C C S E B

EVALUATION BOARD

UNIVERSAL-CCS-Charger Module

for Rechargeable Batteries

Features of CCS-SYSTEM [1)]

☺ Microcomputer-controlled Quick-Charge in 20-90 minutes [2)]
☺ 100%-Fullcharge-Recognition, no overcharge [2)]
☺ Extended battery lifetime, > 5000 charging cycles [3)]
☺ Independent of batterytype or-series (NiCd, NiMH, Lead Acid, SLA, NiFe, etc.) [2)]
☺ No discharge before charging needed
☺ Independent of the precharging-state and external influences [3)]
☺ Secure function also with protection-diodes in the charging-circuit [2)]
☺ Number of cells in series adjustable: 1 - 10 cells [2)]
☺ Charging current adjustable: 100mA, 500mA, 1A, 2 A, (max. 4A) [2)]
☺ Signals: LED-Lamps and Beeper (4kHz, 70dB) [2)]
☺ Automatic battery-control (voltage and charge) [2)]
☺ Automatic recharge [3)]
☺ Improvement of quality at low cost
☺ No Memory-Effect
☺ Foolproof

Applications:
Alarmsystems, Cellular Phones, Computer, HiFi, Home Appliances, Hobby, Instruments, Lamps, Medical Electronics, Pager, Portables, Radio, Telephone, Tools, Video, UPS, etc.

1) patented: worldwide
2) see description
3) as explained in BTI-CCS description or Datasheet

1. TECHNICAL DATA

The CCSEB Evaluation Board can be assembled for any batterypack. For universal application (different batterypacks) it is possible to change the battery-voltage (number of cells) and the charge current with selection switches.
Datasheets and descriptions how to adapt to a certain battery-pack and how to proceed are included.
For a quickstart, parts for the most common applications are included as well (1 to 10 cells, charge current from 100mA to 2A)
On demand it is possible to deliver readily assembled Evaluation Boards for one battery pack.

1.1. Specifications:

Battery type:	NiCd, NiMH, Lead Acid, SLA
Battery voltage:	1.2 to 12 V (or higher, variable)
Number of cells:	1-10 (or more, variable)
Charge current:	100mA, 500mA, 1A, 2A (or other, variable, max. 4A)
Battery capacity:	100mAh to 4Ah (variable)
	higher with CCS9505 or CCS9606, or CCS9620
Charge controller:	CCS9310B2, CCS9505FK, CCS9606, CCS9620
Status indicator:	optical-2 LED,
	audible-Buzzer (4kHz, 70dB)
Print:	85x75mm, double layer, silk screen

Not included: Power source (transformer and rectifier), selection switch

2. POWER SOURCE

2.1 Supply voltage

As supply voltage V_{in} use a rectified 50/60 Hz AC voltage pulsating with a 100/120 Hz frequency.
After the transformer use a full-bridge rectifier (see Application 10. page 9).
Do not use a smoothing capacitor!!

2.2. How to choose the transformer voltage:

The secondary voltage of the transformer has to be equivalent to the values of Table 1.
If the voltage is chosen higher, the loss of the linear transistor T1 will be higher too.

Calculation: Transformer-voltage (for 4 cells and more) = approx. 2V x number of cells.

Table 1

nom.-voltage	1,2V	2,4V	3,6V	4,8V	6,0V	7,2V	8,4V	9,6V	10,8V	12V=
V_{transf} sec.	8	9	9	10	12	14	16	18	20	22V_{eff}

2.3. How to choose the transformer-power:

For safe function 2V per cell (minimum 8V) are necessary.
P_{transf} (VA) = number of cells x 2 (V) x charge current (A)

Example: 1-10 NiCd-cells, battery capacity up to 1,8Ah charging current 2 A, transformer-voltage 9V/16V/21 V, power approx. 62 VA

Table 2

nom.-voltage		1,2V	2,4V	3,6V	4,8V	6,0V	7,2V	8,4V	9,6V	10,8V	12V=
number of NC cells		1	2	3	4	5	6	7	8	9	10
capacity Ah	I_{charge} mA	**TRANSFORMER-POWER in VA**									
to 0.1	100	2	2	2	2	3	3	4	4	5	5
0.5-0.7	500	8	8	8	9	12	12	16	16	16	16
0.8-1.4	1,000	16	16	16	21	21	21	32	32	32	32
from 1..5	2,000	32	32	32	32	40	45	50	62	62	62

All components of the power section, especially the rectifier, the heat sink and the fuse, must be dimensioned sufficiently and assembled as shown in the block diagram (see chapter 8. page 10).

Caution: Use only fully isolated transformers. Isolation between primary and secondary windings must be in accordance with IEC and CEE safety regulations!

3. BATTERY VOLTAGE

3.1. According to number of cells, choose the appropriate resistor R9

Resistor R9 determines the range of the battery voltage (number of cells).
Calculation of R9: R9= (number of cells-1) x 33K, for R10 = 33K, see Table 3

Table 3

nom.-voltage	1,2V	2,4V	3,6V	4,8V	6,0V	7,2V	8,4V	9,6V	10,8V	12V=
number NC cells	1	2	3	4	5	6	7	8	9	10
resistor R9	**1K**	**33K**	**66K**	**100K**	**133K**	**166K**	**199K**	**232K**	**265K**	**298K**

3.2. Different battery packs

To charge a variable number of cells, R9 has to be adjustable. For that purpose connect the resistor R9a with the resistors R9x in series through e.g. a selector-switch (see Fig. 2, page 4).
As an alternative you can use potentiometer with 500K, divided in appropriate steps (see Fig. 3, page 4).

Attention:
Table 3 is valid only for battery packs **without protection-diodes**. If there are 1-2 diodes in the charging circuit, you have to choose the next higher battery-voltage range (higher resistor R9)!

4. CHARGE CURRENT

The charge controller needs a current with a pulsating waveform (e.g. rectified line with 100/120Hz frequency).

CCS9310B2: charge current should come up to approx. $1C_A$ (limits 0.5 - 2 C_A).
CCS9505FK: charge current from $1C_A$ to ¼ C_A (limits 0.125 - 2)
CCS9620: charge current from $1C_A$ to ¼ C_A (limits 0.125 - 2)
CCS9606: charge current from 1 C_A to 1/16 C_A (limits 0.015 - 2)

4.1.The two resistors R8 and R19 determine the charging current:

I_{charge}= 0,38V / (R8 parallel to R19)

Table 4				
Battery	**Current**	**Resistor**	**Value**	**Remark**
to 100 mAh	100 mA	R19a	3.9 Ohm	R19a horizontal
0.5 - 0.7 Ah	500 mA	R8b, R19b	2 x 1.5 Ohm	horizontal, parallel
0.8 - 1.4 Ah	1 A	R19c (> 1W)	0.33 Ohm	R19c vertical
from 1.5 Ah	2 A	R8d, R19d (> 1W)	2 x 0.33 Ohm	vertical, parallel

With the use of a selector-switch (nominal current min. 4 A=) all versions could be realized in one (see Fig. 1)

4.2. Option: 4A-charging current
(not included in this Evaluation Board)

Table 4a				
Battery	**Current**	**Resistor**	**Value**	**Remark**
from 4 Ah	max. 4 A	R19 (5 W)	0.12 Ohm	not on PCB

Replace diode D2 MUR410 (SK304) by Schottky-Diode (e.g. SB540),
and transistor T1 BDW94CFI (TIP 127) by e.g. BDV64B.
Wire external, current leads on PCB can carry up to 2A only!
Charging currents >2A, current lead (heavy line in the SCHEMATIC) must be wired external.
Transformer 22 V_{eff} 120 VA with sufficient cooling:

Selector Switch 10 Pos.

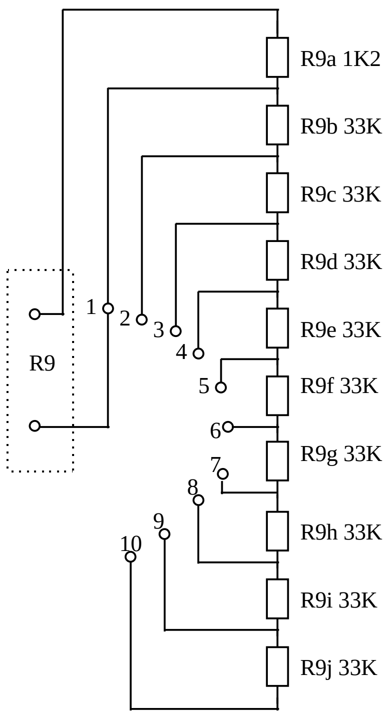


Fig. 2

Selector Switch 4 Pos.

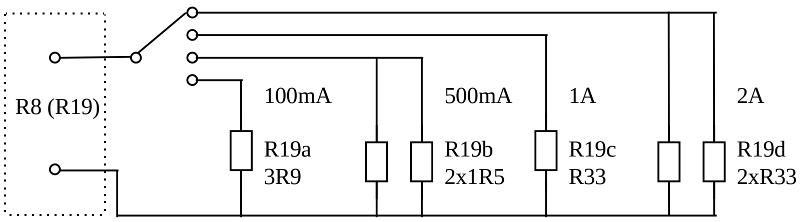


Fig. 1

Potentiometer (Drimmer)

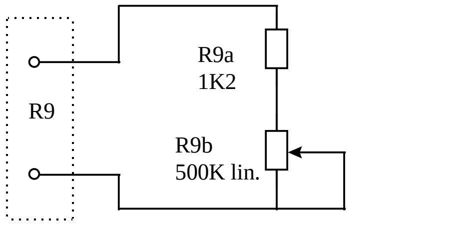


Fig.3

5. PLUGS AND LEADS

Connect the rectifier to the appropriate solderpoints (+) and (-) (take care of the right polarity) as shown on the component/layout side 7.1. page 6 or in Application 10. page 9.

Attention! The circuit is not protected against false polarity! Strictly do not use a smoothing capacitor! Do not drill the holes. The printthrough connection will be destroyed.

5.1. LED-lamps

Use **plug J2** to connect the LED-lamps as shown in chapter 10. (page 9)
Connect the anode (longer pin) of the green LED with resistor R27 (470R) and the cathode to ground. The anode of the red LED-lamp must be connected with "charge" and the cathode with ground.

5.2. Connection of battery

Use plug **J1** to connect the battery:
(+, left pin) to the positive terminal of the battery pack;
(-, right pin) to the negative terminal of the battery pack (see SCHEMATIC on page 8, or Application on page 9)

Final check:
Before the assembled device is set into operation, check again very carefully, if all components are placed correctly, check polarity, remove solder splashes or bad solder contacts.

6. FIRST TIME OPERATION

We assume that the Evaluation Board is supplied by a safe isolated low voltage AC-current.

Attention!
- Contact with voltages above 20V can be dangerous to life!
- The fuse must be dimensioned in a safe region!
- Isolate any blank components or leads carrying voltages above 20V.
- Set appropriate means to avoid any contact to the mains supply.
- In every case use a certified isolated transformer if measurements on the charging unit, connected to the mains voltage, have to be done.
- No measurement instruments may be connected into the charging circuit during the process of battery charge, because this could lead to false calculation of the Battery-Full criteria.

6.1. Final check:

1) Power supply on: green LED on and 1 beep

Standby current, no battery connected: approx. 10-25 mA
V_{DD}: 5 V ± 0,2 V
Pin 15 of IC 3 (CCS controller): square wave - period approx. 6 µsec 5V level.
Pin 17 - " - : - " - approx. 52 msec

2) Power supply off, stop measurement of current (disconnect instruments from the charging circuit) power supply on (1 beep and green LED on),

connect battery (2 short beep, red LED on), 18-20 sec later charging current on.
check of charging current across R8 or R19: approx. 0,4 V level
Watchdog check: Collector of T2 0,2 V...charging current on 0,5xV_{DD}...charging current off

6.2. Checklist in the case of defects:

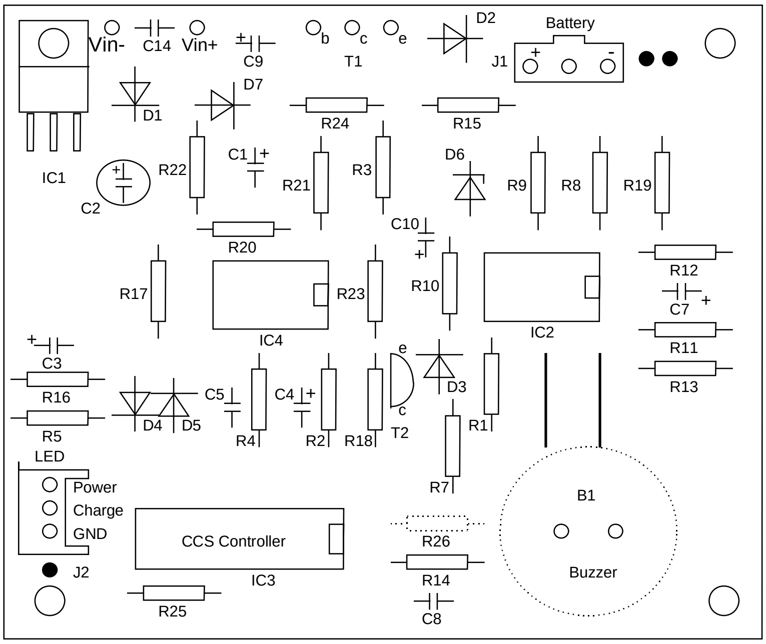
- Power source, rectified AC?
- Fuses OK?
- Diodes, LED's, electrolyte capacitors correct polarity?
- Resistors appropriate value?
- Transistors (base-emitter reversed?), crossed pins?
- IC correctly placed, all pins in socket?
- Shorts on the solder side?
- All solder points soldered with correct contact?
- Broken wires or cables?

Attention!

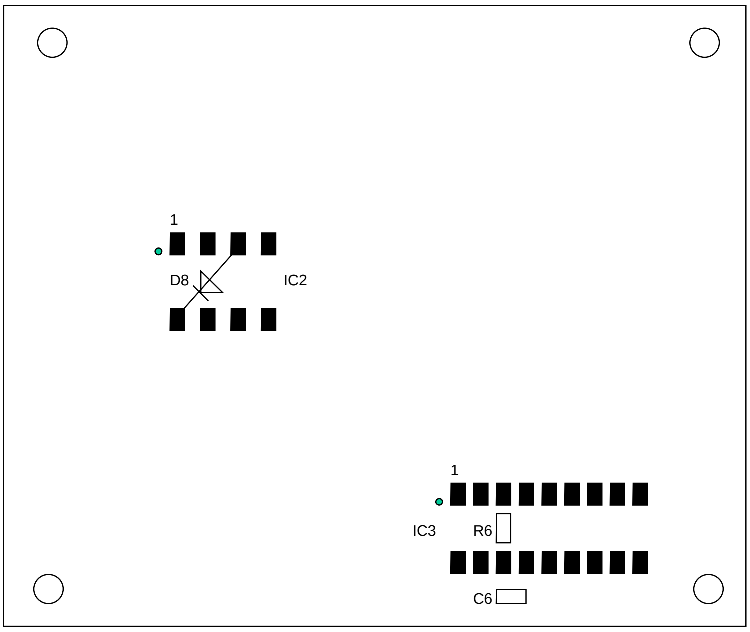
- No protection against false polarity!
- Do not alter the selection of current or number of cells during the process of battery charging!
- Used and old batteries often accept less capacity than nominal capacity, therefore they must be charged with lower current, according to their decreased capacity.
- Deep discharged batteries sometimes need 2 charging cycles!

7. COMPONENT LAYOUT

7.1. Component Side



7.2. Solder Side



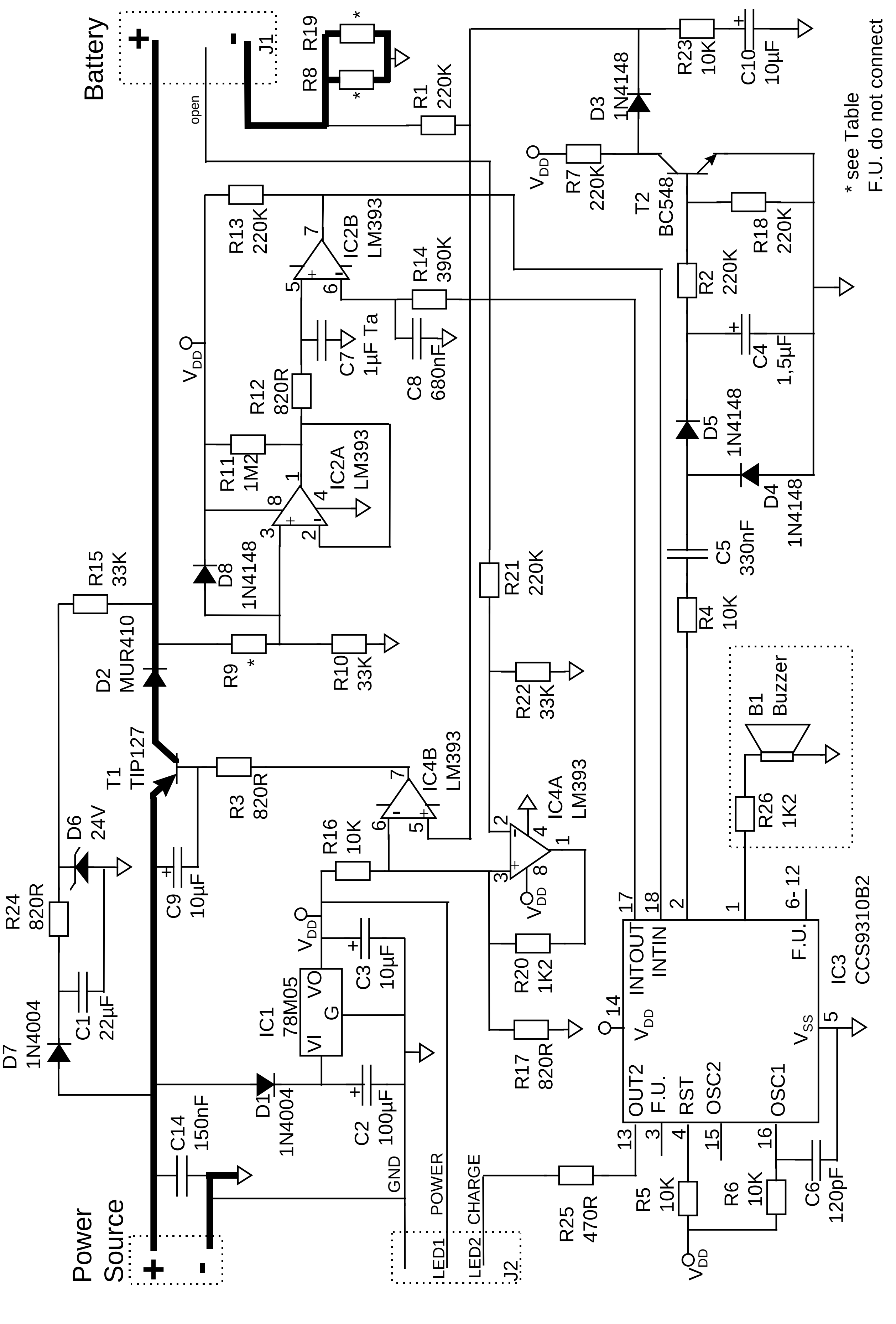
8. PART-LIST

Pos.	Pcs.	Component	Value	Package
1	1	B1	Buzzer	RM 10
2	1	C1	22µF/35V	RM 2.5,5
3	1	C2	100µF/35V	RM 2.5,5
4	3	C3,C9,C10	10µF	RM 2.5,5
5	1	C4	1,5µF (1µF)	RM 2.5,5
6	1	C5	330nF	RM 7.5
7	1	C6	120pF SMD	1206
8	1	C7	1µF (Ta)	RM 2.5,5
9	1	C8	150nF	RM 5,7.5
10	1	C14	680nF	RM 5,7.5
11	2	D1,D7	1N4004 *	
12	1	D2	MUR410, SK304 *	
13	4	D3,D4,D5,D8	1N4148	
14	1	D6	24V/0.3W	
15	1	IC1	78M05	TO220
16	2	IC2,IC4	LM393	DIL8
17	1	IC3	CCS 9310B2	DIL18
			(or CCS9505FK, CCS9606, CCS9620)	
18	8	R1,R2,R7,R13,		
		R18,R21	220K	
18a	1	R14	390K	
19	4	R3,R12,R17,R24	820R	
20	3	R4,R16,R23,R5	10K	
21	1	R6	10K SMD	1206
22	1	R19a	3R9 see Tab. 4 p. 4	
23	2	R8b,R19b	1R5 see Tab. 4 p. 4	
24	3	R8c,R8d,R19d	R33/ >1W see Tab. 4 p. 4	
25	1	R11	1M2	
26	12	R15,R22,R9b-R9j,R10	33K R9b-R9j see Tab 3 p. 3	
27	3	R20,R26,R9a	1K2	
28	1	R25	470R	
29	1	R27 not on PCB	470R	
30	1	T1	TIP127/BDW 94CFI *	TO220
31	1	T2	BC548	TO92
32	2	LED1,LED2 not on PCB	LED red and green	
33	1	EH2PL215	Print, 85x75mm, double layer	

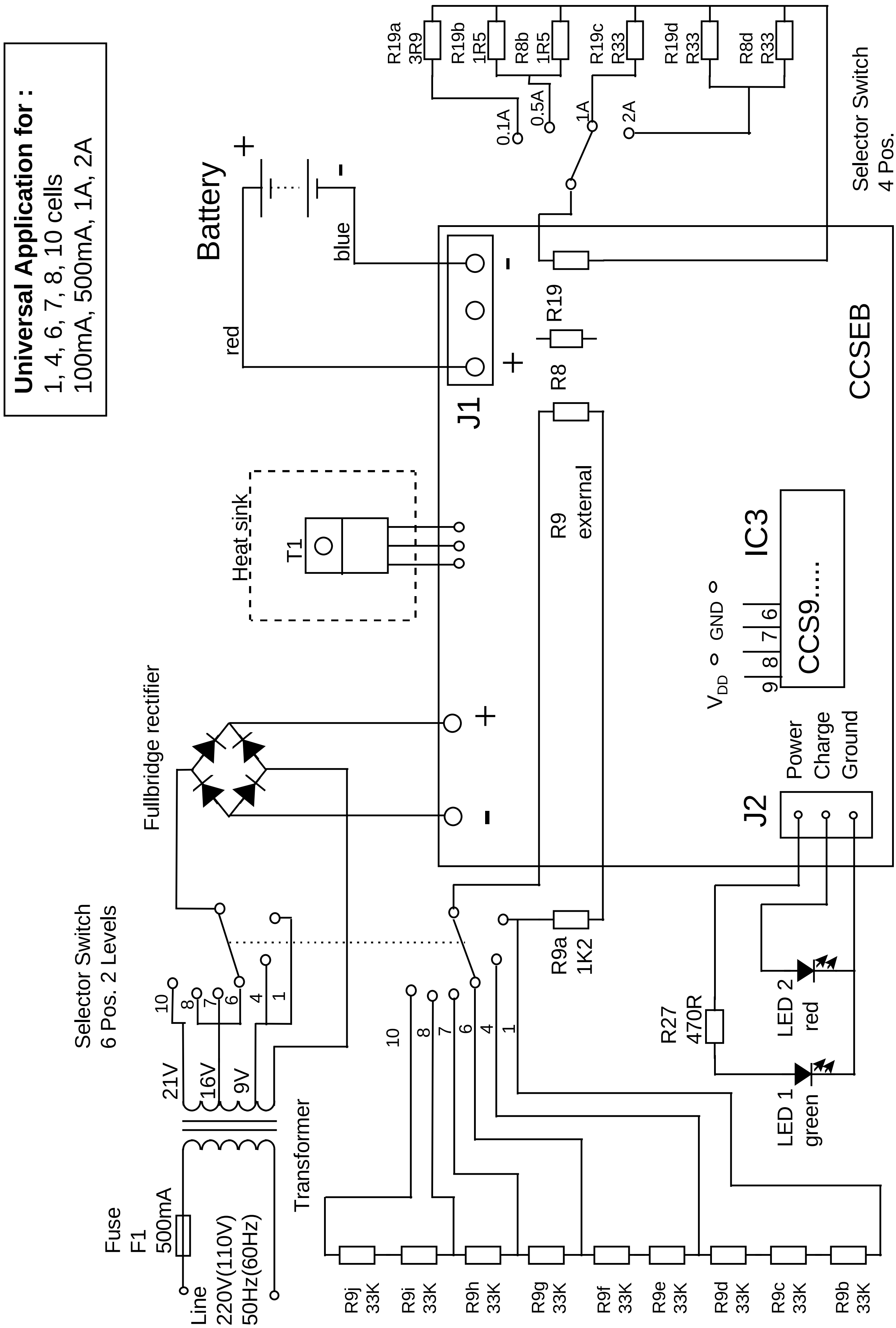
* or similar type

Not included: Transformer (see Table 2 p. 3)
Rectifier
Heat sink
Fuse
Housing
Selector switch

9. SCHEMATIC


Battery
J1
open
R19
R8
R1 220K
R23 10K
C10 10µF
D3 1N4148
R7 220K
T2 BC548
R18 220K
* see Table
F.U. do not connect
R13 220K
IC2B LM393
R14 390K
R2 220K
C7 1µF Ta
C8 680nF
C4 1,5µF
R12 820R
D5 1N4148
R11 1M2
IC2A LM393
D4 1N4148
C5 330nF
R15 33K
D8 1N4148
R21 220K
R4 10K
D2 MUR410
R9 *
R10 33K
R22 33K
B1 Buzzer
T1 TIP127
R3 820R
IC4B LM393
IC4A LM393
R26 1K2
D6 24V
R24 820R
C9 10µF
R16 10K
R20 1K2
C3 10µF
IC1 78M05
VI VO G
D7 1N4004
C1 22µF
R17 820R
IC3 CCS9310B2
INTOUT
INTIN
F.U.
OUT2
RST
OSC2
OSC1
C14 150nF
D1 1N4004
C2 100µF
GND
POWER
CHARGE
R25 470R
R5 10K
R6 10K
C6 120pF
Power Source
LED1
LED2
J2

10. APPLICATION



QUESTIONS & ANSWERS

CCS - a common charging technology?
The CCS-technology differs completely from all other known technologies. It is not based on simple external measured data but, for the first time, on the process within the cell. By this the battery is fully charged up to 100% with maximum reliability and at the same time the battery reaches a high lifespan. CCS is patented worldwide.

Parameters for NiMH
NiMH and NiCd batteries can be charged with one and the same circuitry without any changes or extra adjustments. For both, NiMH and NiCd batteries, the same charge parameters have to be chosen.

Lead-acid batteries
With CCS it is possible to charge lead acid batteries, but it is necessary to set an upper voltage limit and to use a slower charge mode. Lead acid batteries are to charge with max. 2C/3, which means a charge duration of 90 minutes (for the empty battery). (**SLA batteries:** See lead acid batteries.)

DC-supply, car battery
Charge controllers with a DC-Pin, like e.g. the new CCS9620LT, can be used when the power source is a DC-supply. Charge controllers without a DC-Pin require for a correct function the sinusoidal 100/120 Hz pulsation of the rectified line current. The DC-interface, an additional module, has been developed for the purpose that CCS charge controllers can also be used with a DC-supply .

Does batteries have to be discharged before charge?
With CCS it is possible to charge the battery from any precharging state. It is not necessary to discharge the battery before charge. By current and voltage measurement and pattern recognition the CCS controller determines the 100% full charge state of the battery and avoids overcharge by correct shut off.

Batteries with different precharging state
Principally all cells in a battery pack should have the same precharging state. Tests at a battery pack with empty and fully charged cells, showed that after several cycles, differences in the precharging state were equalized. This is because during charge the empty cell accepts more charge (lower impedance) than the full cell. Within the first cycles the empty cells are not fully charged and the full cells are slightly overcharged Automatic shut off is detected more closely at the full cell because of its higher impedance (more influence on the shut off criteria).

Mixture of different batteries
Different batteries (manufacturer) with equal capacity and equal precharging state can be charged in series at the same time.

Maintenance charge, recharge
The CCS controller detects in defined periods the battery and charges, if necessary, again up to 100% full. With this method continuously overcharge by the tiny maintenance charge current is avoided.

More than 10 cells
The number of cells in a battery pack is principally unlimited by CCS. But the number of cells should be as small as possible, because the capacity of the whole battery pack can only be as high as the capacity of the weakest cell.

High charge current
The CCS-technology controls and supervises the charging process. By this there are no limits through the charge current (and battery capacity).

Old batteries
Defective batteries and batteries with high inner impedance may not be charged with high current. These batteries have a lower actual capacity than the nominal capacity. According to this decreased capacity the battery has to be charged with low current. After a few cycles, where the electrodes can be refreshed, the charge current can be increased according to the increasing capacity.

Measurement devices in the charge circuitry
Measurement devices are not allowed in the charge circuitry during the charge process. The calculation of the inner impedance may be disturbed by the measurement devices and a correct charge process can not be guaranteed anymore.

Battery fault detection (see charge controller datasheet)

GENERAL NOTES

! Attention !
Before you start with the assembly of this charging unit, carefully read the following instructions and take special care of all safety rules.

General safety rules!

- Electronic components are not recommended for children!
- Operation of the device only with the correct power supply!
- Operation of the device only in clean and dry rooms!
- Separate the device from liquids!
- Disconnect the device from line current when it is necessary to replace the fuse!

Wrong handling (false polarity, charging current too high, wrong adjustment of number of cells), defective cells or not-rechargeable batteries may lead to gassing, excessive increase of temperature or even to explosion of the cell. The **leaking electrolyte is acidic**. Avoid any skin- or eye-contact by appropriate means for your safety!

Electronic Circuits: Safety Considerations:
For the assembly of electronic circuits, basic knowledge of electronic components and soldering is needed and presumed.

Electronic components and electronic circuits are not recommended for children!

Assembly and handling of devices under mains voltage must be done only under consideration and in conformity with all safety rules (IEC, DIN, VDE, ÖVE, etc.) ! Devices, operated above 35V, must be treated by electronic experts only. All assembly must be done under powerless conditions only. If the kit is operated from the mains, it is absolutely necessary to use a transformer with fully isolated secondary windings. The possibility of misfunction after assembly can be extremely reduced or avoided by correct assembly. Follow exactly the instructions! In most cases of misfunction, the reason is a failure in soldering or wrong placement of components.

Warranty
BTI and its members warranty this product to be from defective components during shipment. As we do not have any influence in the proper assembly, we can only warranty the completeness and correct function of all components (in compliance with the specifications). Other claims are excluded. This warranty does not apply if the product has been damaged by accident, abuse, misuse, or as a result of service or modification. In no event we assume any warranty or responsibility for damages in context with this product and in no event shall we be held liable for incidental or consequential damages, such as lost revenue or lost business opportunities arising from the purchase of this product.
In the case of warranty we reserve the right to repair the product, deliver replacement components or repayment.
Please notice, that we are not responsible for mistakes, made in assembly and operation. As we do not have any influence in proper assembly or handling, we assume any guaranty!

Limitations: This warranty covers no defects in the following cases.
- wrong or by-passed fuses
- unauthorized modification of the charging circuit
- damage by third parties
- destruction of printed circuit board and solder points
- Evaluation Board not appropriate soldered and assembled
- connection to the wrong voltage or type of current
- modifications or unauthorized repairs
- false polarity or excessive stress of components
- misuse, fault operation or careless treatment of the device
- false placement of components and all damages that will occur by this
- neglect or negligence of the description and the instructions, or improper use of the product
- use of other, not originally supplied components of the Evaluation Board
- use of consumable and batteries not compatible with this equipment
- fire, accidents, disasters, improper storage, dropping, shocks, improper packing for return

!Attention!
The person that assembles this Evaluation Board, has to be considered as producer. In the case of transmission he has to deliver all necessary accompany documents too, including his **name and address**. Devices, including this Evaluation Board, have to be considered as **industrial products**!

11. ADJUSTMENT OF THE PARAMETERS

11.1. Charging current

Adjustment with the selector switch as shown in Fig. 1, page 4.
Choose a charging current in between min. C_A up to maximum C_A (see page 4, Table 4 or Table 1 in datasheets). The ideal charging current is around the typ. C_A (for CCS9310 typ. C_A=1), if not possible choose the nearest current to typ. C_A.

Example: When you charge a battery pack (nominal capacity 1Ah) with a charging current of 1A (= $1C_A$) it is fully charged in 1 hour, with a charging current of 500mA (= $0,5C_A$) it is fully charged in 2 hours and with a charging current of 2A (= $2C_A$) it is fully charged in half an hour. If the battery pack was not fully discharged, the charging time will be shorter, in accordance to the precharge state.

Attention!
Do not alter charging current or number of cells during the process of battery charging!

11.2. Charging voltage

Adjustment in accordance to the number of cells of the battery with the selector switch as shown in Fig. 2, page 4.
Battery packs: divide the nominal voltage by 1,2V = the number of cells (also for batteries with other nominal voltage than 1.2V)

11.3. Charging time

Automatically controlled by the **processor**, no adjustments needed.

11.4. Charge Mode

With the charge controllers CCS9505, CCS9606, CCS9620 it is possible to choose the charge mode from super fast (=20 minutes) to slow (=8 hours). How to select see datasheets Table 1 on page 2.

12. HANDLING INSTRUCTIONS

1) Power supply on:	1 beep and green LED on (standby mode).
2) Battery connected:	2 short beep and red LED on.
3) Charging:	click with 1 sec. period and red LED on.
4) Battery full:	1 beep and red LED off.
5) Battery defective:	5 short beep and red LED flashing.
(false current or voltage)	
6) Interrupt:	3 times 2 short beep.
7) Disconnect of the battery:	last signal repeated (full or defective).