Documentation

VARTA EasyPack

Charging Evaluation Kit

Contents

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Introduction

The VARTA EasyPack charging Evaluation Kit is especially designed as a “charging reference design” to charge VARTA EasyPacks.

Thus it is easy for the electronic design engineers to implement the core charging circuitry with the respective components into his application to realize a proper “charger” for VARTA EasyPack.

VARTA EasyPack overview:

Type Designation	Order No.	Voltage (V)	Capacity actual (mAh)	Height (mm)	Length (mm)	Width (mm)	Weight (g)
VARTA EZPack S-3.7V	56445 701 099	3.7	595	6.0	43.7	35.6	14.0
VARTA EZPack L-3.7V	56446 711 099	3.7	1130	6.6	64.7	36.8	28.0
VARTA EZPack XL-3.7V	56446 702 099	3.7	2260	11.6	64.7	36.8	48.0

- please refer to technical drawing for final measures and tolerances
- specification parameters must be considered for design in

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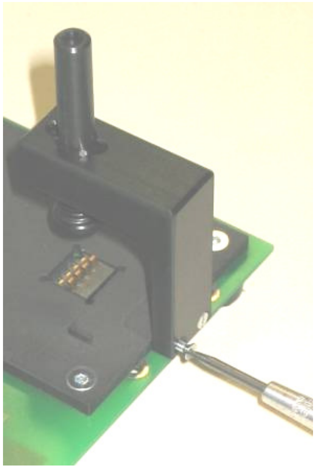
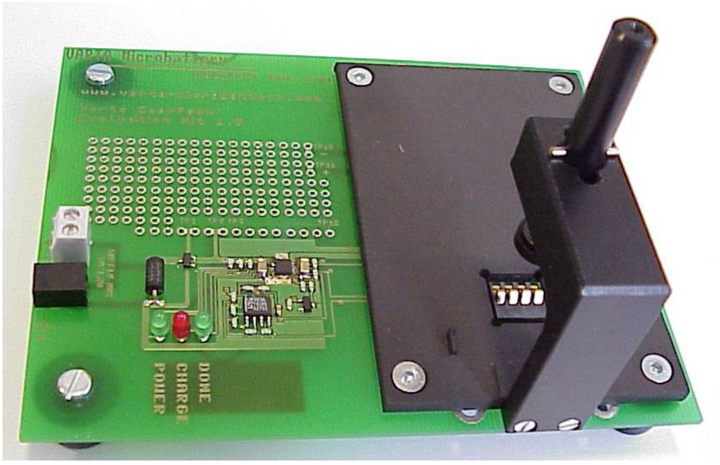
Before you start please mount bracket accordingly

Complete mounted evaluation kit





1 Initialization

The initial use of the evaluation kit requires only an external power source and a VARTA EasyPack (rechargeable Lithium polymer battery) from VARTA Microbattery.

Please ensure the output voltage from the power source is kept precisely at 5V and the maximum tolerance is less than +/- 100 mV. The output current from the power source should not exceed 1.2A as otherwise additional safety circuitry would be needed.

There is a polarity protection on the charging module of the evaluation kit. The charging circuit will only function when the battery is mounted with the correct polarity, which will be indicated by the “POWER” LED.

The operating temperature range for the charging module is between 10°C and 35°C.

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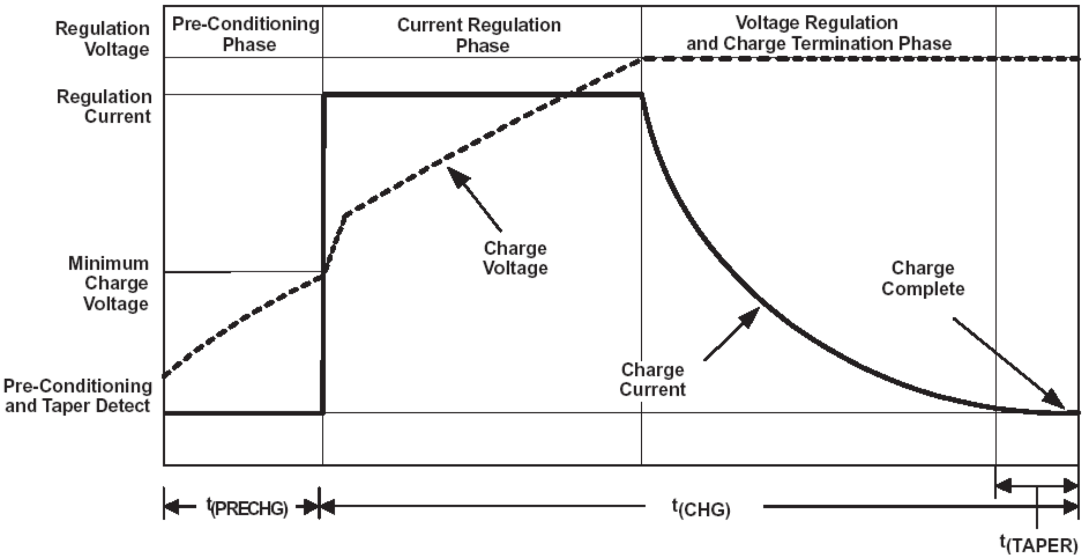
2 Operation



Pre-Conditioning Phase

For a fully discharged battery, the charging module applies a small recharging current to the battery until the battery reaches V_{low} (typical 2.95V). At the same time, a safety precharge timer with a rough duration of 34 minutes will be activated. If the battery cannot reach V_{low} within the time period, the charging module will switch off the charger automatically.

Current Regulation Phase

Once the battery is above or reaches V_{low} during pre-conditioning phase, the charging module switches to current regulation phase and applies a constant charging current until the battery voltage rises to $Vo_{(REG)}$ 4.2V.

Voltage Regulation Phase

When the battery voltage reaches $Vo_{(REG)}$, the charging module switches to voltage regulation phase where the voltage is kept constant at 4.2V and the charging current begins to reduce gradually. When the charging current drops to $I_{(Taper)}$, a safety timer (tTAPER) for approximately 34 minutes is activated. The charging module will automatically terminate the charging when this timer expires.

Taper Current Detection

The taper current detection I(Taper) is determined by the formula below:

$I_{(Taper)} = (K_{SET} \times V_{SET}) / R_{SET}$;

For the charging module of the evaluation kit the taper detection current is a function of the respective VARTA EasyPack . Thus the $I_{(Taper)}$= approx. 65mA for the EasyPack 550, 750 and for EasyPack 1000, 2000 the $I_{(Taper)}$= approx. 100mA.

Charge Time Limitation

For safety protection, the charging module also monitors the overall charging time during charge. Once the charging module enters the current regulation phase, the safety timer $T_{(CHG)}$ will be activated. The maximum charging time allowed by the charging module is approximately 5 hours and 44 minutes.

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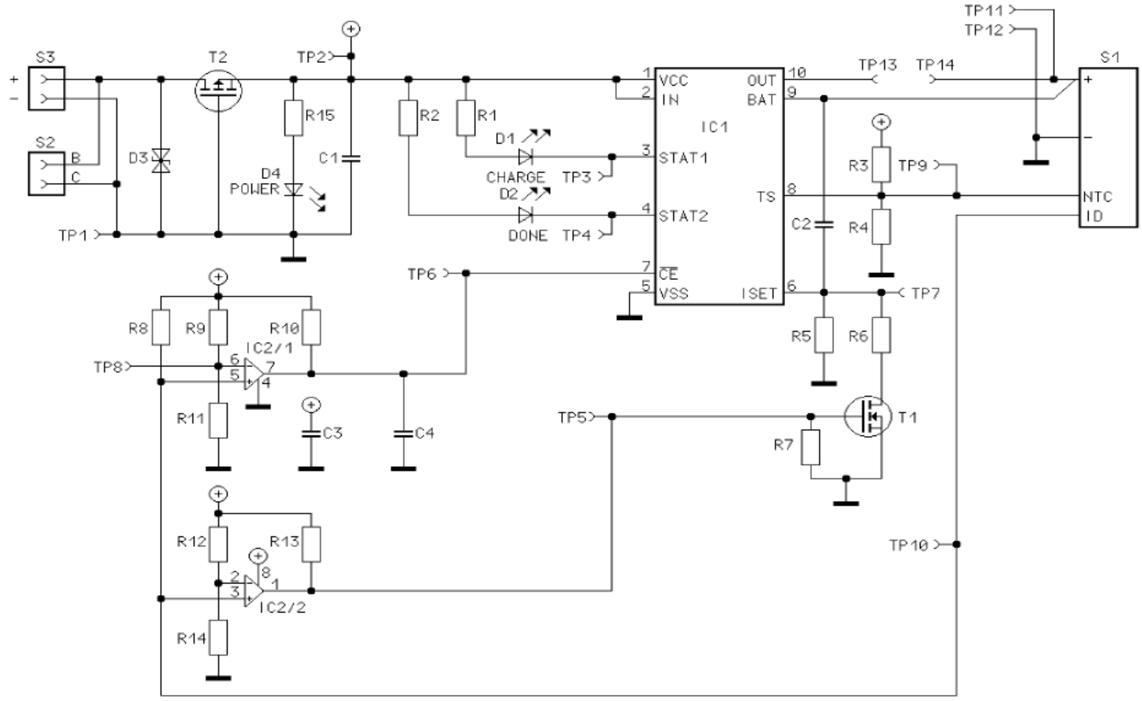
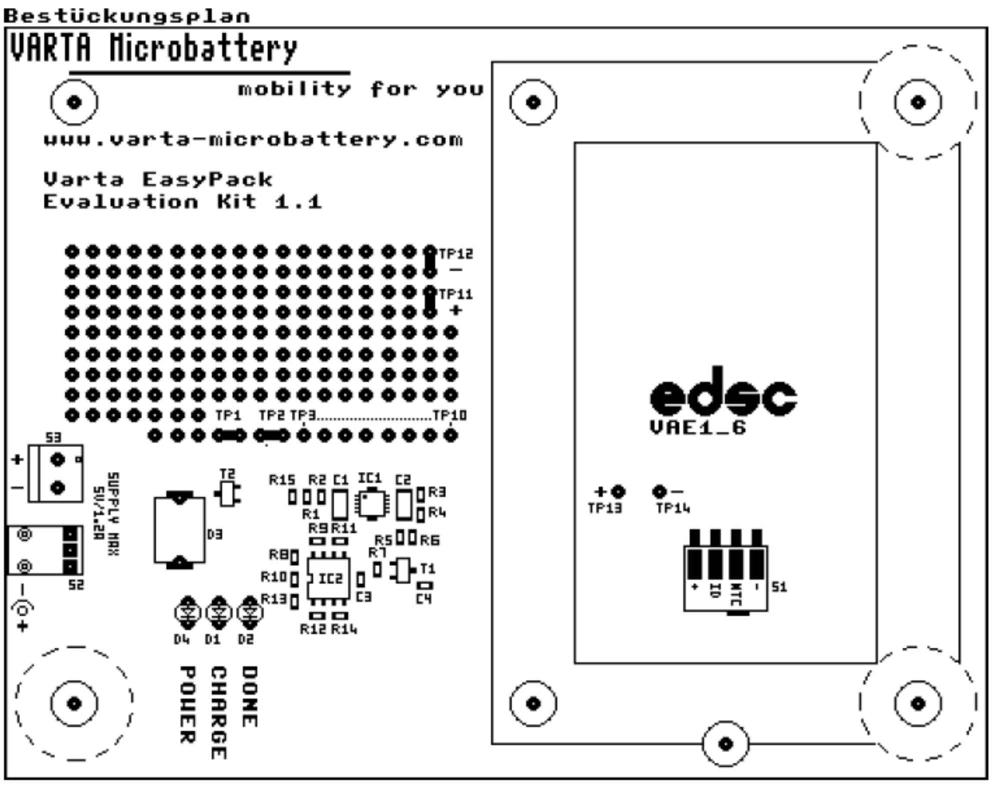
3 Circuit Diagram



4 Layout



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5 Charging

Charging is managed by BQ24014 from Texas Instruments (IC1 in the part list appendix). In regard to complete technical data please refer to TI data sheet. For your own design, please ensure proper heat dissipation for this IC.

The charging process starts automatically once the rechargeable battery “EasyPack” is inserted into the evaluation kit and the charging module is connected to an external voltage supply. No special sequence is required.

The “CHARGE”LED on the evaluation kit will be turned on if charging current is present. An appropriate charging current will be applied automatically based on the type of the battery (see Chapter “ID recognition” for details). The “DONE” LED on the evaluation kit will be turned on once the charging is terminated.

If both LEDs “CHARGE” and “DONE” are not on, please see Chapter 6 “Self Diagnosis” for more information. Possible reasons might include:

- No battery is inserted, or battery not recognizable
- Battery temperature is out of normal range (too high or too low)
- The temperature for TI power management IC is too high
- The total charging time had been exceeded

6 Self Diagnosis

If only the „POWER“ LED is on, an error is recognized by IC. There should be a minimum voltage of Umin=1,8V between Test-Pin 11 and Test-Pin 12. If this is not the case, please check battery voltage.

Battery temperature has to be in the valid range. Between Test-Pin 9 and Test-Pin 1 the voltage has to be in the range between 1.55V and 3.00V (with 5V source voltage). With lower voltage the battery temperature is higher than 45°C, with higher voltage the battery temperature is assumed to be lower than 0°C. A bad contact or a bad connection will have a negative impact on this measurement.

The temperature of the chip IC1 is also a possible cause for a failure. With a Chip temperature >155°C charging is stopped.

The ID resistor between test-pin 7 and test-pin 1 has to be below 0.8V to start charging.

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7 Temperature Control

Battery temperature control is done by the chip IC1 measuring pin 8 (TS). High and Low temperature are set by the voltage divider R3/R4. For VARTA-Easy-Pack Series these are set at +45℃ and 0℃.

8 ID-Recognition

Each VARTA-Easy-Pack battery does have an ID resistor which is related to the battery capacity. This ID resistor plays together with resistor R8 as a voltage divider.

ID-recognition works as follows: Without any ID resistor (ID>36kOhm) charging will be prohibited by R9-R11. With R12-R14 it is possible to switch between 2 charge currents.

With a typical battery capacity of 1000mAh and above (ID > 9,1 k Ohm) the charge current is set between 0.9A and 1 A. With lower battery capacity the charge current is set between 0.45A and 0.50A.

A charge current of around 0.5A is set by using R5 connected to pin 6 (ISET) of the IC1. By switching resistor R6 in parallel to R5 by the FET T1 the charge current is doubled to around 1A. To calculate the charge current please us the following formula:

$$I = Kset * Vset / Rset$$

Kset=335; Vset=2,5;

(for tolerance please see date sheet IC1, Texas Instruments BQ24014)
Resistor R7 defines a fixed input resistance value for FET T1. For details please see data sheets for IC2 and T1.

9 Polarity and over-voltage protection

A wrong polarity is covered by using FET T2. With correct source voltage the resistance of FET T2 is 52mOhm in ON state.

As overvoltage protection a suppressor diode D3 is used. This especially is designed against static loads and voltage peaks between S2 and S3.
For technical details please see datasheets for T2 and D3.

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10 Test-Pins

There are 14 test-pins which will allow easy measurements and additions to his circuit. All pins are marked and do have the following functions:

TP 1: Reference for voltage measurements (ground)
TP 2: Supply voltage for IC1 and IC2
TP 3: Charge control
Open collector – output on IC1.

TP 4: Charge message „DONE“.
Open Collector – output on IC1.

TP 5: ID condition
Voltage is below 1.0V with charge current around 0,5A.
Voltage is higher than 4.0V with charge current around 1A.

TP 6: ID failure.
Voltage is lower than 0.8V with valid ID-resistor (<36kOhm).
Voltage is higher than 2.0V with wrong or missing ID-resistor (>36kOhm).

TP 7: Charge current control
Please see date sheet IC1

TP 8: Charge Interruption
This test pin is for future additional features
Connecting TP8 with TP1 (ground) will stop charging

TP 9: NTC-voltage.
Please see datasheet IC1

TP 10: ID-voltage.
Please see ID recognition

TP 11: Battery Positive
TP 12: Battery Minus

TP 13, 14: Current Measurements
To measure the current, the connection on the board between TP13 and TP14 has to be removed. With some additional shunt and a voltage meter the current can be calculated.

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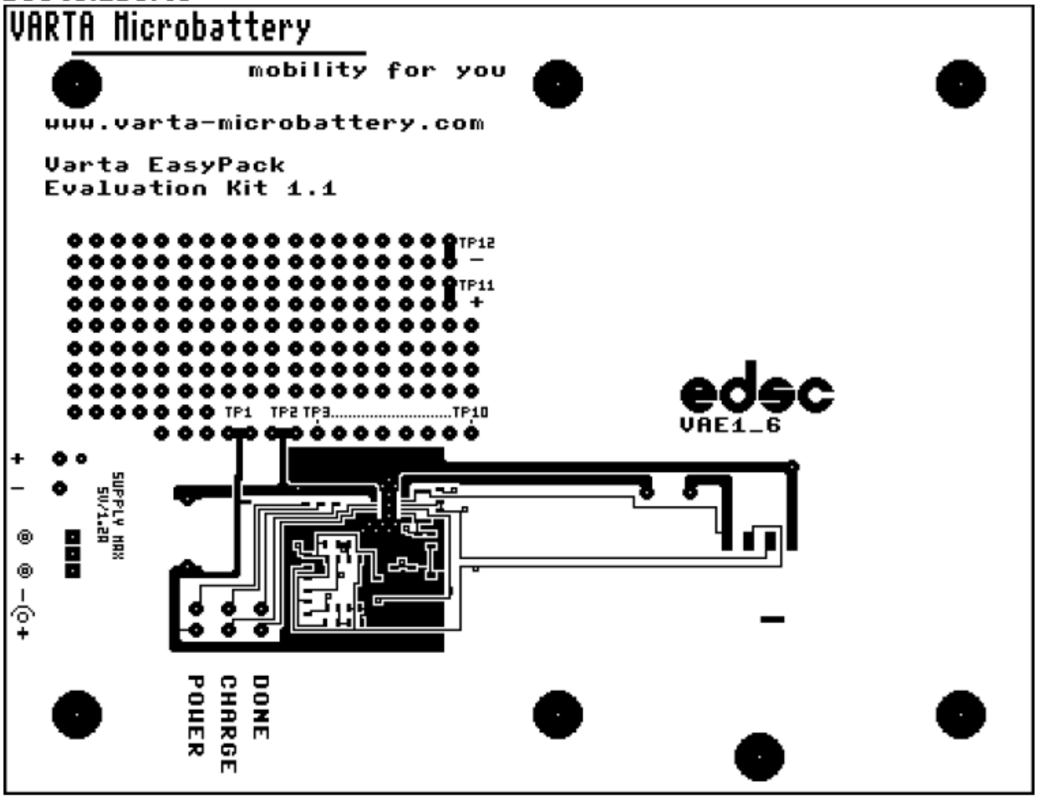
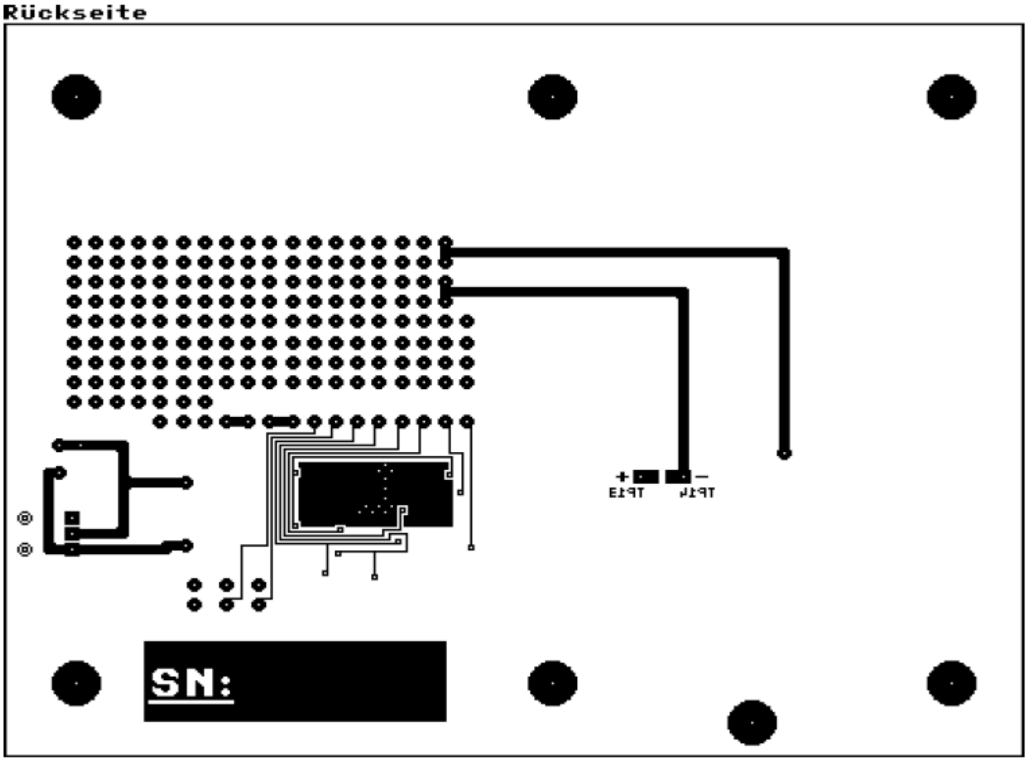
11 Board Layout

Bauteilseite



Rückseite



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12 BOM

1,8 k, 1 %, 1/16 W, size 0603	R1,R2,R5,R6,R15
9,1 k, 1 %, 1/16 W, Size 0603	R14
10 k, 1 %, 1/16 W, Size 0603	R3, R13
15 k, 1 %, 1/16 W, Size 0603	R8, R9, R12
30 k, 1 %, 1/16 W, Size 0603	R4
36 k, 1 %, 1/16 W, Size 0603	R11
100 k, 1 %, 1/16 W, Size 0603	R10*
1 M, 1 %, 1/16 W, Size 0603	R7
0,1 uF, 10 V, Size 0603	C3, C4*
4,7 uF, 10 V, Size 1206	C1
1 uF, 10 V, Size 1206	C2
BZW 06-5V8	D3
LED 3mm red, 2mA	D1
LED 3mm green, 2mA	D2,D4
FDN359AN	T1
FDN304P	T2
Texas Instruments BQ 24014DRCR	IC1
LM393A	IC2
Suyin 4 pin contact block Type: 2501A-04G4T	S1
Suyin DC Power Jack Type: 040012MR003S200ZL	S2
Clamp 2 pin	S3
Board type VAE1_5	

* For filter R10/C4 also 10k/1µF is usable

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