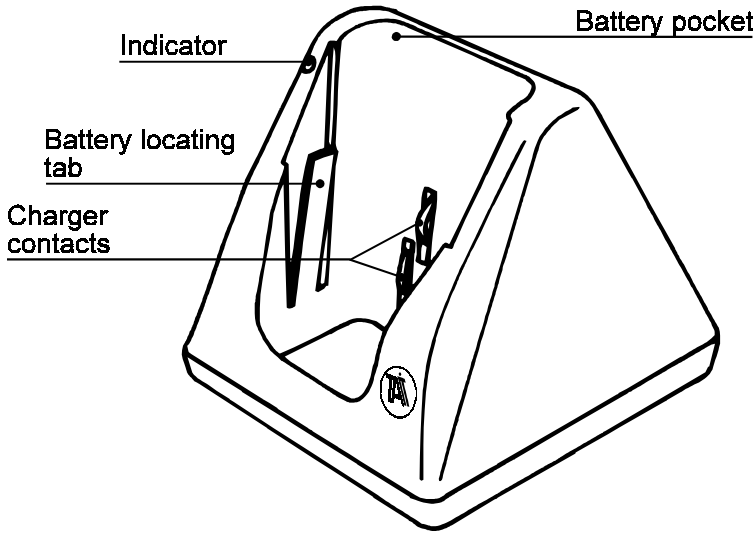
7.11 T3003 Trickle Charger

7.11.1 Introduction



The T3003 desktop trickle charger is designed to charge T3000 rechargeable battery packs, with one slot for either the combined battery and radio or for the battery alone. The charger is powered by either a dedicated T952 AC/DC plug pack, complying with the local requirements of the country into which it is sold, or a suitable DC supply. A dual coloured red and green LED displays the charge status of the battery.

Although the T3003 is primarily intended for use in desktop situations, it may be used in vehicles with a nominal 12V supply voltage, in conjunction with the T952-050 vehicle supply cable. The vehicle supply cable is 1.5m long and has a cigarette lighter adapter plug at one end and a DC jack (centre pin positive) at the other.

The T3003 is not recommended for use with the T3000-1010 high capacity battery pack unless the battery is already discharged to less than 7.2V at the terminals (no load).

The T3003, T3003 plug packs and vehicle supply cable are available under the following IPNs:

T952-050	Vehicle Supply Cable
T952-010	T3003 Plug Pack Australia/New Zealand
T952-020	T3003 Plug Pack UK
T952-030	T3003 Plug Pack Germany
T952-040	T3003 Plug Pack USA
T3003-0000	T3003 Trickle Charger

7.11.2 Warnings

- **Avoid extreme temperatures and direct sunlight when charging a T3000 battery pack. The required temperature range for the charger is 5°C to 40°C. Charging efficiency is maximised around normal room temperature i.e. 15°C to 25°C.**

- **Switch off the radio when it is attached to the charger. This ensures that the battery receives the correct charging current. If the radio is used when the battery is charging, there is no guarantee that the battery will be fully charged when the green LED illuminates.**

- **For maximum battery life, do not recharge the battery until the 'low battery warning' is activated. This will avoid reduced battery capacity.**

7.11.3 Operation

Place the charging unit on a stable horizontal surface and power the unit either from the T952 plug pack or the T952-050 vehicle supply cable.

Check that the connectors are properly pushed home to ensure reliable electrical contact.

Place the battery to be charged, with or without its radio, into the charging unit with the 4 silver contacts to the rear.

- To locate a battery pack correctly in the charger, lean the top of the battery as far forward as possible to seat the bottom of the battery. Pivot the battery back against the contacts and it should snap into place.

- In normal operation, the red LED on the top corner of the charger illuminates. After about 12 hours, the charge current terminates. The green LED then illuminates, indicating that the battery is fully charged.

- The battery may be left in the charger until needed, where it will be trickle or standby charged, with no risk of damage.

- The indicator beside the packet indicates the charge status, as shown in the following table.

LED	Function
off	• Battery fault (open or short circuit). • Incorrectly seated battery. • Input supply voltage too low. • Charger powered but no battery present. • No power connected.
red	Battery correctly charging.
green	Battery charged.

7.11.4 Circuit Description

The Constant Current Circuit

The constant current circuit consists of semiconductors Q9, Q11, and IC1 op-amp pins 8, 9 & 10. The op-amp is configured for supply independent differential mode operation, employing the four resistors (R41, R42, R43 & R44) so that the emitter of Q11 remains at the supply voltage and no current results in R50, R51 and R52, and therefore Q11.

A constant current is derived by the battery capacity resistor providing a current path to ground via the emitter of Q9. This results in a constant current being injected into the differential mode op-amp from the collector of Q9. The output constant current derived in Q11 is given by the product of this current and R41 = 10kΩ, divided by Q11's emitter resistor = 3.33Ω. The total emitter resistance of Q9 is chosen to set up a charge current of C/8. This equates to 125mA for a 1Ah battery and 187.5mA for a 1.4Ah battery.

Battery Present Detector

Current charge is initiated by detecting the presence of the battery via IC1 op-amp pins 5, 6 & 7. The 10k thermistor accessed via the TEMP terminal of the battery results in pin 6 of the op-amp being pulled down via the 1s time constant, consisting of R26 and C39. Pin 7 then goes high and removes the reset on pin 2 of the timer (IC2) via Q1.

If the battery makes intermittent contact, the large 1s time constant ensures that the timer does not reset each time that the contact fails. Note that Q7 is normally held on via R19 if the battery presence is not detected and inhibits the constant current source by pulling the base of Q9 low.

The Timer

IC2 consists of a nominal 194Hz oscillator combined with a 24 stage counter, which together define a minimum 12 hour charging period. 194Hz divided by 2^{24} gives an output with a period of 24 hours. Q24, however, will go high in a period of half this time i.e. 12 hours. This results in the charge being terminated by the collector of Q7 being pulled low via R18, which in turn pulls down the base of Q9 and inhibits current injection from Q9 into the differential constant current loop. The oscillator is also inhibited by pulling the collector of Q2 down via R9.

Battery Open Circuit Comparator

The battery open circuit comparator consists of the op-amp IC1 pins 1, 2 & 3. If there is no charging current due to the battery being open circuit, no voltage is formed across R50. The comparator non-inverting input, pin 3, is biased positively, so that the comparator output is high. This results in the timer being inhibited via R10 and Q2.

Battery Voltage Limit

If the battery is open circuit, the collector of Q11 could deliver enough voltage directly to the radio to cause damage, depending on the supply input voltage. Q10 serves to limit the output voltage to between 9.5V and 11.5V. The collector of Q11 rises and Q10 starts to turn on when its base gets close to 5.6V. Q10 acts as a transconductance amplifier and causes a collector current to be set up, so as to reduce the output current of Q11. Equilibrium is achieved for zero output current when Q9 and Q10 collector currents are equal.

Foldback Current Limit

If the battery is short circuit or low in voltage, foldback current limiting is used to avoid excessive dissipation in Q11. At battery voltages lower than approximately 7V, Q8 behaves as an emitter follower and starts to pull down the base of Q9 via R23, as the battery voltage is further reduced. This results in the collector current of Q9 reducing and therefore folding back the charge current. For the 1Ah battery, the short circuit current is approximately 45mA.

LED Display

With power on but with no battery present, the LED is off. For the red LED to be on, Q5 must be off, so that a charging current must be present. This means that pin 1 of the open circuit comparator must be low, indicating the presence of a charging current.

The red LED is turned off either by the battery being open circuit, via the comparator via R12, or the timer Q24 going high and also switching on Q5 via R11, or the battery being short circuit. When the battery is short circuit or its voltage is low, emitter following via Q8, Q6, and Q4 results in the red LED going off. The red LED rapidly illuminates if the battery voltage rises from the short circuit condition. The green LED can only be switched on as a result of timer Q24 going high and driving the emitter of Q3 high.

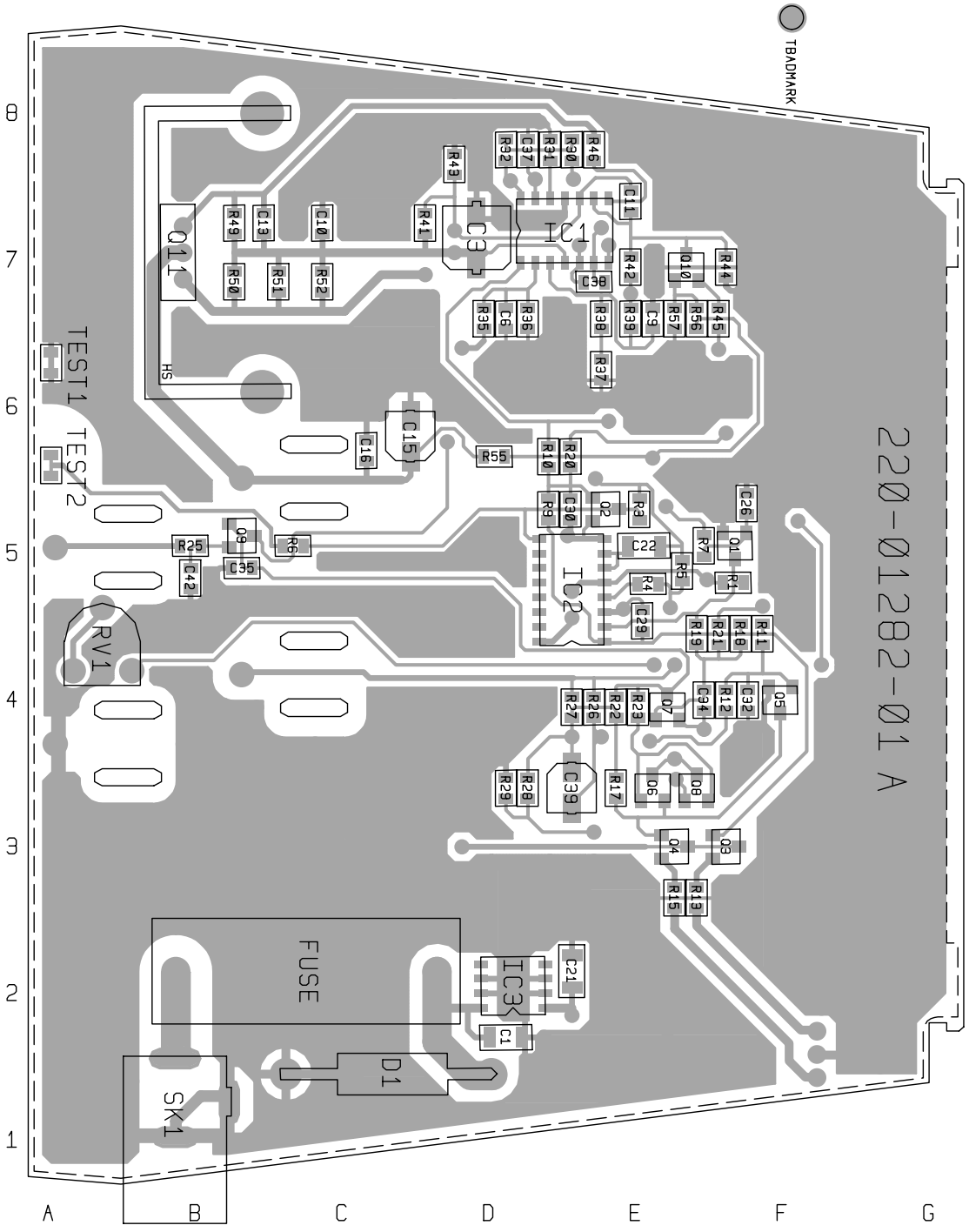
T3003 Parts List (IPN 220-01282-01)

Ref	VAR	IPN	Description
C34		015-24100-08	CAP CER 0805 CHIP 1N 10% X7R 50V
C35		015-24100-08	CAP CER 0805 CHIP 1N 10% X7R 50V
C37		015-24100-08	CAP CER 0805 CHIP 1N 10% X7R 50V
C38		015-24100-08	CAP CER 0805 CHIP 1N 10% X7R 50V
C39		016-08100-01	CAP ELECT 6X4MM CHIP 10M 20% 16V
C42		015-24100-08	CAP CER 0805 CHIP 1N 10% X7R 50V
D1		001-00062-40	(S) DIODE P6KE24A TRANSIENT SUP
D2		008-02099-00	(S) LED RED/GREEN BI-COLOUR 3.1MM
IC1		002-10003-24	(S) IC SMD 324 QUAD OP AMP SO14
IC2		002-10452-10	(S) IC SMD 4521 CMOS 24 STAGE DIVIDER
IC3		002-10078-05	(S) IC SMD 78L05 5V REG
Q1		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN F
Q2		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q3		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q4		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q5		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q6		000-10008-57	(S) XSTR SMD BCW70/BC857-215 PNP
Q7		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN F
Q8		000-10008-57	(S) XSTR SMD BCW70/BC857-215 PNP SF
Q9		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q10		000-10008-48	(S) XSTR SMD BCW60/BC848B215 NPN
Q11		000-00011-70	(S) XSTR BD136 PNP AF PWR TO126
RV1		042-05100-06	RES PRESET 10K CARBON 6MM FLAT
R1		036-15100-10	RES M/F 0805 CHIP 10K 1%
R3		036-15560-00	RES M/F 0805 CHIP 56K 5%
R4		036-15180-00	RES M/F 0805 CHIP 18K 5%
R6		036-15100-10	RES M/F 0805 CHIP 10K 1%
R7		036-15180-00	RES M/F 0805 CHIP 18K 5%
R9		036-16100-00	RES M/F 0805 CHIP 100K 5%
R10		036-16100-00	RES M/F 0805 CHIP 100K 5%
R11		036-15390-10	RES M/F 0805 CHIP 39K 1%
R12		036-16100-00	RES M/F 0805 CHIP 100K 5%
R13		036-13560-00	RES M/F 0805 CHIP 560E 5%
R15		036-13560-00	RES M/F 0805 CHIP 560E 5%
R17		036-14180-00	RES M/F 0805 CHIP 1K8 5%
R18		036-16100-00	RES M/F 0805 CHIP 100K 5%
R19		036-16100-00	RES M/F 0805 CHIP 100K 5%
R20		036-16100-00	RES M/F 0805 CHIP 100K 5%
R21		036-16100-00	RES M/F 0805 CHIP 100K 5%
R22		036-15100-10	RES M/F 0805 CHIP 10K 1%
R23		036-14470-00	RES M/F 0805 CHIP 4K7 5%
R25		036-15390-10	RES M/F 0805 CHIP 39K 1%
R26		036-16100-00	RES M/F 0805 CHIP 100K 5%
R27		036-15390-10	RES M/F 0805 CHIP 39K 1%
R28		036-15100-10	RES M/F 0805 CHIP 10K 1%
R29		036-15100-10	RES M/F 0805 CHIP 10K 1%
R30		036-15390-10	RES M/F 0805 CHIP 39K 1%
R31		036-14390-00	RES M/F 0805 CHIP 3K9 5%
R32		036-17100-00	RES M/F 0805 CHIP 1M 5%
R35		036-15100-10	RES M/F 0805 CHIP 10K 1%
R36		036-15390-10	RES M/F 0805 CHIP 39K 1%
R37		036-14100-00	RES M/F 0805 CHIP 1K 5%
R38		036-15390-10	RES M/F 0805 CHIP 39K 1%
R39		036-15100-10	RES M/F 0805 CHIP 10K 1%
R41		036-15100-10	RES M/F 0805 CHIP 10K 1%
R42		036-15100-10	RES M/F 0805 CHIP 10K 1%
R43		036-15390-10	RES M/F 0805 CHIP 39K 1%
R44		036-15390-10	RES M/F 0805 CHIP 39K 1%
R45		036-14180-00	RES M/F 0805 CHIP 1K8 5%
R46		036-14180-00	RES M/F 0805 CHIP 1K8 5%
R49		036-14100-00	RES M/F 0805 CHIP 1K 5%
R50		036-12100-10	RES M/F 0805 CHIP 10E 1%
R51		036-12100-10	RES M/F 0805 CHIP 10E 1%
R52		036-12100-10	RES M/F 0805 CHIP 10E 1%
R55		036-14680-00	RES M/F 0805 CHIP 6K8 5%
R56		036-14180-00	RES M/F 0805 CHIP 1K8 5%
R57		036-15100-10	RES M/F 0805 CHIP 10K 1%
SK1		240-02020-07	SKT DC JACK 5.5MM HOLE 2.5MM PIN PCB
		005-10000-10	TEST POINT SMD 0805 2.0 X 1.25 X 1.45
		220-01282-01	PCB T3003 BAT CHARGER (TRICKLE)
		265-00010-63	FUSE 0.5A 5X20MM NORMAL BLOW C/W (
		303-20051-00	COVER TOP A1M2800 T3003 TRCKL C

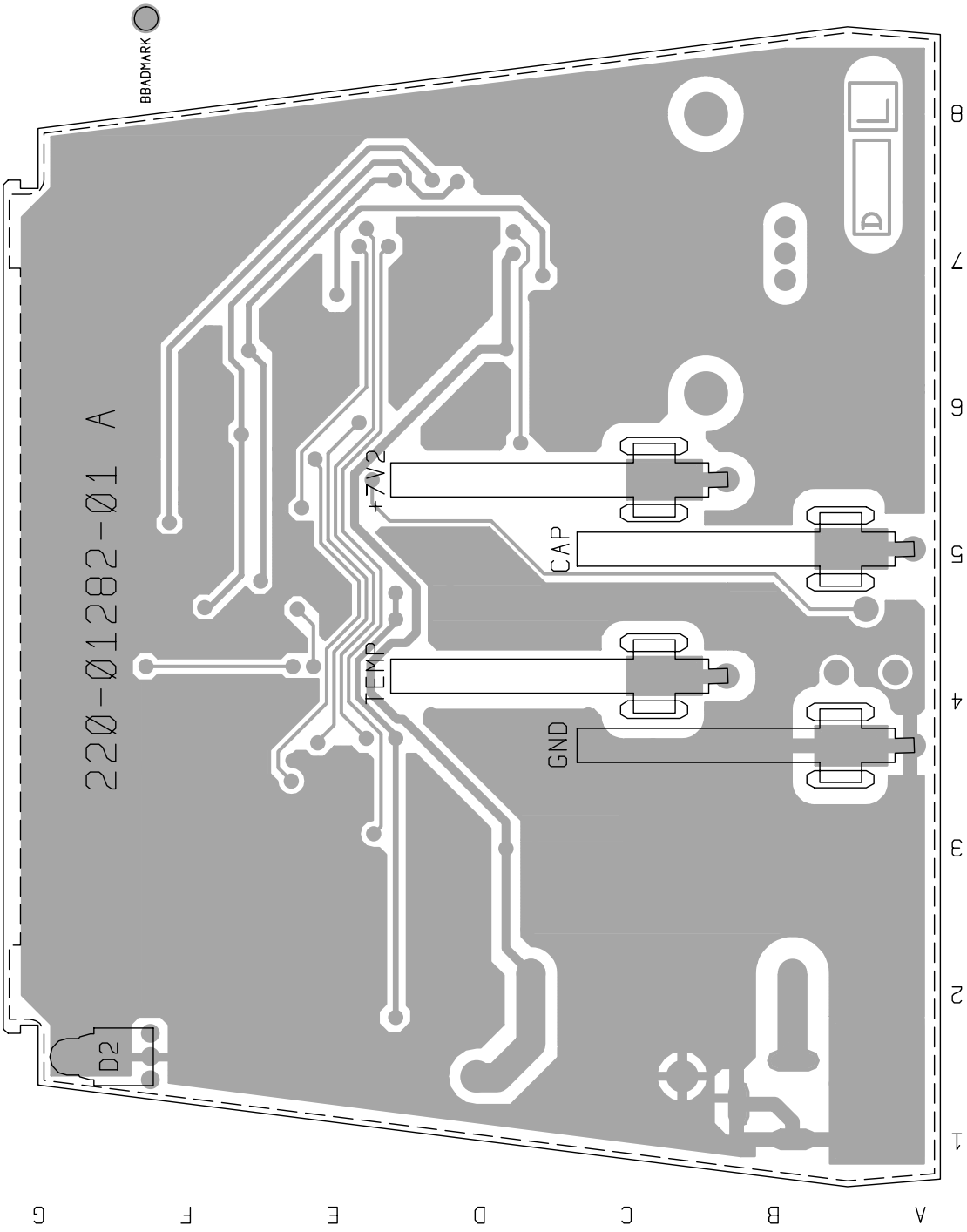
T3003 Grid Reference Index (IPN 220-01282-01)

Device	PCB	Circuit
+7V2	2:B6	1-L5
CAP	2:A5	1-L4
C1	1:D2	1-B7
C3	1:D7	1-D7
C6	1:D7	1-F5
C9	1:E7	1-G5
C10	1:C7	1-J7
C11	1:E7	1-H6
C13	1:C7	1-J7
C15	1:D6	1-K6
C16	1:C6	1-K6
C21	1:E2	1-B4
C22	1:E5	1-C3
C26	1:F5	1-C1
C29	1:E5	1-E2
C30	1:E5	1-E1
C32	1:F4	1-F3
C34	1:F4	1-G2
C35	1:B5	1-H2
C37	1:D8	1-K0
C38	1:E7	1-J2
C39	1:E3	1-K3
C42	1:B5	1-H4
D1	1:D2	1-B7
D2	2:F2	1-E3
		1-F3
FUSE	1:B2	1-B8
GND	2:A4	1-L1
HS	1:B7	
IC1	1:E7	1-F6
		1-J6
		1-J3
		1-J1
		1-D7
IC2	1:E5	1-D2
IC3	1:D2	1-A4
Q1	1:F5	1-B1
Q2	1:E5	1-D2
Q3	1:F3	1-E4
Q4	1:E3	1-F4
Q5	1:F4	1-G3
Q6	1:E3	1-G3
Q7	1:E4	1-H2
Q8	1:E3	1-H3
Q9	1:B5	1-H4
Q10	1:E7	1-J5
Q11	1:B7	1-K7
R1	1:F5	1-B4
RV1	1:A4	1-C3
R3	1:E5	1-C3
R4	1:E5	1-C3
R5	1:E5	1-C3
R6	1:C5	1-C4
R7	1:F5	1-C1
R9	1:D5	1-E2
R10	1:D6	1-E2
R11	1:F5	1-E3
R12	1:F4	1-E4
R13	1:E3	1-E3
R15	1:E3	1-F3
R17	1:E3	1-G4
R18	1:F5	1-G2
R19	1:E5	1-G2
R20	1:E6	1-F2
R21	1:F5	1-H2
R22	1:E4	1-H4
R23	1:E4	1-H4
R25	1:B5	1-J4
R26	1:E4	1-K3
R27	1:E4	1-K3
R28	1:D3	1-K3
R29	1:D3	1-K2
R30	1:E8	1-J2
R31	1:D8	1-J0
R32	1:D8	1-J1
R35	1:D7	1-F7
R36	1:D7	1-F5
R37	1:E6	1-G5
R38	1:E7	1-G6
R39	1:E7	1-G7
R41	1:D7	1-H7
R42	1:E7	1-H7
R43	1:D8	1-H5
R44	1:F7	1-H5
R45	1:F7	1-J5
R46	1:E8	1-J6
R49	1:B7	1-K7
R50	1:B7	1-K7
R51	1:C7	1-K7
R52	1:C7	1-K7
R55	1:D6	1-K6
R56	1:E7	1-K6
R57	1:E7	1-K5
SK1	1:B0	1-A8
TEMP	2:B4	1-L3
TEST1	1:A6	1-C4
TEST2	1:A6	1-C4

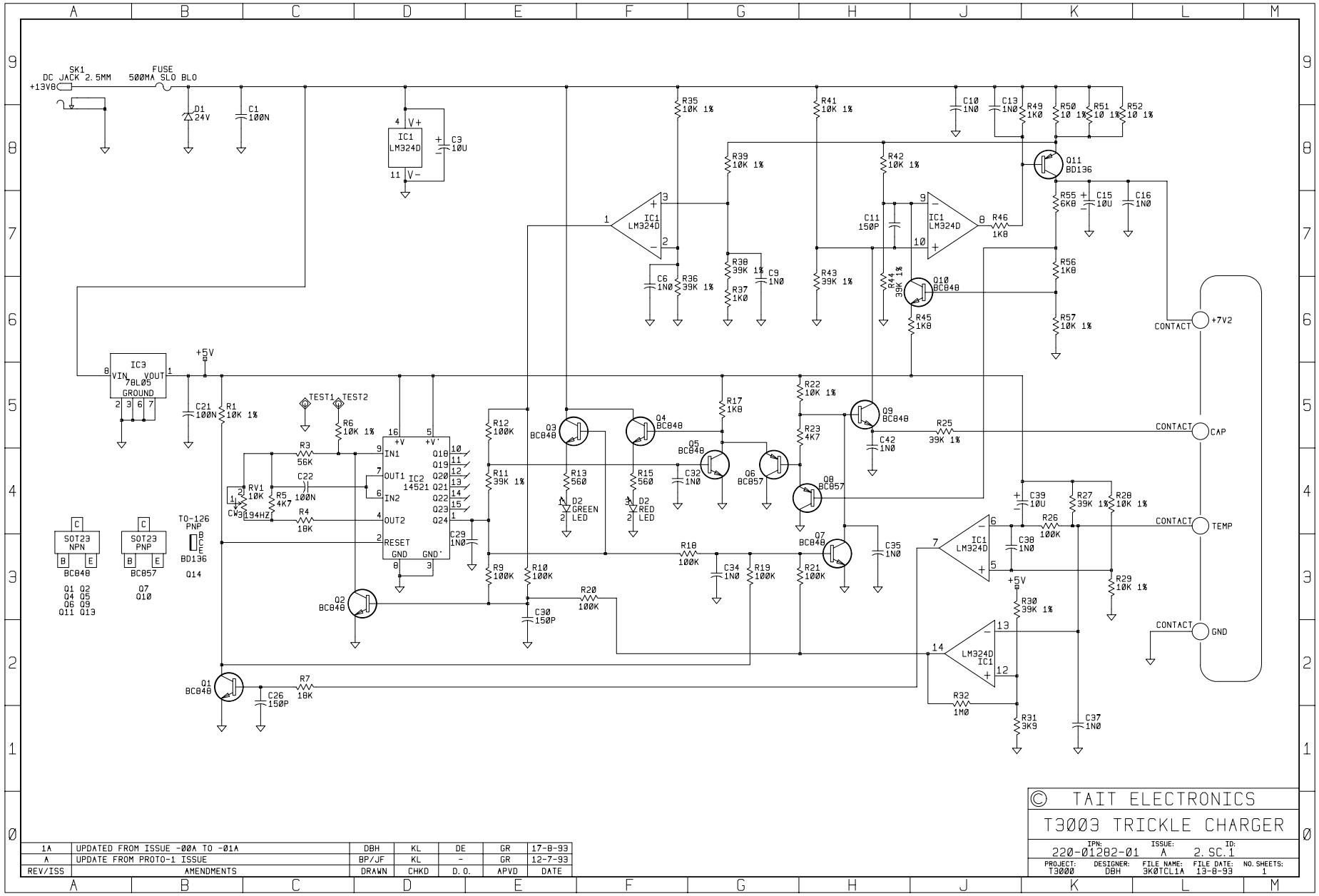
Device	PCB	Circuit



T3003 Trickle Charger PCB (IPN 220-01282-01) - Top Copper



T3003 Trickle Charger PCB (IPN 220-01282-01) - Bottom Copper



REV/ISS	AMENDMENTS	DRAWN	CHKD	D. O.	APVD	DATE
1A	UPDATED FROM ISSUE -00A TO -01A	DBH	KL	DE	GR	17-8-93
A	UPDATE FROM PROTO-1 ISSUE	BP/JF	KL	-	GR	12-7-93

© TAIT ELECTRONICS

T3003 TRICKLE CHARGER

IPN:	ISSUE:	ID:
220-01282-01	A	2. SC. 1

PROJECT:	DESIGNER:	FILE NAME:	FILE DATE:	NO. SHEETS:
T3000	DBH	3K0TCL1A	13-8-93	1

