

DESCRIPTION

Demonstration circuit 783 is a complete Fast Battery Charger capable of charging 1, 2, 3 or 4 series connected NiMH or NiCd cells. Charge termination includes $-\Delta V$, peak voltage and a safety timer. Included on the board are jumpers to select NTC thermistor functions, battery chemistry, number of series cells, safety timer length, recharge voltage and two LEDs to indicate charger status. A power path FET is also included that provides a low loss path between the battery and an external system load when the input power is removed. Terminals are included for PAUSE and SHUTDOWN.

The power portion of the circuit consists of a PNP power transistor constant current source which can provide up to 2A of charge current under some conditions. Jumpers are provided for programming charge currents of 0.5A, 1A or 2A. Other charge currents can be programmed by adding an external resistor to the "PROG" terminal post. Charge current greater than 2A can also be programmed by paralleling an external current sense resistor (R5) with the internal LTC4060 sense resistor). See "Extending Charge Current" section of the data sheet for more information. For more power dissipation capability than the pc board can provide, terminals are included for adding an external PNP pass transistor mounted on a suitable heat sink.

Also included on this board is a power path MOSFET that provides a low resistance path between the battery and a load (SYSTEM LOAD) when the input power is removed. When the input voltage is present, the load is powered from the input voltage.

The pc board used for this demo circuit is a 4 layer board with generous amounts of copper surrounding the heat producing components. It also includes vias

to internal copper layers to maximize the power dissipation capabilities. Since this is a linear charger,

under some conditions, the power dissipated by the charger can be high. To minimize power dissipation, close attention to the input voltage must be observed.

Charging NiMH or NiCd batteries.

Nickel based batteries are typically charged with a constant current and allowing the battery voltage to rise to the level it requires (within limits) to force this current. When batteries are fast charged (1 to 2 hours) the charge cycle must be terminated when the battery reaches full charge. This demo circuit

determines when the battery is fully charged using the $-\Delta V$ method with peak voltage and timer as a backup termination.

The $-\Delta V$ method measures the battery voltage as it is being charged with a constant current. The voltage will rise as the battery accepts charge. When it approaches full charge, the battery voltage will begin rising faster, reach a peak, then begin to drop. When the battery voltage drops a fixed number of mV (depending on battery chemistry), the battery is fully charged and the charge cycle terminates.

For the $-\Delta V$ charge termination method to work correctly, the charge current must be programmed to a sufficiently high current level (C/2 to 2C). "C" is a measure of cell capacity in mAHr. For example, to charge an 1800 mAHr battery at 1C would require a charge current of 1.8A.

Design files for this circuit board are available. Call the LTC Factory.

QUICK START PROCEDURE

FEATURES INCLUDE:

- Jumper to select battery chemistry, NiMH or NiCd
- Jumpers to select number of cells
- Jumper to select NTC Thermistor function
- Jumper to select recharge voltage level
- Jumper to select safety timer period
- Jumper to select charge (0.5A, 1A & 2A)
- Terminals for custom timer periods and charge current
- Terminals for system load
- Resistor pads for optional external current sense resistor
- LEDs to indicate charger status
 - ACPR – Sufficient input voltage for charging
 - CHRГ – Charging

TYPICAL DEMO BOARD SPECIFICATIONS

Minimum Input Voltage (1 series cell) - 4.5V
(2 series cells) - 4.5V
(3 series cells) - 6.9V
(4 series cells) - 8.6V

Maximum Input Voltage - 10V

Constant Charge Current - 0.5A, 1A & 2A ($\pm 8\%$)

Safety Timer - 1.5Hrs & 3Hrs ($\pm 20\%$)

$-\Delta V$ Termination (NiCd) - 16mV ($\pm 2\text{mV}$)

$-\Delta V$ Termination (NiMH) - 8mV ($\pm 1.5\text{mV}$)

Recharge Threshold Voltage-OFF, 1.2V & 1.3V ($\pm 5\%$)

Precharge Current - 20% of Programmed Current ($\pm 8\%$)

TEST EQUIPMENT REQUIRED FOR DEMO BOARD EVALUATION:

Lab Power supply for input power. 0 to 10V @ 2A

Digital multimeter for measuring battery voltage (VBAT). 3-1/2 digits

Digital multimeter for measuring charge current

4 cell, 2000 mAh NiCd or NiMH battery pack (10k Ω NTC thermistor optional)

10 Ω 10W power resistor for System Load (optional).

Table 1. Jumper Descriptions

Jumper Name	Jumper Description	Comments				
NTC	Selects thermistor function for sensing battery temperature	OUT - Disables thermistor function				
		BAT - Selects thermistor in battery pack				
CHEM	Selects battery chemistry	NiMH - Nickel Metal Hydride charge termination				
		NiCd - Nickel Cadmium charge termination				
SEL 1 SEL 0	Selects number of series cells to be charged	# of Cells	1	2	3	4
		SEL 0	A	B	A	B
		SEL 1	A	A	B	B
RECHARGE	Programs Recharge Voltage	1.3V				
		1.2V				
		OFF – No Recharge				
CHARGE CURRENT	Programs Charge Current	2A				
		1A				
		0.5A				
TIMER	Programs Maximum Safety Timer (<i>Time is also dependant on charge current program resistor</i>)	Charge Current	Charge Rate	Time Period	Jumper Position	
		0.5A	1C	1.5Hr	A	
		1A	1C	1.5Hr	B	
		1A	0.5C	3Hr	C	
		2A	1C	1.5Hr	C	
		2A	0.5C	3Hr	D	

QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 783

NIMH/NICD CHARGER

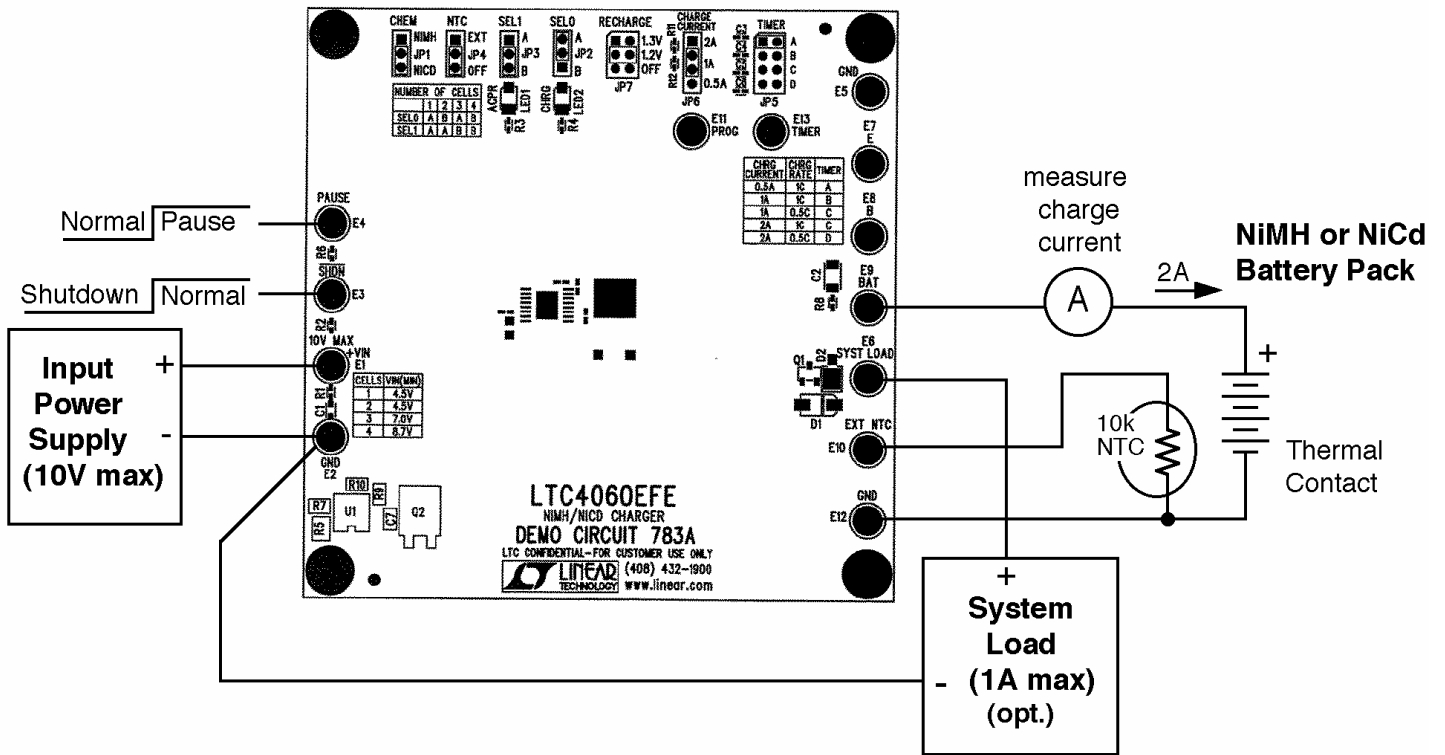


Figure 1. Proper Measurement Equipment Setup

DEMO CIRCUIT EVALUATION:

Begin evaluation by placing the jumpers for CHEM, NTC, # of CELLS (SEL 1 & SEL 0) RECHARGE, CHARGE CURRENT and TIME in the correct location. If the battery has a thermistor to measure the battery temperature, move the NTC jumper (JP4) to the EXT position. If a thermistor is not used, locate the jumper to the OFF position. For charging a 2000mAh battery at a 1C rate, select the 2A charge current jumper position and place the TIMER jumper in the "C" position. Locate the CHEM (chemistry) jumper to the appropriate position for the type of battery being charged.

Connect the Input Power Supply, battery and voltmeters to the demonstration circuit as shown in Figure 1. For this evaluation, use four series connected cells for the battery. Connect a digital voltmeter between the BAT terminal and ground, and an ammeter between the BAT terminal and the positive side of the battery to measure charge current. Do not connect the system load (5Ω Resistor) at this time.

With the power supply voltage set to 0V, switch on the input power supply and slowly increase the voltage to approximately 9V. The ACPR LED will light when the input exceeds approx 8.6V. The battery voltage will determine what will happen next. If the single cell voltage of the four series connected cells is less than 900mV (or 3.6V for the four cells) the charger enters the trickle charge mode at 20% of the programmed charge current.

In the event that a battery is defective resulting in the single cell voltage exceeding 1.9V, the trickle charge will stop. In this case, to restart the charge cycle, the charger must be reset by either removing and reapplying the input voltage, replacing the battery or toggling the SHDN pin low to high. During charging, the battery voltage and battery temperature (provided a NTC thermistor is used) are constantly monitored. See curve shown in Figure 3.

During the constant current charge, the battery voltage slowly rises. When the battery voltage reaches a peak, then begins to drop slightly, the

charge cycle terminates (CHRG LED turns off). This is called $-\Delta V$ charge termination. For a NiCd battery, the $-\Delta V$ is approximately 16mV decrease per cell and approximately 8mV decrease per cell for NiMH batteries. After a complete charge cycle has ended, the charger continues to monitor the battery voltage. If the single cell voltage drops below 1.2V or 1.3V (depending on the location of the recharge jumper) because of either self discharge or the system load, a recharge cycle will begin. The recharge feature can also be turned off by moving the recharge jumper to the OFF position.

Terminals are provided on the board to externally pause the charge cycle and also shut down the charger. Releasing pause does not restart the charge cycle whereas releasing the shutdown pin resets the timer and restarts a new charge cycle.

To check the power path section, connect a 10Ω 10W resistor from the SYST LOAD terminal to GND. With input voltage applied, connect a voltmeter between SYST LOAD and Vin. The meter should indicate approx 250mV. Now remove the input voltage and measure the voltage between the BAT and SYST LOAD. It should be approx 30mV because when the input voltage is removed, Q1 FET turns on thus providing a low loss path from the battery to the load.

To program a charge current other than the three currents selected by jumper JP6, an external resistor can be added from the PROG terminal to GND. Note that R9 & R10 are connected to the PROG pin and must be included in the equation for charge current as shown in the data sheet.

For higher power dissipation or higher charge current situations, an external PNP pass transistor mounted on a heat sink and, if needed, a current sense resistor can be added to the demo circuit. Lift the emitter and base connections to the on-board transistor when an external transistor is used. Pads for an external current sense resistor (R5) are included on this pc board. This resistor is

in parallel with the internal sense resistor and is selected to have approx 100mV from Vcc to SENSE at the programmed charge current.

Other time periods can be programmed by adding a suitable capacitor on the TIMER terminal.

Please refer to the LTC4060 data sheet for additional information.

DIFFERENCES BETWEEN NiCd AND NiMH BATTERIES:

NiCd batteries exhibit very little temperature rise during most of the charge cycle. The temperature rise mainly occurs near the end of the charge cycle. NiMH batteries are different in this respect, where the battery temperature rise continues during the charge cycle and accelerates near the end of the charge cycle.

The $-\Delta V$ that occurs when charging a NiMH battery is less than a NiCd. This makes $-\Delta V$ termination somewhat more difficult to detect for a NiMH battery.

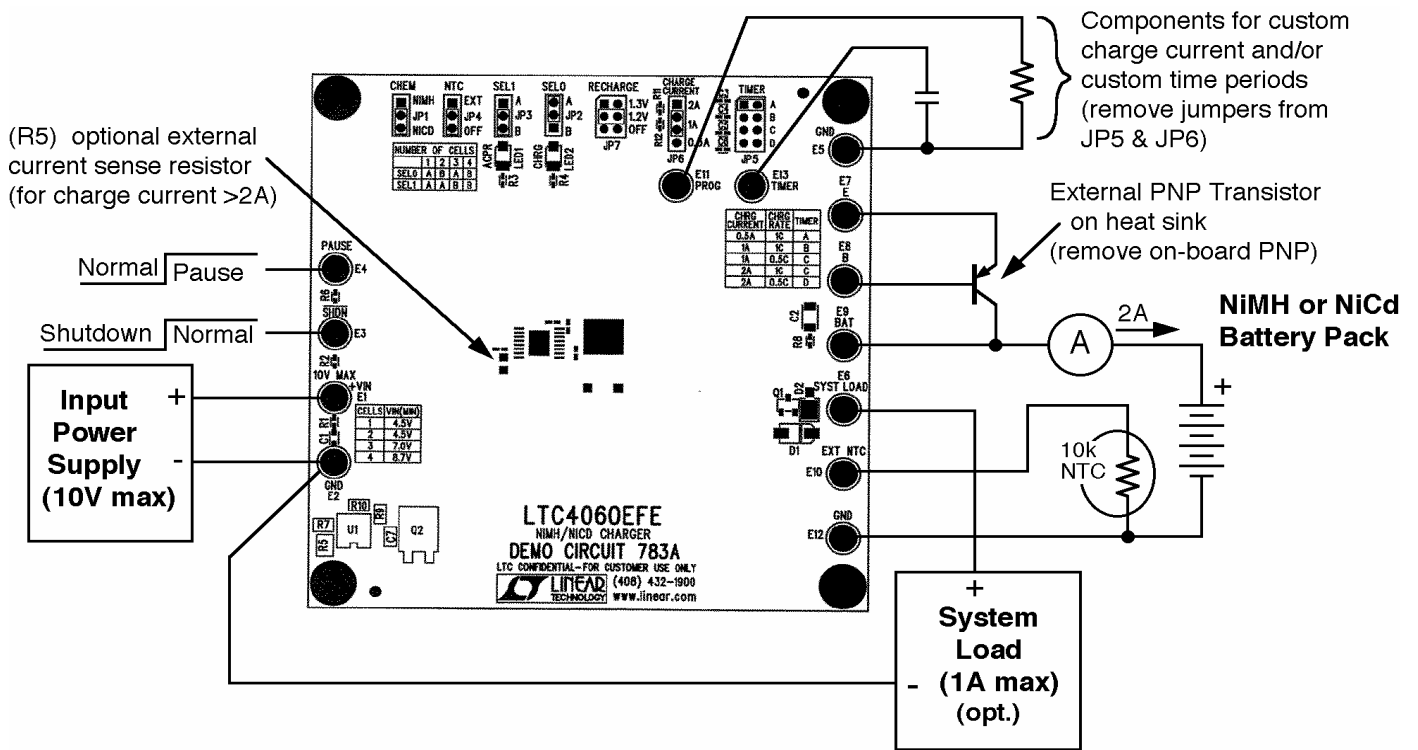


Figure 2. Optional Demo Board Features

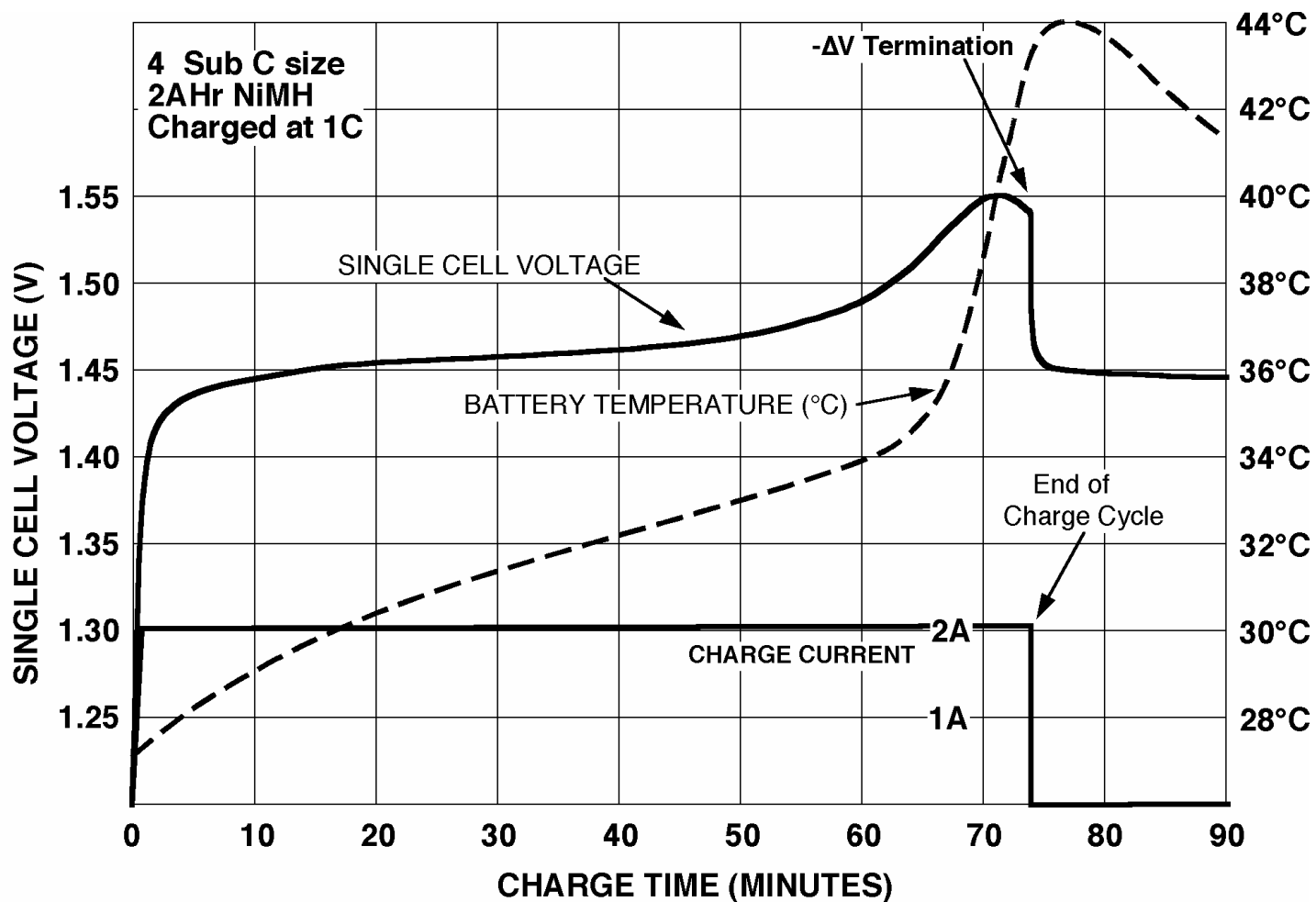
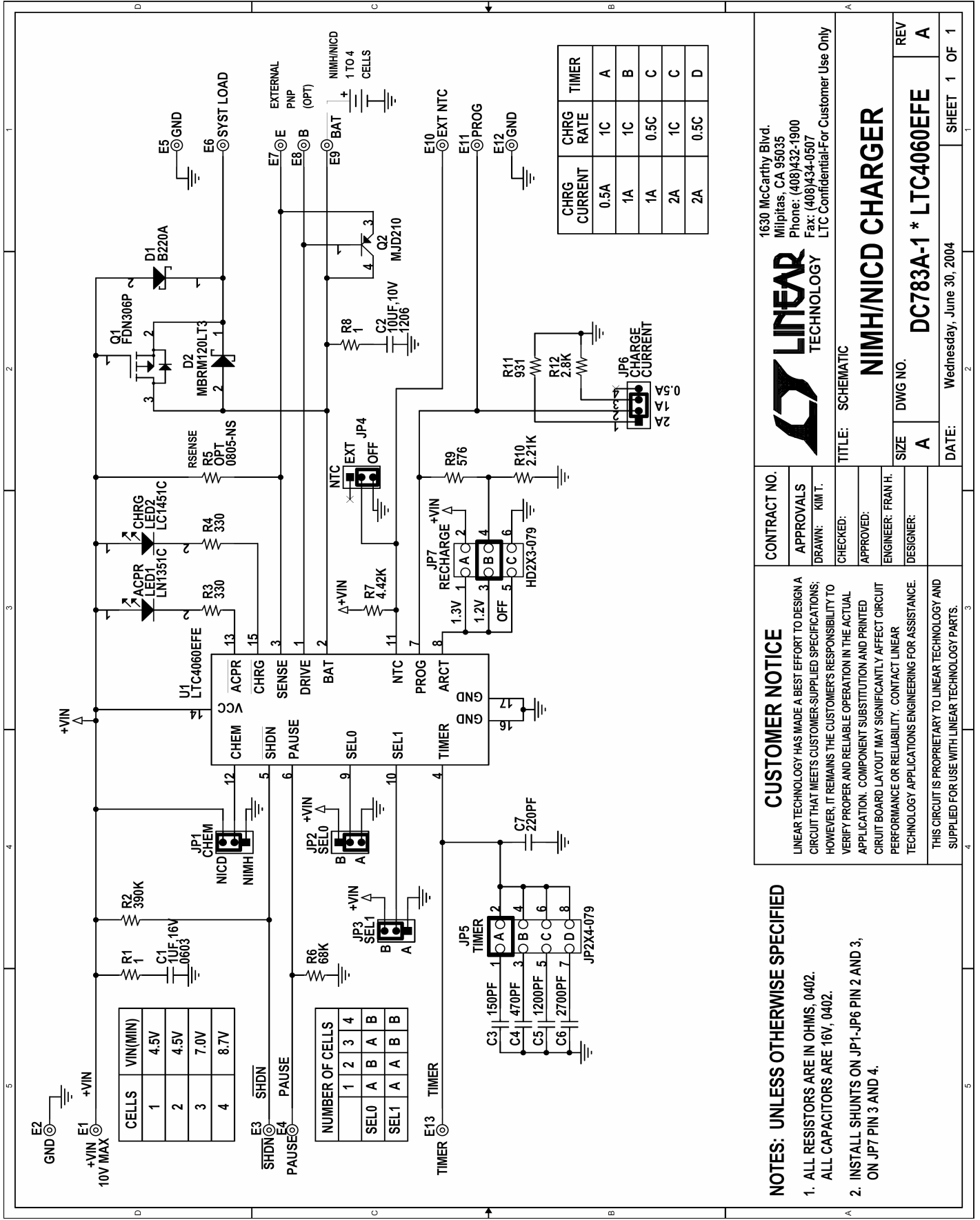


Figure 3. NiMH Charge Profile

QUICK START GUIDE FOR DEMONSTRATION CIRCUIT 783

NIMH/NICD CHARGER



CONTRACT NO.
APPROVALS
 DRAWN: KIM T.
 CHECKED:
 APPROVED:
 ENGINEER: FRAN H.
 DESIGNER:

CUSTOMER NOTICE
 LINEAR TECHNOLOGY HAS MADE A BEST EFFORT TO DESIGN A CIRCUIT THAT MEETS CUSTOMER-SUPPLIED SPECIFICATIONS; HOWEVER, IT REMAINS THE CUSTOMER'S RESPONSIBILITY TO VERIFY PROPER AND RELIABLE OPERATION IN THE ACTUAL APPLICATION. COMPONENT SUBSTITUTION AND PRINTED CIRCUIT BOARD LAYOUT MAY SIGNIFICANTLY AFFECT CIRCUIT PERFORMANCE OR RELIABILITY. CONTACT LINEAR TECHNOLOGY APPLICATIONS ENGINEERING FOR ASSISTANCE.
 THIS CIRCUIT IS PROPRIETARY TO LINEAR TECHNOLOGY AND SUPPLIED FOR USE WITH LINEAR TECHNOLOGY PARTS.

NOTES: UNLESS OTHERWISE SPECIFIED

- ALL RESISTORS ARE IN OHMS, 0402.
ALL CAPACITORS ARE 16V, 0402.
- INSTALL SHUNTS ON JP1-JP6 PIN 2 AND 3, ON JP7 PIN 3 AND 4.

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LINEAR TECHNOLOGY

TITLE: SCHEMATIC

NIMH/NICD CHARGER

SIZE A **DWG NO.** DC783A-1 * LTC4060EFE **REV** A

DATE: Wednesday, June 30, 2004 **SHEET** 1 OF 1

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