



## MAX712 Linear-Mode Evaluation Kit

### General Description

The Linear-Mode evaluation kit (EV kit) is a complete battery charger for Nickel Metal Hydride (NiMH) and "fast-charge" Nickel-Cadmium (NiCd) cells. The number of cells, charging current, and maximum charging time are selected by setting DIP switches. The board is easily tailored for the optimum charging parameters of a variety of "fast-charge" batteries, and can be used with either the MAX712 or MAX713.

The MAX712 EV kit automatically initiates the high-current, fast-charge cycle when batteries are installed into the holder. An LED indicates that the fast-charge sequence is in progress. Fast charge terminates when the maximum charging time has lapsed, or the circuit detects that full charge has been achieved, and/or if the temperature is beyond acceptable limits.

Thermistors are provided for optionally monitoring the battery temperature. The fast-charge cycle can be inhibited if the battery is too cold, or terminated if the battery temperature rises beyond limits. The temperature thresholds are adjustable using potentiometers on the board.

### Features

- ◆ Selectable Number of Cells (1 to 16)
- ◆ Selectable Maximum Fast-Charging Timeout
- ◆ Selectable Charging Current
- ◆ Battery Temperature Monitoring Capabilities
- ◆ Adjustable Temperature Limits
- ◆ LED Indication of Fast-Charge Cycle
- ◆ On-Board Battery Holder for 1 or 2 AA Cells
- ◆ Voltage-Slope Fast-Charge Termination

### Ordering Information

PART	TEMP. RANGE	BOARD TYPE
MAX712EVKIT-DIP	0°C to +70°C	Through-Hole

### Component List

DESIGNATION	QTY	DESCRIPTION
C1, C3	2	10 $\mu$ F, 35V electrolytic capacitors
C2, C7	2	1.0 $\mu$ F ceramic capacitors
C4	1	0.01 $\mu$ F ceramic capacitor
C5, C6	2	0.022 $\mu$ F ceramic capacitors
C7	1	0.01 $\mu$ F ceramic capacitor
D1	1	1N4001 diode
J1	1	3-pin jumper header
LED1, LED2	2	Red LEDs
Q1	1	2N6109 PNP power transistor
R1	1	200 $\Omega$ , 5% resistor
R3, R5	2	470 $\Omega$ , 5% resistors
R4	1	150 $\Omega$ , 5% resistor
R6, R7	2	10k $\Omega$ multiterm potentiometers
R8	1	20k $\Omega$ multiterm potentiometer
R9-R11	3	1k $\Omega$ , 5% resistors
R12-R15	4	1.0k $\Omega$ , 5% 1/2W resistors
R16	1	2.0 $\Omega$ , 5% 1/2W resistor
R17	1	3.9 $\Omega$ , 5% 1/2W resistor

DESIGNATION	QTY	DESCRIPTION
R18	1	8.2 $\Omega$ , 5% 1/2W resistor
R19	1	16 $\Omega$ , 5% 1/2W resistor
R20	1	330 $\Omega$ , 5% 1/2W resistor
SWA	1	12-position DIP switch
SWB	1	8-position DIP switch
TR1-TR3	3	10k $\Omega$ at +25°C thermistors. Alpha thermistor part number 13A1002 NTC. Phone (800) 235-5445.
IC1	1	MAX712CPE
None	1	16-pin IC socket
None	2	Battery holder for two AA cells
None	1	2-pin power connector
None	1	3-pin power connector
None	1	Shunt for J1
None	1	4.0" x 4.0" PC board
None	4	Rubber feet
None	1	MAX712/MAX713 data sheet
None	1	MAX712/MAX713 EV kit manual



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## Quick Reference

The MAX712 evaluation kit (EV kit) is ready to charge two fast-charging AA NiMH cells. The switches and voltages are set at the factory per Tables 5, 6, and 7. Simply connect a 7V, 1A supply to the  $V_{IN}$  power connector and insert two discharged AA NiMH cells.

The MAX712 EV kit can be used to evaluate the MAX713 for charging NiCd batteries by replacing the MAX712CPE (included in this kit) with a MAX713CPE.

### NOTE:

**The EV kit is intended for use with cells capable of the high currents needed for fast-charging cycles. The proper charging current and period will depend on the exact type of battery being charged. Be sure the kit is configured properly.**

**Check the default values and switch settings before applying power to the board. Refer to Tables 6 and 7 for the default settings. To ensure the board is operating, verify Table 8's voltages after power is applied and without a battery inserted.**

The power-indicating LED will light as soon as power is applied. The voltage across the battery terminals, BATT+ and BATT-, will be two times the voltage on the VLIMIT pin. When batteries are inserted into the holder, the MAX712/MAX713 start a fast-charge cycle and light the charge-indicator LED. The default battery current is set to 250mA during the fast-charge cycle. Battery voltage can be monitored by connecting a voltmeter across the BATT+ and BATT- terminals.

## Detailed Description

The MAX712 EV kit provides the regulated high currents used for recharging the increasingly popular "fast-charge" batteries. The kit is shipped ready to charge two AA NiMH cells. Be sure the programmed current does not exceed the maximum charging current of the batteries to be charged. Tables 1-5 list the different user options available on the EV kit. Tables 6, 7, and 8 list the levels preset at the factory for the various charging parameters.

### Choosing Between the MAX712 and the MAX713

The MAX712 is intended to charge only NiMH batteries because it uses a zero delta voltage full-charge detection scheme. The MAX713 can be used to charge either NiCd or NiMH batteries because its 2.5mV-per-cell resolution allows it to detect the very slight peak in the NiMH charge characteristic. Some NiMH batteries require three different current levels when charging: an initial high current, an intermedi-

ate topping-off current, and a low trickle current. Neither the MAX712 nor the MAX713 is intended to charge this type of NiMH battery.

### Input Source

The MAX712/MAX713 require an input 1.5V greater than the maximum charging voltage, with a 6V minimum. Because of Q1's power-dissipation limits, the EV kit operates ideally with the input voltage set to 7V. This allows charging currents up to 1A while dissipating less than 5W from Q1. Higher input voltages and charging currents can be used if Q1's power dissipation is reduced or a sufficient heat sink is attached to Q1.

For input voltages greater than 11V, it may be necessary to change R1's value, which must allow greater than 5mA for the MAX712/MAX713 plus approximately 16mA for drive current to the LED indicators. See the *Powering the MAX712/MAX713* section of the data sheet for more information about R1 selection. For the EV kit, the input source must be capable of handling the charging current plus 25mA. Connect the source to a 2-terminal connector on the board marked +VIN and GND.

When choosing an adapter for use with the MAX712/MAX713, make sure that the lowest wall-cube voltage level during fast charge and full load is at least 1.5V higher than the maximum battery voltage while being fast charged. Typically, the voltage on the battery pack is higher during a fast-charge cycle than while in trickle charge or while supplying a load. The voltage across some battery packs may approach 1.9V/cell.

The 1.5V of overhead is needed to allow for worst-case voltage drops across the pass transistor (Q1), the diode (D1), and the sense resistor (RSENSE). This minimum input voltage requirement is critical, because its violation may inhibit proper termination of the fast-charge cycle. A safe rule of thumb is to choose a source that has a minimum input voltage =  $1.5V + (1.9V \times \text{the maximum number of cells to be charged})$ . When the input voltage at DC IN drops below the  $1.5V + (1.9V \times \text{number of cells})$ , the part will oscillate between fast charge and trickle charge and may never completely terminate fast charge.

### Battery Connection

The battery connects across the battery high (BATT+) and battery low (BATT-) pins of the MAX712/MAX713. The pins connect to the battery holder and the 3-pin terminal block on the board. The battery holder charges one or two AA cells, depending on J1's position. Jumper J1 should be placed across pins 2 and 3 for a single cell and across 1 and 2 for two cells.

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External batteries can be connected across the BATT+ and BATT- pins of the 3-pin output connector. The third terminal is connected to the input ground (GND). The GND pin is used when driving external loads while charging.

When using external batteries, jumper J1 has no effect. Remove all batteries from holder before installing external batteries.

### Sense-Resistor Selection

The charging rate is determined by the value of the sense resistor connected between BATT- and GND. The 8-position DIP switch (SWB) can select several different values. For fast charge, the sense voltage is fixed at 250mV and the resistor value is selected for the desired current. The sense resistor also sets the trickle current. Choose RSENSE using the following formula:

$$R_{SENSE} = 0.25V/I_{FAST}$$

See the MAX712/MAX713 data sheet for complete information on setting the currents for fast (I<sub>FAST</sub>) and trickle charging.

**Table 1. Switch-Selected Sense-Resistor Values**

SWITCH	RESISTOR (Ω)
1	1.0
2	1.0
3	1.0
4	1.0
5	2.0
6	3.9
7	8.2
8	16.0

**Note:** A 330Ω resistor (R20) is paralleled across the sense resistor to prevent the open-sense line condition.

An unused resistor position (R21) is also provided so the user can mount a selected value.

### Mode Selection

Four pins on the MAX712/MAX713 are used to select the number of cells, maximum charging time, and interval between battery voltage measurements. PGM0 and PGM1 are used in combination to indicate the number of cells in the battery.

Whenever changing the number of cells to be charged, PGM0 and PGM1 need to be adjusted accordingly. Attempting to charge more or fewer cells than the number programmed may disable the voltage-slope fast-charge termination circuitry. The internal ADC's input voltage range is limited to between 1.4V and 1.9V and is equal to the voltage across the battery divided by the number of cells programmed. When the ADC's input voltage falls out of its specified range, the voltage-slope termination circuitry is disabled.

The MAX712/MAX713 multiply the input voltage on the VLIMIT pin by the programmed number of cells to be charged. This becomes the maximum output voltage of the MAX712/MAX713. VLIMIT should be set between 1.9V and 2.5V. If VLIMIT is set below the maximum cell voltage, proper termination of fast-charge cycle may not occur. Cell voltage can approach 1.9V/cell, under fast charge, in some battery packs. Tie VLIMIT to VREF for normal operation.

PGM2 and PGM3 are used in combination to select the maximum charging time (timeout) and the time interval between samples taken by the internal ADC. The fast-charge cycle terminates regardless of the battery level when the timeout period expires. Timeout intervals between 22 and 264 minutes can be selected.

The interval between the ADC samples varies with the timeout selection. If the voltage-slope fast-charge termination circuitry is enabled, the readings are also compared to the previous reading. Fast charge ceases if the delta is not more positive than zero for the MAX712 or -2.5mV for the MAX713.

PGM3 also sets the sense voltage for the trickle-charge phase.

The inputs to the programming pins (PGM0-PGM3) are set with the 12-position DIP switch (SWA). For example, to connect PGM2 to BATT-, first open (OFF) S7, S8, and S9, then close (ON) S8.

**Table 2. Programming Pin Input Selection**

INPUT	PGM0	PGM1	PGM2	PGM3
Open	—	—	—	—
REF	S1	S4	S7	S10
BATT-	S2	S5	S8	S11
V+	S3	S6	S9	S12

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### How to Use the Thermistors

Thermistors TR1 and TR2 detect when the battery temperature exceeds the ambient temperature. With two of the same type of thermistors, as long as the battery temperature is the same as the ambient temperature, the voltage at TEMP will be 1.0V. At +25°C ambient temperature and +35°C battery temperature, TR2 has 10k $\Omega$  resistance and TR1 has 5.2k $\Omega$  resistance (see the graph labeled "Alpha Thermistor Part No. 13A1002" in the *Typical Operating Characteristics* of the data sheet); thus TEMP equals 1.3V. Fast charge terminates once TEMP exceeds THI. Adjust the voltage on THI to set the over-temperature trip point.

Thermistor TR3 detects when the temperature is too cold to fast charge the battery. Before charging has started, TEMP will equal 1.0V since the battery temperature will be the same as ambient. At 0°C, TR3 has 33k $\Omega$  resistance. Setting R8 to 33k $\Omega$  inhibits fast charging for temperatures below 0°C, since TR3's resistance will be greater than 33k $\Omega$  at temperatures below 0°C and thus the voltage at TLO will be greater than 1.0V.

If the MAX712/MAX713's temperature detection features are not used, do not forget to disable the temperature comparators by tying THI = V+ and TLO = BATT-. TEMP should be connected to a voltage divider consisting of a 68k $\Omega$  resistor to VREF, and a 22k $\Omega$  resistor to BATT-. Refer to the *Typical Operating Circuit* of the MAX712/MAX713 data sheet.

**Table 3. Programming the Timing Functions**

Timeout (min)	Sample Interval (sec)	Slope Limit	PGM2 Connection	PGM3 Connection	S7-S9	S10-S12	Sense Voltage in Trickle (mV)
22	21	Off	Open	V+	–	S12	4
22	21	On	REF	V+	S7	S12	4
33	21	Off	V+	V+	S9	S12	4
33	21	On	BATT-	V+	S8	S12	4
45	42	Off	Open	Open	–	–	8
45	42	On	REF	Open	S7	–	8
66	42	Off	V+	Open	S9	–	8
66	42	On	BATT-	Open	S8	–	8
90	84	Off	Open	REF	–	S10	16
90	84	On	REF	REF	S7	S10	16
132	84	Off	V+	REF	S9	S10	16
132	84	On	BATT-	REF	S8	S10	16
180	168	Off	Open	BATT-	–	S11	32
180	168	On	REF	BATT-	S7	S11	32
264	168	Off	V+	BATT-	S9	S11	32
264	168	On	BATT-	BATT-	S8	S11	32

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**Table 4. Programming the Number of Cells**

Number of Cells	PGM0 Connection	PGM1 Connection	S1–S3	S4–S6
1	V+	V+	S3	S6
2	V+	Open	S3	–
3	V+	REF	S3	S4
4	V+	BATT-	S3	S5
5	Open	V+	Open	S6
6	Open	Open	Open	–
7	Open	REF	Open	S4
8	Open	BATT-	Open	S5
9	REF	V+	S1	S6
10	REF	Open	S1	–
11	REF	REF	S1	S4
12	REF	BATT-	S1	S5
13	BATT-	V+	S2	S6
14	BATT-	Open	S2	–
15	BATT-	REF	S2	S4
16	BATT-	BATT-	S2	S5

**Table 5. Trickle-Charge Sense-Voltage Selection**

PGM3	S10-S12	Sense Voltage (mV)
V+	S12	4
Open	–	8
REF	S10	16
BATT-	S11	32

**Table 6. Factory Settings Before Shipment**

Number of Cells	2
Timeout	264 minutes
ADC Interval	168 seconds
Fast-Charge Current	250mA
Trickle-Charge Current	32mA
Battery Temperature Rise Cutoff	+15°C
V <sub>LIMIT</sub>	2.0V

**Table 7. Evaluation Board Switch Settings For Charging Two NiCd AA Cells (Pre-Shipment Settings)**

Switch A (SWA)	On Switches (all others off)	Function
PGM0 = V+, PGM1 = Open	S3, –	Indicates two cells
PGM2 = BATT-, PGM3 = BATT-	S8, S11	264min timeout, 168sec ADC interval, slope limit on
<b>Switch B (SWB)</b>		
S1	R <sub>SENSE</sub> = 1.0Ω	Fast-charge current = 250mA
<b>Jumper J1</b>		
J1	1 & 2	Set for charging two AA batteries

**Table 8. Voltage Values**

Voltage	Value	Function
VREF	2.00	Internal fixed reference voltage
VLIMIT	2.00	Sets maximum charging voltage; R6 is adjusted to set the level. Set VLIMIT to VREF for normal operation.
VTHI	1.33	High-temperature trip voltage. Fast charge ceases when the TEMP pin exceeds this voltage. R7 is adjusted to set the level.
VTLO	0.66	Low-temperature trip voltage. Fast charge will not start when the TEMP pin is below this voltage. R8 is adjusted to set the level.
VTEMP	1.00	This voltage is 1/2 of VREF as long as the two thermistors, TR1 and TR2, are at the same temperature. A <i>Typical Operating Characteristics</i> graph in the MAX712/MAX713 data sheet shows how this voltage will vary with battery temperature. TR1 must be in contact with the battery casing to sense the battery temperature.

Evaluates: MAX712/MAX713

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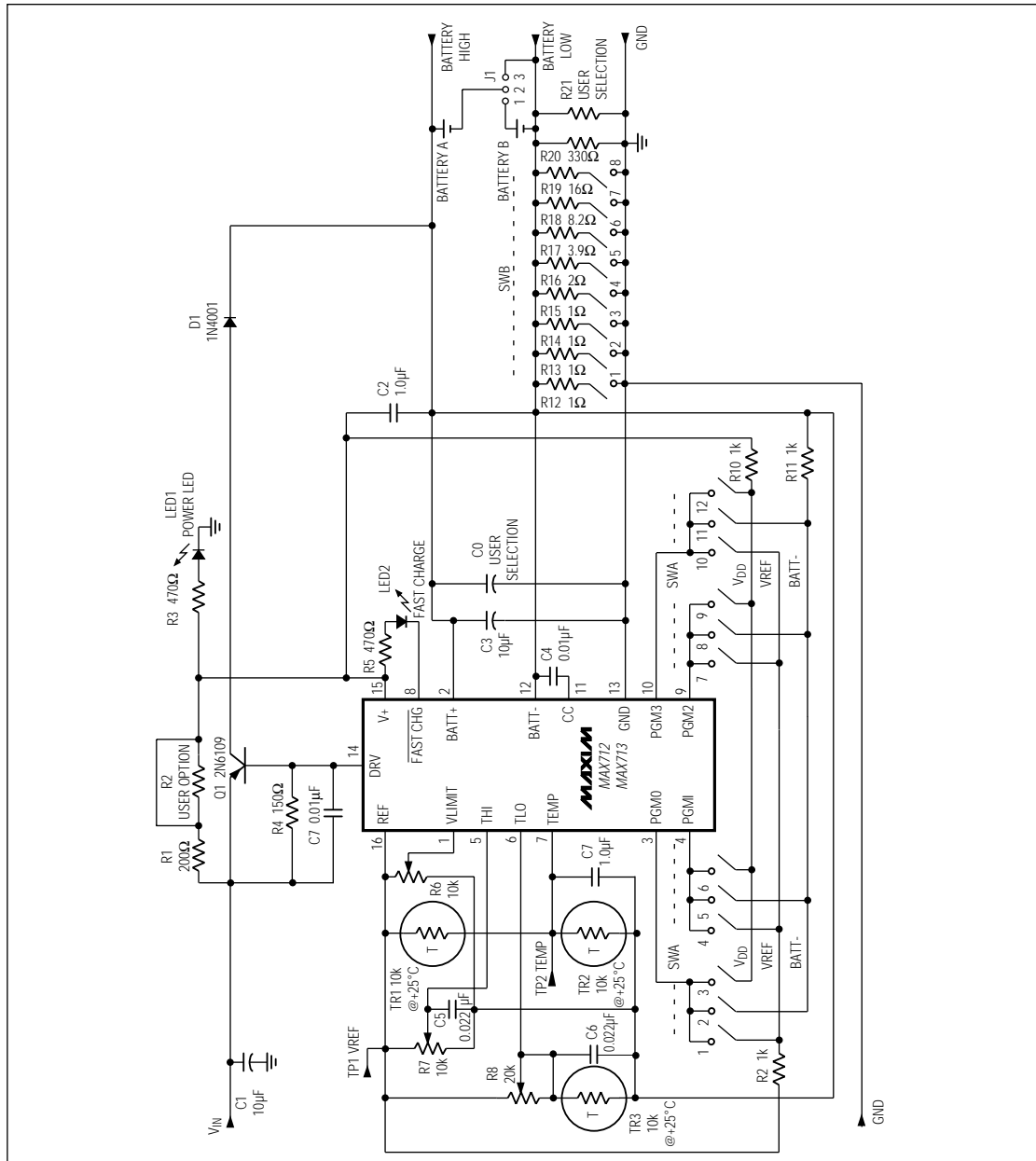


Figure 1. MAX712 Linear-Mode EV Kit Schematic