DC or AC (rectified 50/60Hz)**
- ☺ **Wide battery capacity range (1:16)**
- ☺ **Battery protection against total discharge**
- ☺ **External charge and buzzer enable**
- ☺ **Serial Data Out, PC connection**

CCS Basic Features:

- ☺ Microcomputer controlled quickcharge up to 100% exactly in 20-30 minutes
- ☺ CCS charge termination
- ☺ No overcharge, no memory effect
- ☺ Extended battery life, >5000 cycles
- ☺ Independent of battery type: NiCd, NiMH, 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)

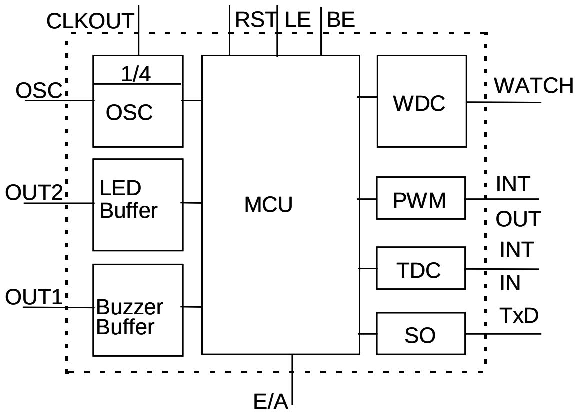
Characteristics:

Input voltage: 3V 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

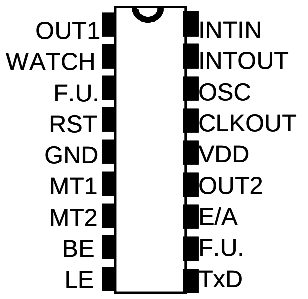
Storage temperature: -65 to +150 °C

Block Diagram:



Pin Configuration

Pin		*Pin*	
1	OUT 1 Buzzer	10	TxD
2	WATCH	11	F.U.
3	F.U.	12	E/A
4	RESET	13	OUT2 LED
5	GND	14	VDD
6	MT1	15	CLKOUT
7	MT2	16	OSC
8	BE	17	INTOUT
9	LE	18	INTIN



F.U. = Factory Used

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-Nr. 4,6,7,8,9,16,18	-	+/- 500	µA
OUTPUT-port pin-Nr. 1,2,10,12,13,15,17	-	+/- 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:
The calculation of the inner impedance requires a variable charging current. If a DC-power supply is used, the E/A (Pin) of the CCS9620can drive a programmable current source to generate the needed wave form itself, so that a correct calculation of the end of charge can be achieved.

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 the typ. value C_A (see Table 1).

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.

Process Timing:
The moment, the power supply is switched on (t0), the processor 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 CCS9620 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 charge 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. If the recharge time is shorter than TDRL, the delay will be doubled (max. 5 days). If the recharge time is longer than TDRH, the delay will be half (min 1hour). If the recharge time is between TDRL and TDRH, the recharge delay is not altered.

TDRL = 10 min	TDRH = 20 min

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).

Additional Functions:

★DC-power source: The controller generates the DC-input into the required wave form (frequency)
★Buzzer On/Off:
★Charge On/Off: Every charge ON signal on Pin 9 means, that any battery will be treated as a just connected battery. With charge OFF on Pin 9 it is possible to stop the charge process.
★Data transfer: With pin 10, a graphical presentation and recording of the parameters via BTI-Adapter from the charging circuitry to the PC is possible.
★ Battery protection: To protect the batteries against total discharge during standby operation, the charge process will start automatically when the battery voltage sinks below 1V/cell.
★Selection of charge mode (time, current): With pin 6 and pin 7 it is possible to select a slow or fast charge mode. The MT-setting is used for the CCS pattern recognition and determines the data collection window (comparable to the range at measurement devices), it is not a Maximum Time or Charge Current setting. With one and the same power source it is possible to charge batteries with low and batteries with high capacity. Status of Pin 6, 7 is accepted during initialization after Power On or Reset only.

Table 1: charge mode (charge time, charge current

MT 2	MT 1	cycle time	charge current	typ.	charge time *	typ. *
Pin 7	**Pin 6**	**sec**	**C_A**	**C_A**	**h**	**h**
0	0	15	1/2 - 2	1	0.5 - 2	1
0	1	30	1/4 - 1	1/2	1 - 4	2
1	0	45	1/6 - 2/3	1/3	1.5 - 6	3
1	1	60	1/8 - 1/2	1/4	2 - 8	4

0 low 1 high *max. time for a fullcharge of an empty battery!

Process-Timing

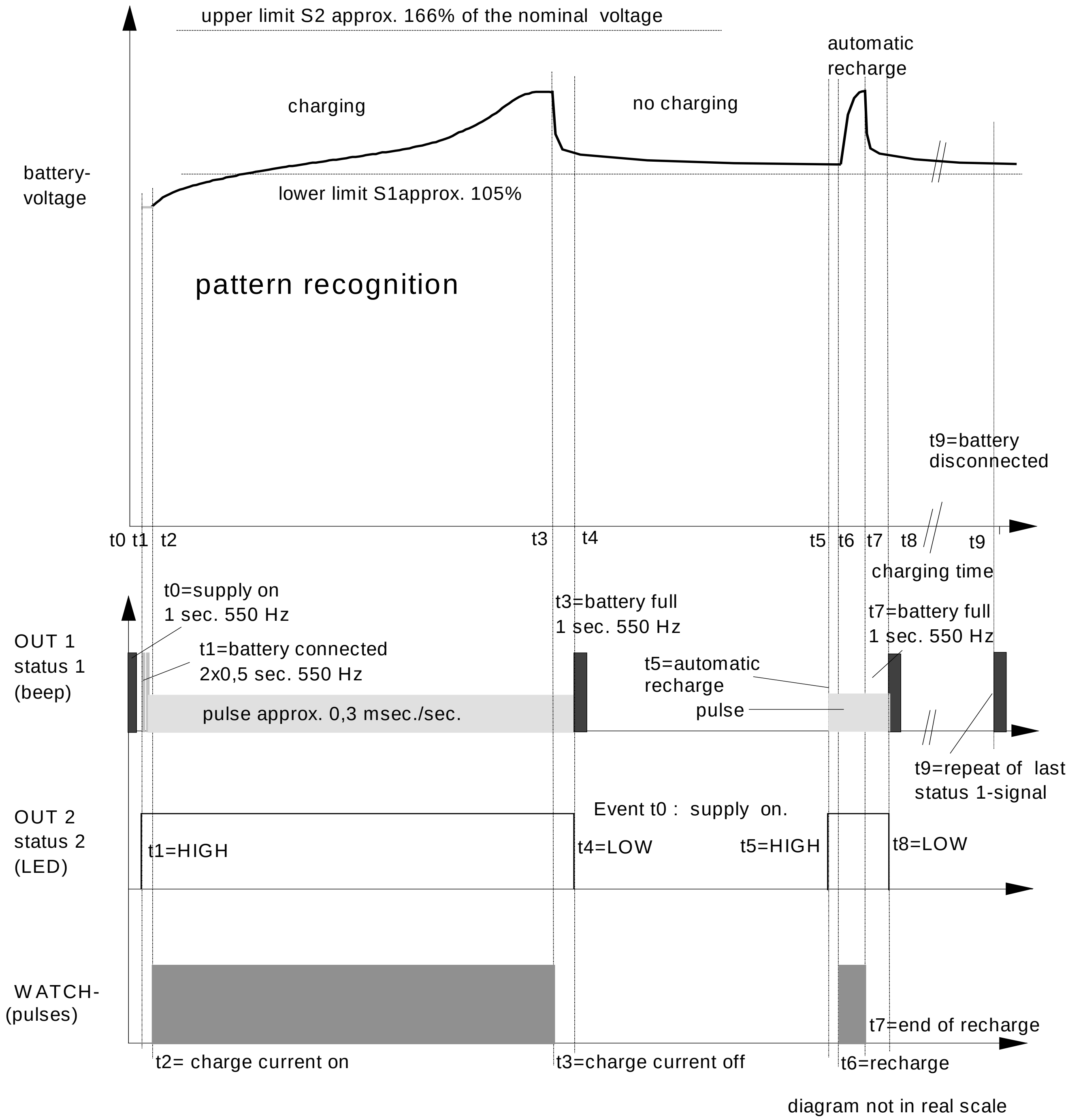
t0-t1	Delay	Until battery is connected.
t1-t2	Measurement	Approx. 20 sec.
t2-t3	Charging	Until 100% fullcharge of the battery Time depends on precharging state and charging current From 1 min. to approx. 60 min. at 1C (see table 1)
t3-t4	Measurement	Approx. 30 sec
t4	Measurement	Battery fault detection
t4-t5	Delay	Until next recharge approx. 1 hour (MC-controlled)
t5-t7	Charging	Recharge (similar to t1-t3)

Pin Description

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 = 52 msec $\pm$ 18% Duty cycle (H/T) < 37%...battery connected, limit S2 (V_{nom} = 1.99V) Duty cycle (H/T) approx. 23% to 37%... measurement, battery full Duty cycle (H/T) < 23%...battery fault, limit S1 (V_{nom} = 1.26V) Duty cycle (H/T) over 37%...battery fault, limit S2, no battery
Pin 18	INTIN	Integrator input
Pin 2	WATCH	Control output 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 pulses until next recharge
Pin 8	BE	Buzzer enable: On/Off during charge process, Level is detected, reaction max. 15 sec later Pin HIGH: buzzer activated Pin LOW: buzzer not active
Pin 9	LE	Charge enable: charge process On/Off, Level is detected, reaction 1 sec later Pin HIGH: charge process on Pin LOW: charge process off
Pin 12	E/A	Charge current ON/OFF
Pin 6	MT 1	Selection of charge mode: see table 1, the configuration is detected at t0.
Pin 7	MT 2	Selection of charge mode: see table 1, the configuration is detected at t0
Pin 10	TxD	Serial data out, via BTI-Adapter to PC

Pin 16: For a new design use R6=3k6 and C6=330pF, oscillator is more stable!
Pin 6,7 (see table 1) and 8,9 must be connected to 0V or 5V!
Do not connect F.U. Pins!

CHARGE-DIAGRAM: FULLCHARGE OF A BATTERYPACK



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

Application for DC-supply:

Power Source: As supply voltage V_{in} use DC-Input, e.g. LT1510CS
For the application with the LT1510CS V_{in} must be at least more than 12V DC and at least more than 7V higher than the nominal battery voltage, to guarantee a stable current.

R9 Battery Voltage: Nominal battery voltage (V_{nom} , V_{bat}) must be divided to 1,2V by the resistor divider R9/R10 for correct resolution of the CCS-Charge-Controller.

$$V_{nom} = 1{,}2 * \left(1 + \frac{R_9}{R_{10}}\right) \qquad R_9 = R_{10} * \left(\frac{V_{nom}}{1{,}2} - 1\right)$$

The following table shows typical values for R9 @R10=33k

V_{nom}	1,2	2	2,4	3,6	4	4,8	6	7,2	8	8,4	9,6	10	12	V
R9(R10=33)	0	22	33	68	74	100	130	160	187	200	237	240	297	kΩ

R1 Charging Current:

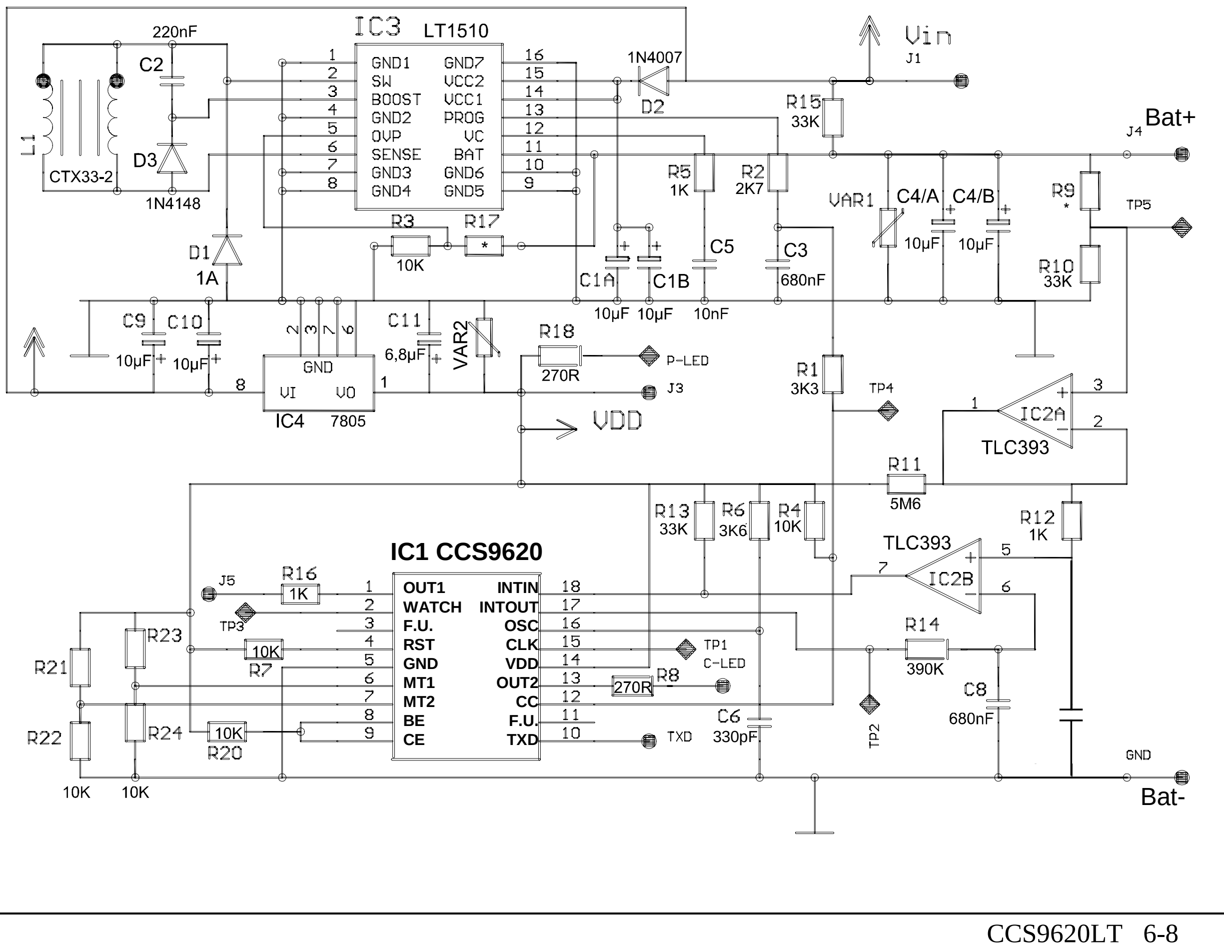
$$I_{ch} = \frac{2{,}465 * 2000 * 0{,}86}{R_1 + R_2} \qquad I_{ch} = \frac{4{,}24}{2{,}7 + R_1[k\Omega]}[A]$$

The table shows typical values for R1 @R2=2k7

R1	0,68	1,5	2,2	3,3	5,6	10	15	33	39	kΩ
I_{ch}	1,250	1,000	860	707	511	333	240	120	100	mA

Charge Mode: MT1, MT2 setting see table 1, page 3

Schematic for DC-supply:



Application: for rectified AC-supply

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.

R9 Battery Voltage: Number of cells unlimited

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

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

R9@R10=33k

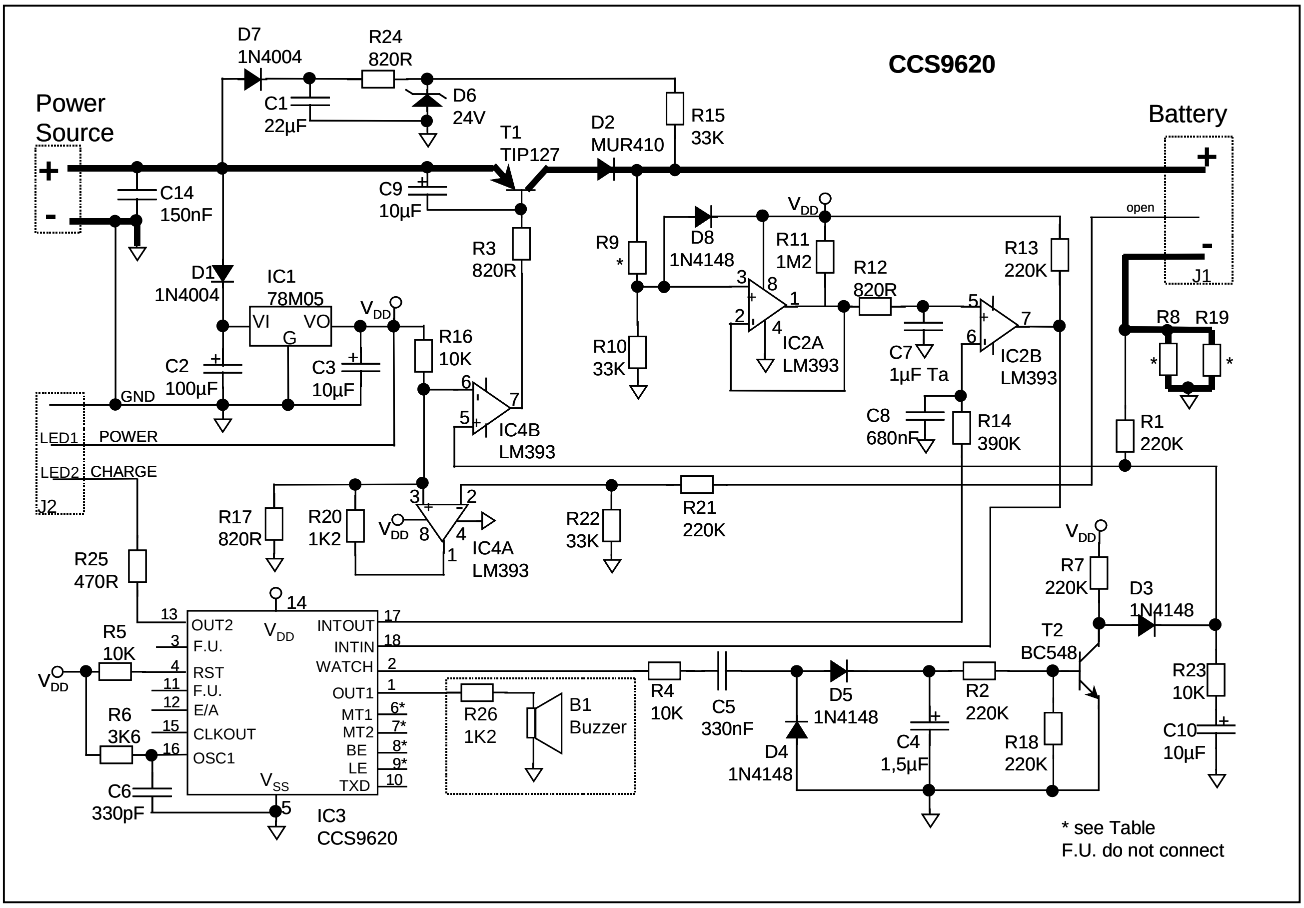
Batt. nom. Voltage	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	V=
Number of cells	1	2	3	4	5	6	7	8	9	10	
Resistor R9	1	34	67	100	133	166	199	232	265	298	kOhm
V_{in} typ.	9	9	9	10	12	14	16	18	20	22	V_{eff}

R8,R19 Charge Current: I_{charge} = U_{ref} / Resistor R8 parallel R19 with U_{Ref}= 0,38V
Examples:

Icharge	100	500	1,000	2,000	3,000	mA
Resistor R8//R19	3.9	0.76	0.38	0.19	0.13	Ohm

Pin 6, 7 Charge Mode: Selection of charge current see table 1 page 3.

Schematic for rectified AC-supply

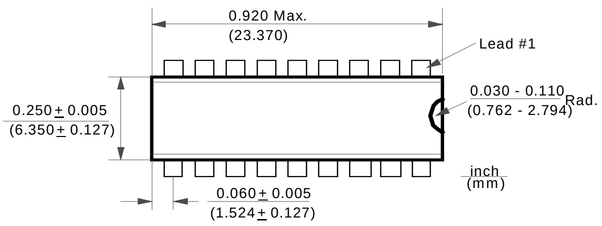


Operating Instructions:

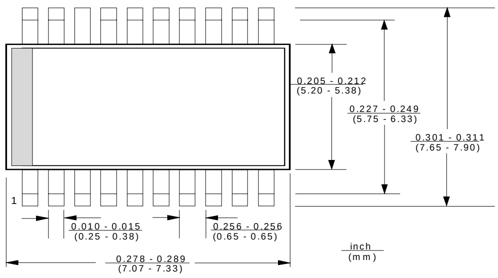
1) Power supply on:	1 beep and green LED (LED 1) on (standby).
2) Battery connected:	2 beep and red LED (LED 2) on. (not protected against false polarity!)
3) Battery fully charged:	1 beep and red LED off.
4) Battery fault:	5 short beep and red LED flashing.
5) Interrupt:	3 times 2 short beep.
6) Battery disconnected:	last signal repeated (full or defective).
7) During charge:	click with 1 sec period and red LED on (if BE = high)

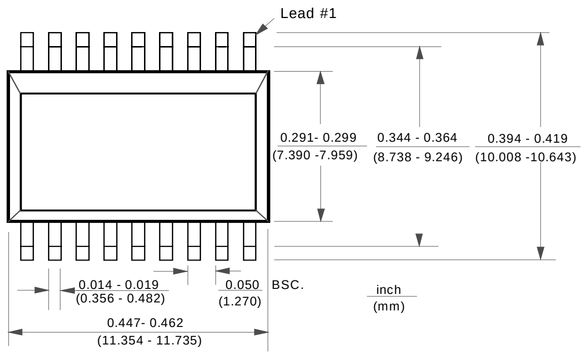
Package:

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



20 - Lead Plastic Surface Mount **SSOP**





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

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