Batteries and Charging Systems for QRP

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Topics

- Summary and Selection of Battery Types
- Calculating battery capacity needed
- Charging batteries
- Using solar panels to charge batteries
- Summary

Batteries Commonly Used by QRPers

- Primary Batteries - Use once
  - Carbon Zinc
  - Alkaline
  - Lithium
- Secondary Batteries - Rechargeable
  - Nickel Cadmium
  - Lead Acid
  - Nickel Metal Hydride
  - Lithium

Carbon-Zinc Batteries Not Recommended

- Carbon Zinc are essentially useless for QRP
  - Poor capacity, despite being sold as "Heavy Duty"
  - Poor discharge characteristics
  - Often leak when stored
  - Very cheap, included in cheap toys & Flashlights
  - WB5QYT reports that a set of Carbon-Zinc batteries lasted 20 minutes in his FT-817 *without* transmitting
  - Fortunately, these are getting hard to find

Alkaline Is Good, Inexpensive, Choice for One Time Use

- Widely available
    - Available at nearly every gas station/convenience store
    - Can “borrow” AA batteries from flashlights, radios, CD players, and tape players when backpacking
- High capacity (2X Ni-Cds)
- Long shelf life (5 years or more)
- Only 50% capacity at 32° F
- Rig should operate from 0.9V to 1.5 V per cell (7.2 V to 12 V for QRP applications) to extract all available energy

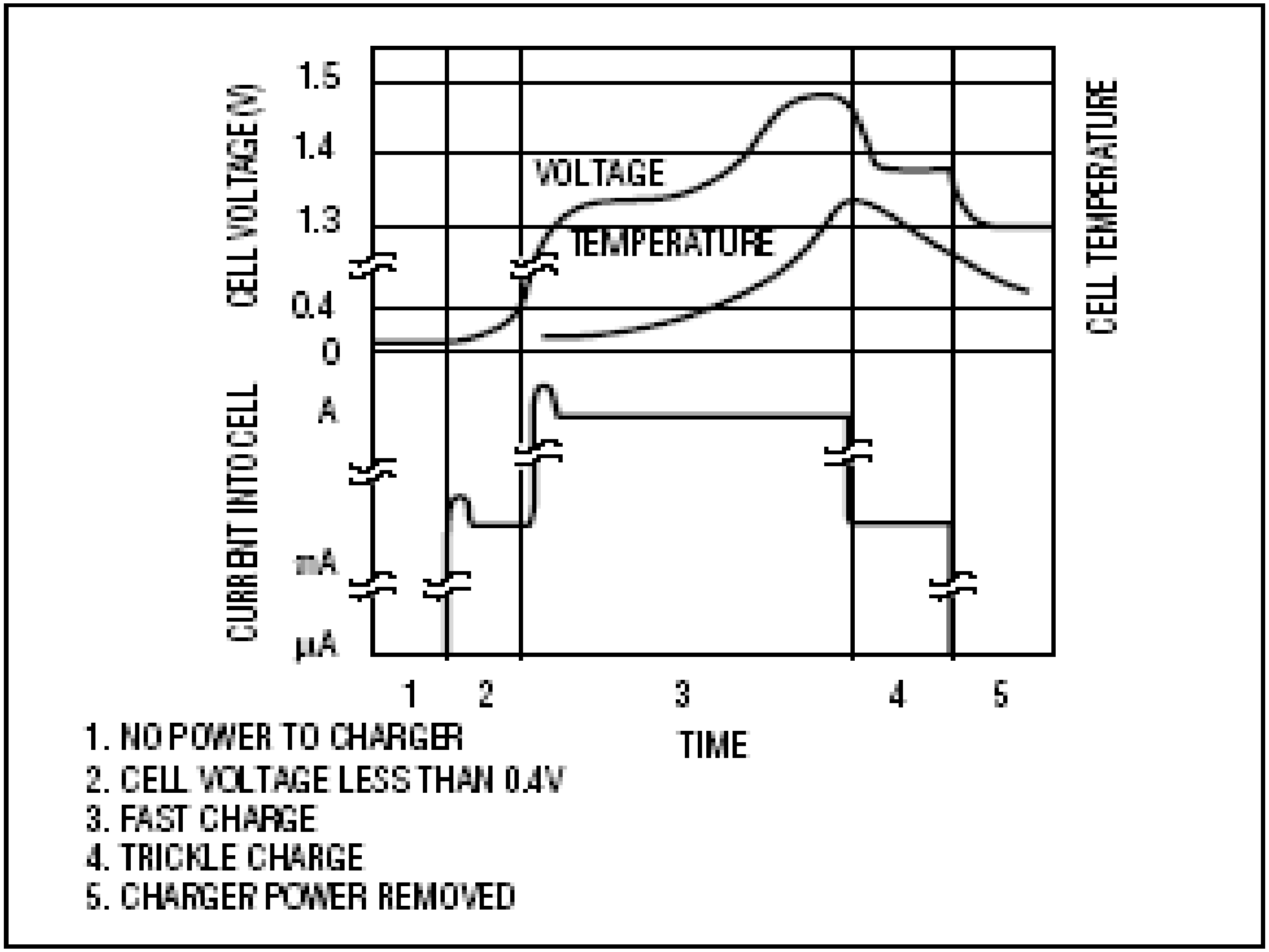
Lithium Have High Capacity, But Are Expensive

- About twice the capacity of Alkaline
- Good capacity at 32° F
- Equipment must handle 2.5 - 3 V per cell to extract most stored energy (10 V to 12 V for typical QRP application)
- A 9V Lithium cell has 1000mAH! Good match with 49er or Rockmite for demonstrations

Nickel Cadmium (Ni-Cd) Good All Around Choice

- Can tolerate some overcharge at 0.1C
- Flat discharge
- Equipment should handle 1.0 to 1.35 V/cell or 10 to 13.5 V for QRP rigs) to extract most energy form cells
- Good capacity at 32°F
- High self discharge (10%/month)
- Beware of Ni-Cd C and D cells that are really sub C cells - Check AH rating
- Widely available, moderately priced
  – 2/3 C or “sub C” Nii-Cd is good value

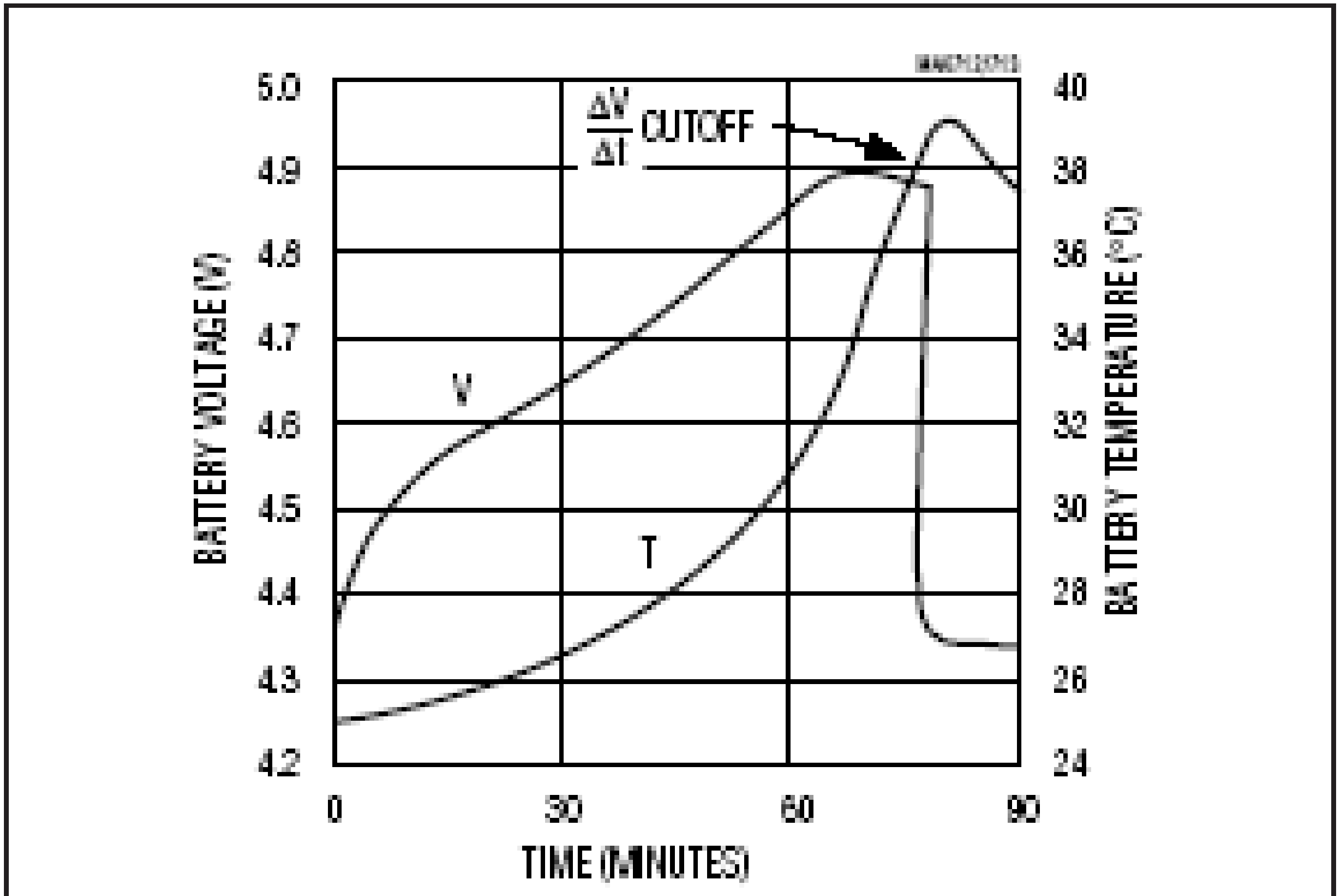
Charging Properties of Ni-Cd



Nickel Metal Hydride (Ni-MH) Rechargeable Cell of Choice in AA Size

- Widely available in AA size, in large capacities, 2500 mAH
- Greater (1.5X to 2.5 X) capacity than Ni-Cds
- Flat discharge curve
- Good capacity at 32° F
- Not tolerant of overcharging
- Special attention to charging required
- High self discharge (15% -20%/month)

Charging Properties of Ni-MH Cells



Sealed Lead-Acid Batteries Good Choice Where Weight Is Not a Concern

- Widely available, but not in smaller than C size
- Easy to charge, easy to float
- 80% of capacity at 32°F
- Low self discharge (1% to 5% per month)
- Less capacity than Ni-Cds, much less at high discharge rates
- V drops linearly as discharged (not flat)
- Equipment must handle (1.7 to 2.3 V/cell or 10.2 to 13.8 for QRP) to extract most stored energy
- “Pulls” available cheap or free

Rechargeable Lithium Expensive & Not Available in 12 V Sizes

- High capacity for weight (2-3 X Ni-Cds)
- Good Cold Temperature Operation
- Long Shelf life
- Crucial charging requirements
- Expensive, but becoming more widely available
- Available in 3.6 V and 7.2 V cells/batteries, Not too convenient for 12 V supply

Calculating Required Battery Capacity

- Determine receive current, Irec
- Determine transmit current, Itran
- Determine transmit duty cycle, D
  - CW is usually 30 to 40 %, SSB is usually 20 to 30 %, RTTY 50 %, PSK-31 50%, AMTOR 75 %
- Calculate average current, Iavg required from :

  Iavg = Itran*DC+Irec(1-DC)

- Calculate Amphour capacity, C, using the number of hours, N, of operation required

  C = Iavg*N

- If a lead acid battery is being used and N is small multiply this number by 1.5 - 2.0

Battery Capacity Calculation Example 1

- My OHR rig draws 120 mA on receive and 0.9 A on transmit
- I wish to operate QRPTTF on CW, a 6 hour contest
- Iavg = 0.9(0.4) + 0.1(1-0.4) =0.42 A
- C=(0.42)6=2.56AH
- Choices
  - Alkaline AA at 2.85 AH, C at 7.8 AH
  - Ni-Cd C at 2.5 AH, D at 4.8 AH
  - Ni-MH AA at 2300 mAH, sub C at 3000, D at 7.5 AH
  - Sealed Lead Acid at 4.5 AH, 7AH
    - (3AH SLA won't cut it as SLA discharge rate is based on 20 hrs)

Battery Capacity Calculation Example 2

- Mark, K5DP, is going on a 2 week backpacking trip per QRP-L
- His SW20+ draws 20 mA on receive and 500 mA on transmit
- He wants to operate an hour a day on 9 AA batteries
- Iavg = 0.5 (0.4) +(0.02)(0.6) =0.212 A
- C = 14(0.212) = 2.97 AH
- Alkaline AA batteries have a 2.85 AH capacity so he will be close

Battery Sizes and Capacities

Cell size	Alkaline (mAH)	Lead-Acid	Ni-Cd (mAH)	Ni-MH (mAH)
AAA	1100	NA	250	700
AA	2450	NA	1000	2300
2/3 C ("sub C")	NA	NA	1500	3000
C	7100	2500	2400	NA
D	14000	4500	4400	6500
Lantern Battery	20,000 (6 V)	NA	NA	NA

Charging Methods

- Constant Voltage
- Constant Current
- Multimode, combination of above
- Detecting full charge
  - Voltage
  - Current
  - Temperature

SLA Preferred Charging Methods

- Constant Voltage trickle
  - 13.2V to 13.8V
  - Current limit to C/10
- Constant Current
  - C/10 to C/4
  - Stop at 14.4 V
- Multi-mode
  - Constant Current to 14.4 V, then constant voltage until current drops to 1/10, then constant voltage at 13.2 to 13.8 V
- Texas Instruments (Unitrode) IC, UC3906 is good chip, plans in data sheet or ARRL Handbook

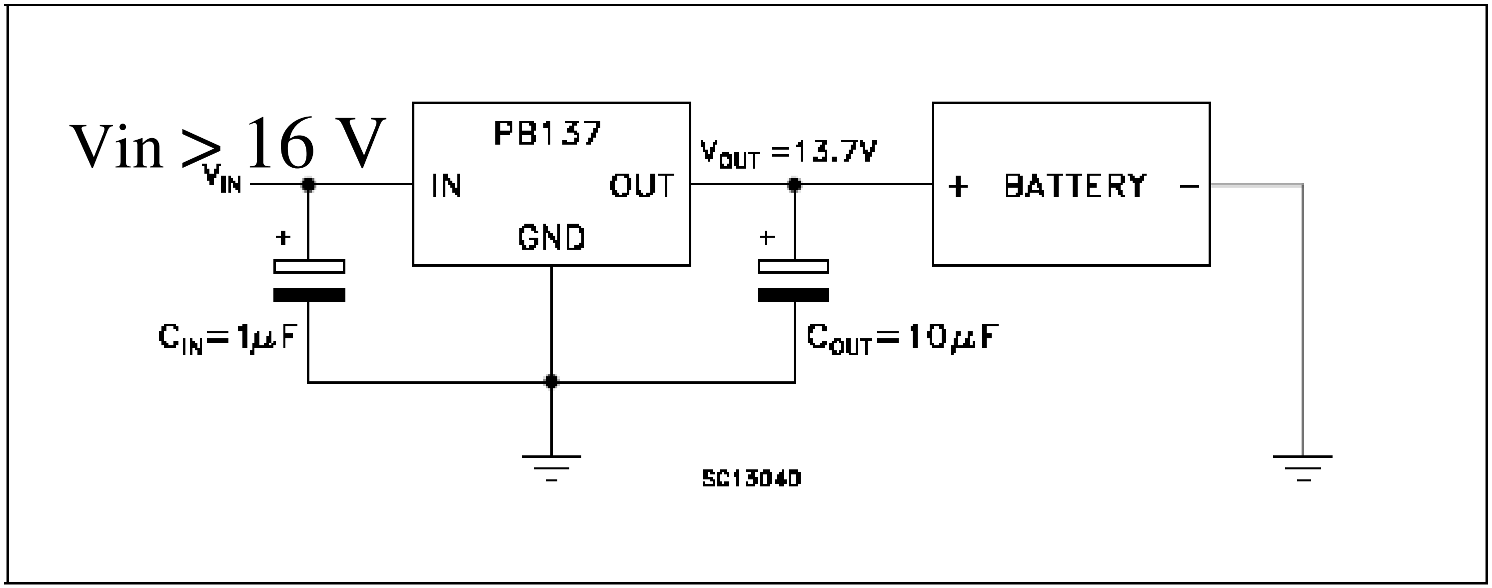
Ni-Cd Preferred Charging Methods

- Constant current at less than C/10
  - If long term, limit current to < 0.05C
  - Or limit with timer to 1.4 times full charge
  - Or limit when T rises
- Constant current to dv/dt < 0, then trickle charge at 0.02C
- Maxim 712/713 ICs for versatile charging of Ni-Cds
  - ARRL handbook or data sheet
- Can charge with Ni-MH chargers

Ni-MH Preferred Charging Methods

- Constant current at 0.05C
  - Time limit at 28 hours, takes a long time!
- Constant Current to dv/dt = 0
- Does not withstand overcharging well
- Maxim MAX712 good IC for Ni-MH
- Commercial chargers are also good and inexpensive – don’t charge on Ni-Cd chargers

Simplest SLA Trickle Charger

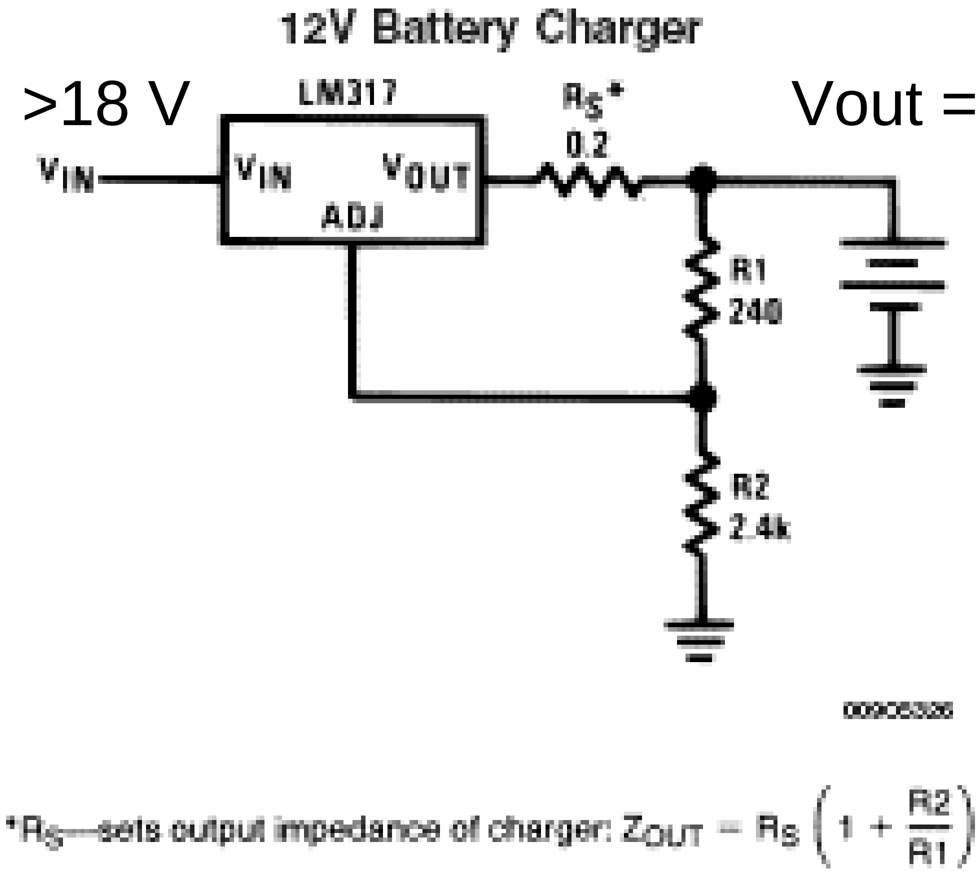


- Adequately heat sink PB137 (TO-220)
- Cin, Cout are electrolytics, tantalum preferred
- 1.5 Amperes maximum

Simple Constant Voltage Charger

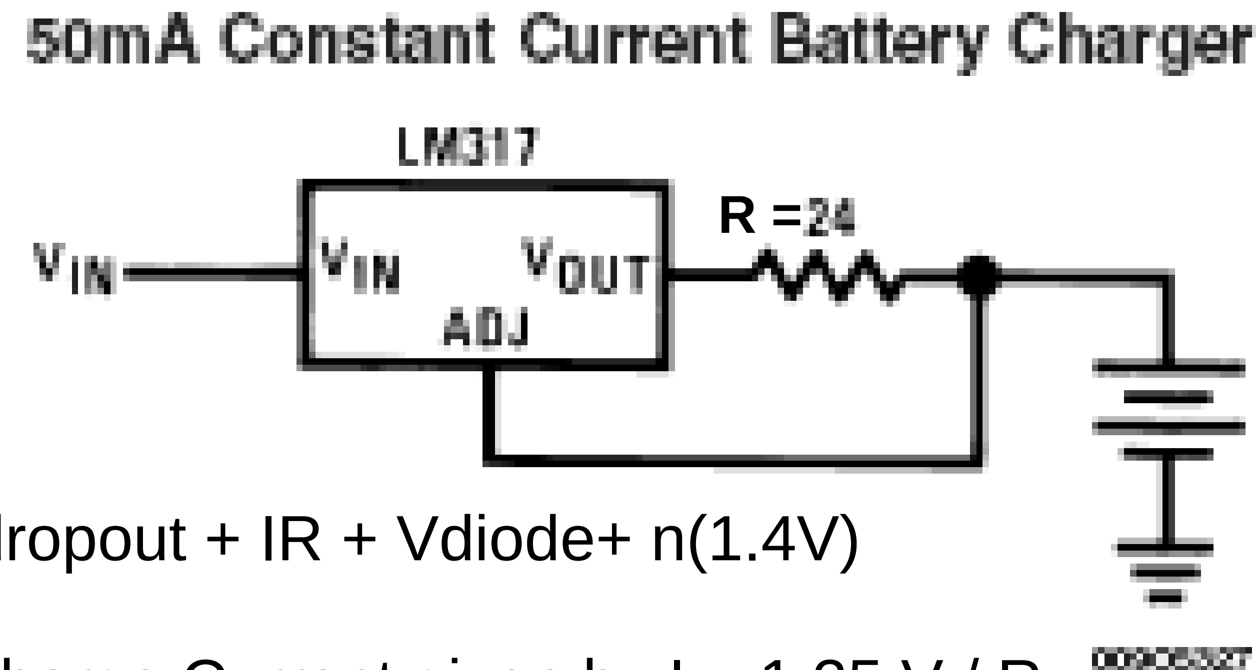
Vin >18 V

Vout = 1.25 (1 + R2/R1)



A diode (preferably Schottky) can be added between the R2/RS junction and the battery for short circuit protection

Simple Constant Current Charger



Vin = Vdropout + IR + Vdiode+ n(1.4V)

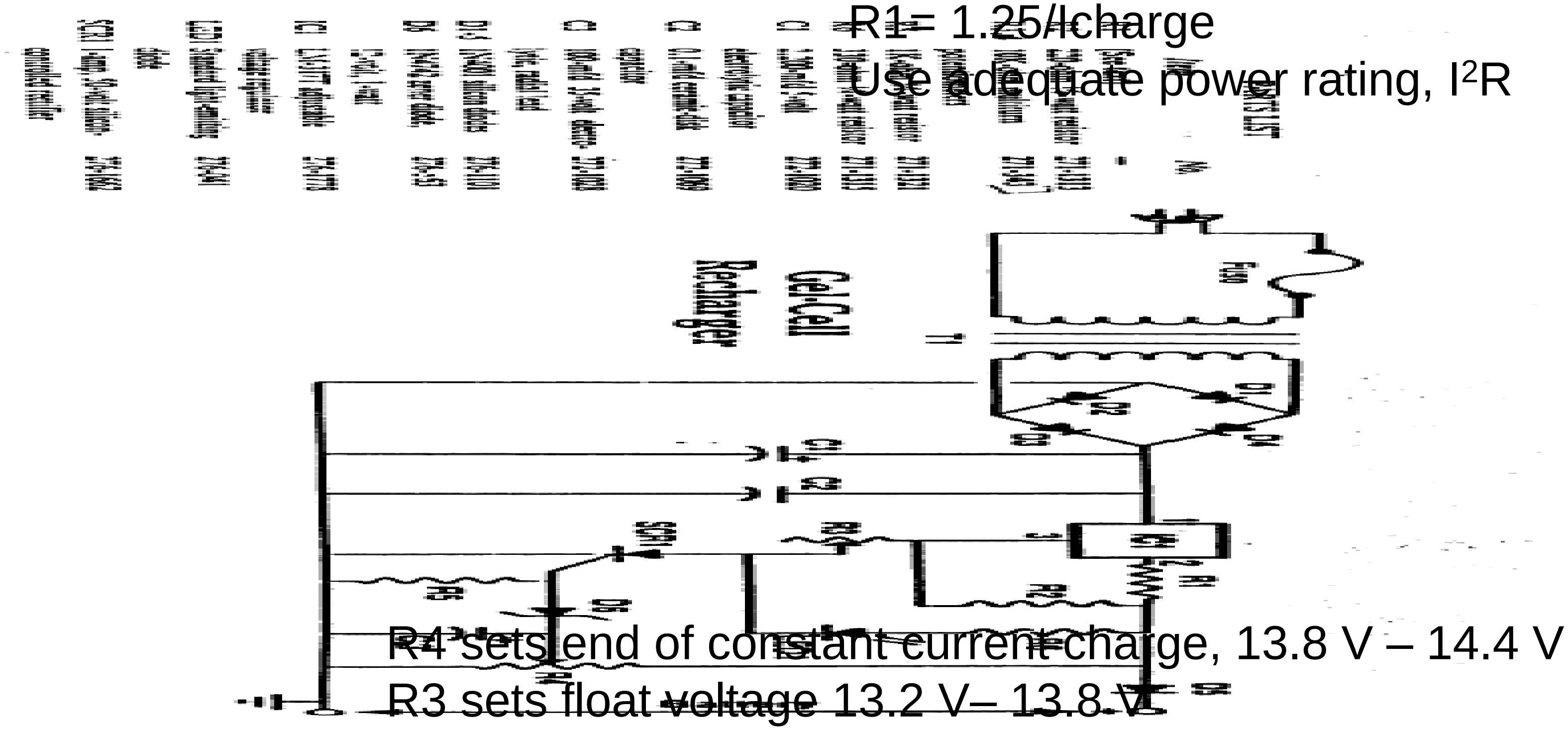
Charge Current given by I = 1.25 V / R

Use series diode between R and battery for short circuit protection

Simple Constant/Constant Voltage Charger for Gel Cells

R1= 1.25/Icharge

Use adequate power rating, I^2R

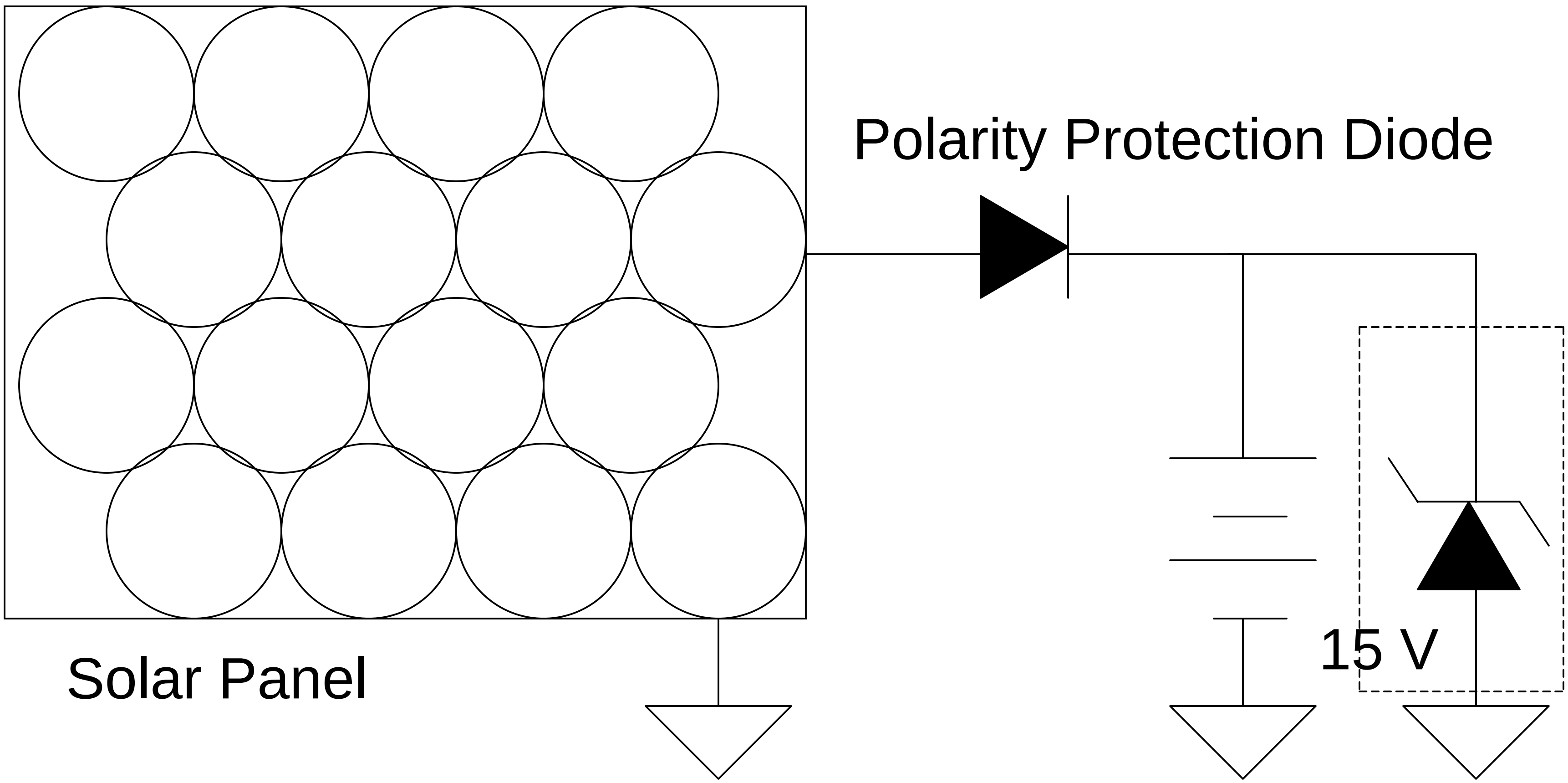


R4 sets end of constant current charge, 13.8 V – 14.4 V

R3 sets float voltage 13.2 V– 13.8 V

by Marvin Harner, Sky and Telescope, July 1987

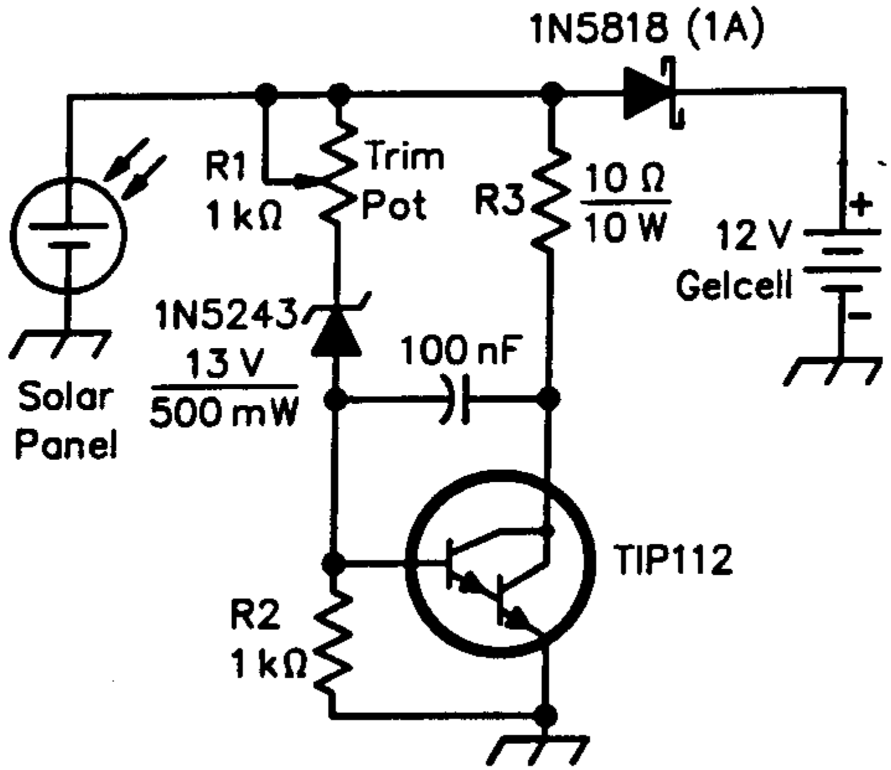
Solar Panel is Constant Current Charger



Zener diode may be omitted if panel output is 0.1C or less

Simple Shunt Charge Controller for Solar Panel

From "QRP Power", p 3-24



For 100 mA or Smaller Panels (≤ 2 W)
use R1= 10 k, R2= 10 k, R3= 100 Ω 1W

Some Charging Rules of Thumb, SLA

- Lead acid batteries can be charged at constant voltage (13.8 volts) forever, but full charge won't be achieved
  - Can be charged at constant 14.4 to 14.8 V until battery reaches that voltage, then trickle charged at 13.8 V
  - Can be charged with constant current (0.1 to 0.3 C) until 14.4 to 14.8 V is reached then trickle charged
  - Batteries should be recharged once every 6 months
  - It is pretty much impossible to fully charge a lead acid battery
- Do not store in discharged state

Charging Rules of Thumb, Ni-Cd

- Ni-Cd batteries can be charged with constant current at 0.1 C for 14 hours
  - Battery should be removed from charger after 14 hours to avoid overcharging - use household timer
  - Ni-Cds should be “topped off” once a month
  - Ni-Cds stored on trickle charge over long period may have voltage depression which can be remedied by several charge-discharge cycles
- *Do not* fully discharge before charging
  - this will reduce lifetime
- Ni-Cds are robust to overcharging, susceptible to undercharging
- Do not store in discharged state

Charging Rules of Thumb, Ni-MH

- Ni-MH batteries can be charged with constant current at 0.05 C for 28 hours
  - Battery should be removed from charger after 28 hours to avoid overcharging
- Ni-MHs should be "topped off" every two weeks
- Ni-MHs are susceptible to overcharging and should not be stored on trickle charge
- Ni-MHs are also susceptible to undercharging, do not store uncharged
- *Do not* fully discharge before charging
  - This will reduce battery life

Strategies for Managing Batteries

- Use standard connectors – 2.1mm coaxial standard QRP connector, Anderson Power Poles, leads with alligator clips
- Power all equipment with the same type battery – AA cells are good choice
- Use 10 cell holder with terminal after 8 cells –Alkaline cells can be substituted for Ni-CD/Ni-MH
- Scavenge from other devices, flashlights, garage door openers, multimeters, tape players, CD players
- Bring spares
- Use micropower regulators for accessories

How to Make Your Batteries Last

- Don't overcharge
- Don't discharge fully
- Charge immediately after using
- Store fully charged
- Maintain charge on stored batteries periodically
- Avoid continual trickle charging Ni-Cds

Suggestions for Batteries

- Use alkaline if you only occasionally need battery power
- If weight is not a problem, use sealed lead-acid (Gel-Cells)
- For lightweight applications, such as backpacking use AA Ni-MH
- For cold weather applications, Ni-Cd, Ni-MH, or lithium are best

Good Battery References

- http://michaelbluejay.com/batteries/
- http://www.buchmann.ca/
- http://www.batteryuniversity.com/
  - Condensed version of Buchmann site
- http://www.greenbatteries.com/documents/Battery_Guide.pdf
  - This is the National Institute of Justice Battery Handbook
  - On CD
- Horowitz and Hill, “The Art of Electronics”
- Manufacturers application guides and web sites
  - Use Google to find Manufacturer o0f your battery