Charge Controller

C C S 9 6 3 3

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

☺ **Singlechip for a threefold (3 in 1) battery charger**
☺ **Serial, automatic charge of 3 battery packs**
☺ **Minimized hardware**
☺ **Option: PC-Interface**

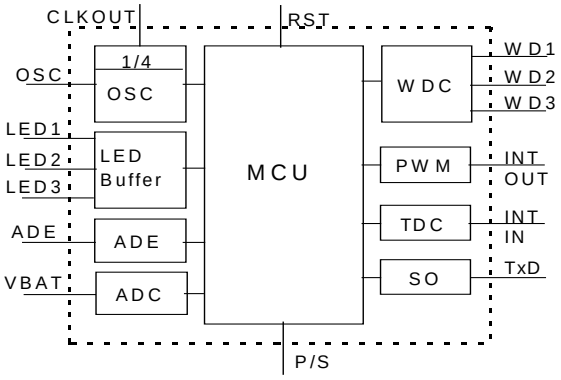
CCS Basic Features:

☺ 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
☺ 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:

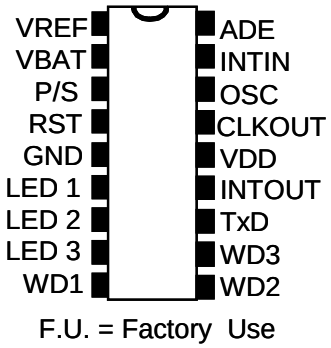
Input voltage:	3.0V to 5.5V
Low power:	< 2 mA
Package:	PDIP 18, SOIC 18, SSOP 20
Operating temperature:	
Commercial:	0 to +70 °C
Industrial:	-40 to +85 °C
Storage temperature:	-65 to +150 °C

Block Diagram:



Pin Configuration:

1	VREF	10	WD 2
2	VBAT	11	WD 3
3	P/S	12	TxD
4	RST	13	INTOUT, Integrator
5	GND	14	V_{DD}
6	LED 1	15	CLKOUT
7	LED 2	16	OSC
8	LED 3	17	INTIN, Integrator
9	WD 1	18	ADE



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, 14, 17, 18	-	+/- 500	µA
OUTPUT-port pin-No. 6-13, 15, 16	-	+/- 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 (3k@330pF, 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 Supply:
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.

Charging 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 $1C_A$ ($0{,}5C_A$ - $2C_A$).

Process Timing:
When the power supply is switched on, the processor is in standby operation. When a battery connection is detected in one of the 3 battery shafts, the CCS9633 starts the measurement of the inner impedance and switches on a pulsating charging current. When the measurement of the inner impedance of the battery points to a 100% full charge, the processor switches off the charging current.

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 30 sec after charge termination, 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 119% of V_{nom} = 1.43V / cell

For the second battery and all the next batteries, the above mentioned procedure will be repeated.

Recharge:

The recharge for the first battery starts approx. 1h later. The shut off is detected by measurement of the inner battery parameters as mentioned before.

Charge Order:

Order for battery plug-in: optional!

At any time and in any battery shaft it is possible to plug in a battery or to replace a fully charged or defective battery with another battery.

Order for battery charging: battery A1, battery A2, battery A3

a) With battery A1:
   Battery A1 will be charged first! All other batteries will be charged serially (A1, A2, A3, A1, etc.).
b) Battery A2 and A3, without battery A1:
   If both batteries, A2 and A3, are put into the charging station at the same time, the battery, that is put in first, will also be charged first.
c) Battery A1 plug in during charge:
   If battery A1 is put into the charging station while another battery (A2 or A3) is charged, the charging process stops and the charger begins immediately with the charge of battery A1!
   All other batteries will then be charged serially (A1, A2, A3, A1, etc.).

Recharge Order:

If recharge is necessary, it will always follow the order A1, A2, A3.
In any case every battery will be charged only one time (charge and recharge). If a battery shaft is empty or a battery is already charged + recharged, the CCS9633 turns over to the next battery shaft. If all batteries are fully charged, the charging station stays in standby position. The moment when a battery is replaced, a new charging process starts and all batteries will be recharged.

Signals:

LED 3 (green): Power

LED 1, LED 2, LED 4 (red): Battery status

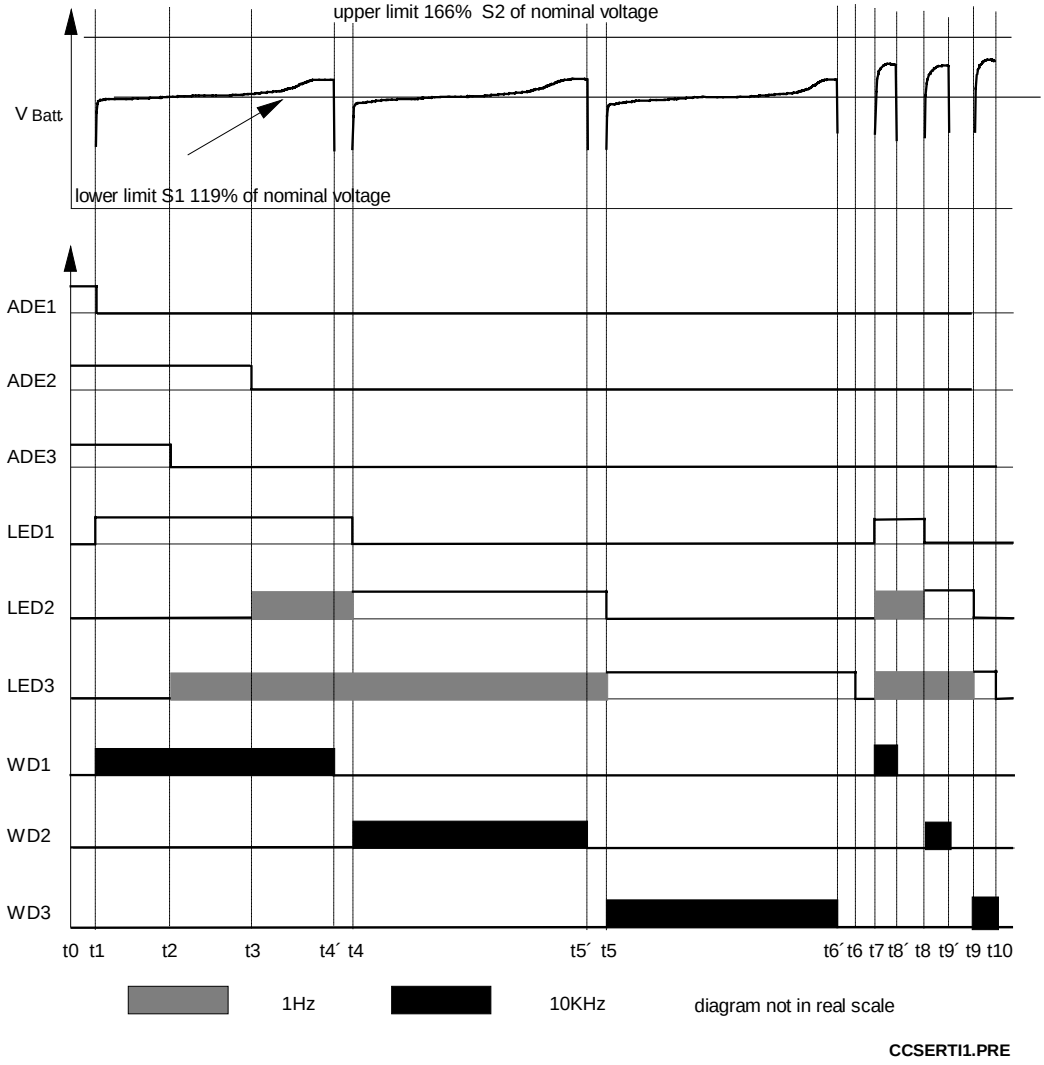
LED 3	on	Power, standby operation
LED 1,2,4	on	Battery charging
LED 1,2,4	flashing slowly	Battery waiting for charge
LED 1,2,4	flashing fast	Battery defective
LED 1,2,4	off	Battery fully charged, or no connection

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 13	INTOUT	Integrator output: pulse, period T = 52 msec ± 18% Duty cycle (H/T) < 23%...battery connected Duty cycle (H/T) approx. 14% to 23%... measurement, battery full Duty cycle (H/T) < 14%...battery fault, limit S1 Duty cycle (H/T) over 23%...battery fault, limit S2, no battery
Pin 17	INTIN	Integrator input
Pin 12	TxD	Datatransfer output, BTI-Adapter to PC
Pin 9 Pin 10 Pin 11	WD 1-3	Control output for charging current (off = 0V, on = 5V approx. 10 kHz) Output LOW: no battery or battery waiting for charge Pulse signal: Battery charging
Pin 18	ADE	Control input for battery detection Input HIGH: no battery connected Input LOW: battery connected
Pin 6 Pin 7 Pin 8	LED 1-3	Status indicator (level 0V-5V) Battery connected: output HIGH Charging cycle: output stays HIGH Battery full: output LOW Battery waiting: 1 Hz pulses Battery fault: 2 Hz pulses until next recharge
Pin 1	VREF	F.U. do not connect
Pin 2	VBAT	Battery voltage input
Pin 3	P/S	Serial operation, connect to V_{DD}

Pin 16: For a new design use R6=3K and C6=330pF, oscillator is more stable.
Do not connect F.U. pins!!

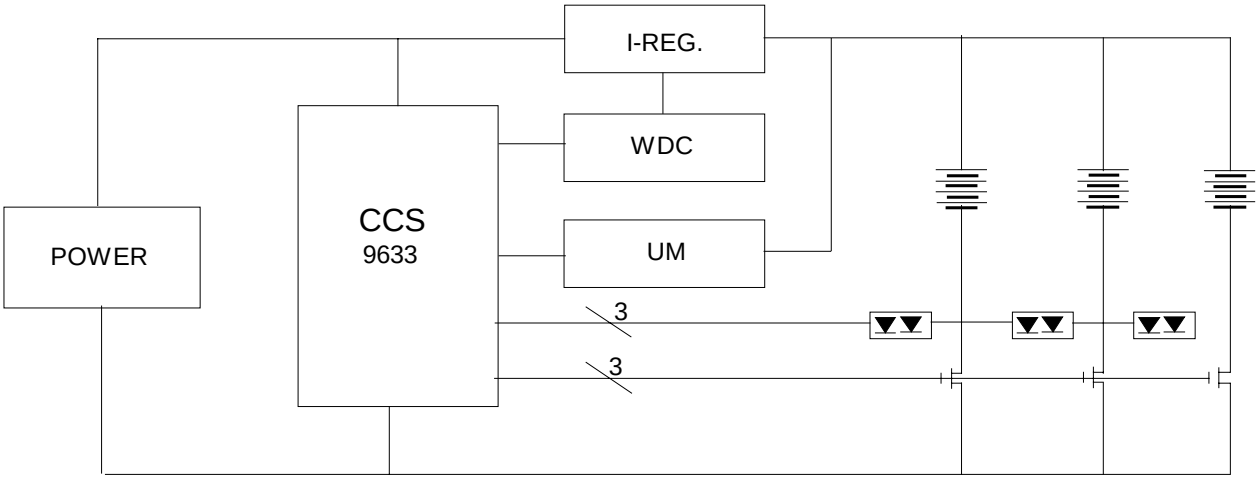
Charge Diagram: example (order of battery connection A1, A3, A2)



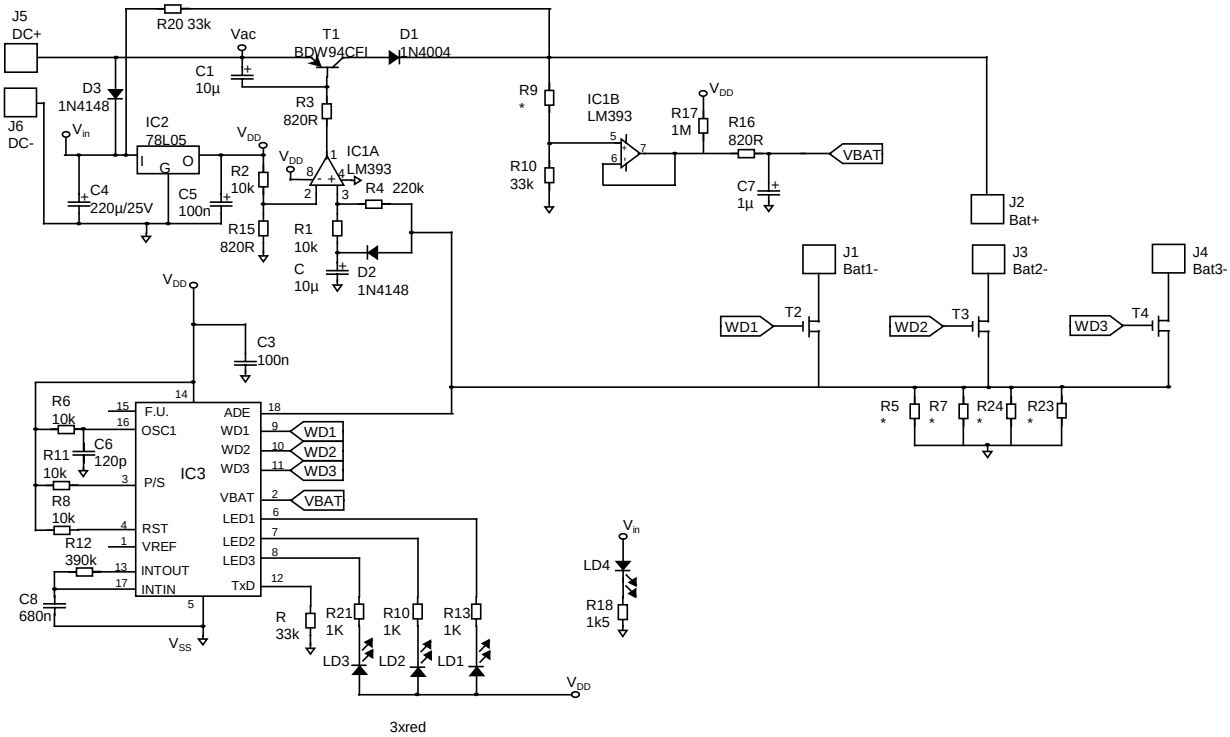
Process-Timing: example (order of battery connection A1, A3, A2)

t0-t1	Standby	until battery is connected.
t1		first battery A1 connected
t2		second battery A3 connected
t3		third battery A2 connected
t1-t4'	Charging	A1 until 100% fullcharge of the battery time depends on precharge and charging current from 1 min. to approx. 60 min. at $1C_A$ (120 min. at $0{,}5C_A$; 30 min. at $2C_A$)
t4-t5'	Charging	A2 until 100% fullcharge of the battery , see above
t5-t6'	Charging	A3 until 100% fullcharge of the battery, see above
t6-t7	Standby	until next recharge, approx. 1 hour (MC-controlled)
t7-t8'	Charging	recharge A1 (similar to t1-t4')
t8-t9'	Charging	recharge A2 (similar to t4-t5')
t9-t10	Charging	recharge A3 (similar to t5-t6')
tx'-tx	Delay	approx. 5 min (no reaction when battery connected/disconnected)

Block Diagram:



Schematic:



Application:

The circuit must be supplied with a full bridge rectifier - **no smoothing capacitor!**

Supply Voltage:
As supply voltage V_{in} use a rectified 50/60Hz voltage pulsating with a 100/120Hz frequency.

Charge Current:
$I_{charge} = U_{ref}$ / (Resistor R5, R7, R24, R23 all parallel) with $U_{ref} = 0{,}38\ V_{eff}$
The charge current must be stabilized around $1C_A$.
Limits: min ½ C_A (2 hours charge) to max. $2C_A$ (20-30 minutes charge)

Number of Cells:

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

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	
V_{in} typ.	7	7	9	10	12	14	16	18	20	22	V_{eff}
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 IC3 (CCS 9633): square wave - period approx. 6 µsec 5V level.
Pin 17 - " - : - " - approx. 53 msec 5V Level

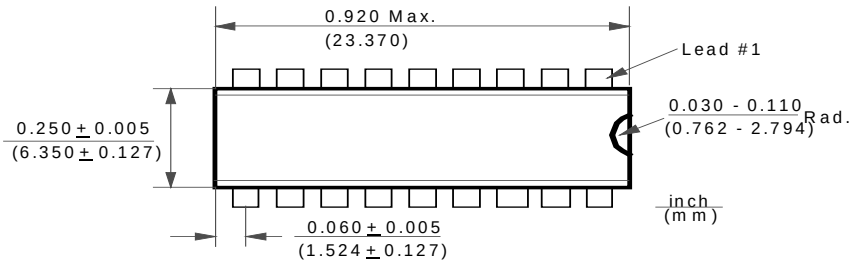
2) With battery
Connect battery (2 short beep, Charge LED on), 18-20 sec later charging current on.
Check of charging current with Amperemeter (low inner resistance). After check disconnect measurement device!

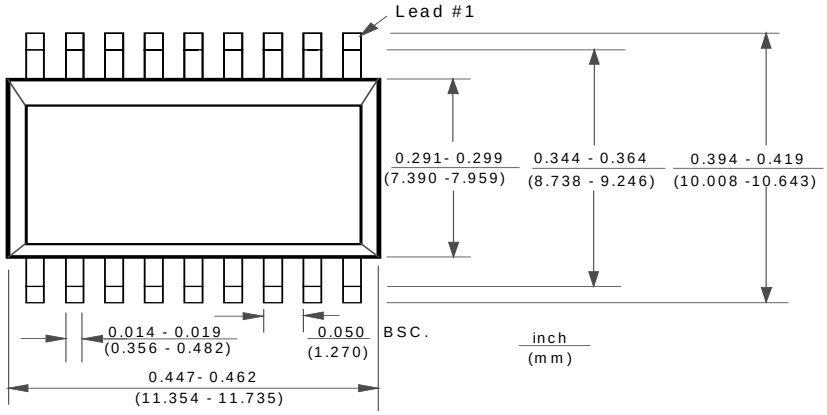
Operating Instructions:

1) Power supply on: green LED on (standby).
2) Battery charging: red LED on. (not protected against false polarity!)
3) Battery fully charged: red LED off.
4) Battery fault: red LED flashing fast
5) Battery waiting: red LED flashing slowly.
6) Battery change during charge possible

Package:

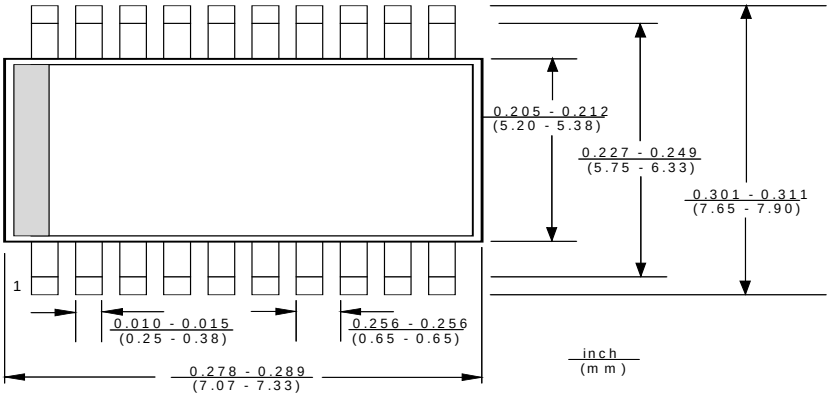
18 - Lead Plastic Dual In-line **DIP 18**





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

20 - Lead Plastic Surface Mount **SSOP**



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