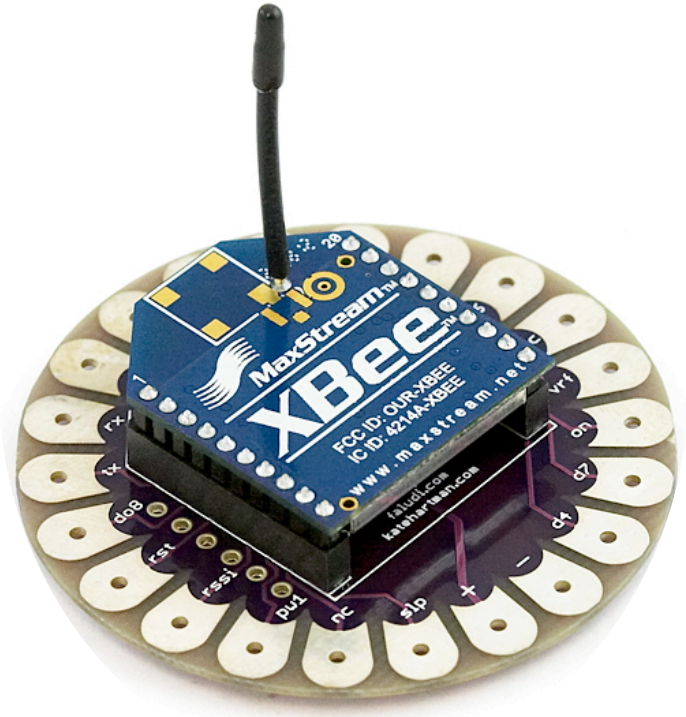
Wireless Wearables

Rob Faludi & Kate Hartman

Motorola Radio Set SCR-300

LilyPad XBee



Projects

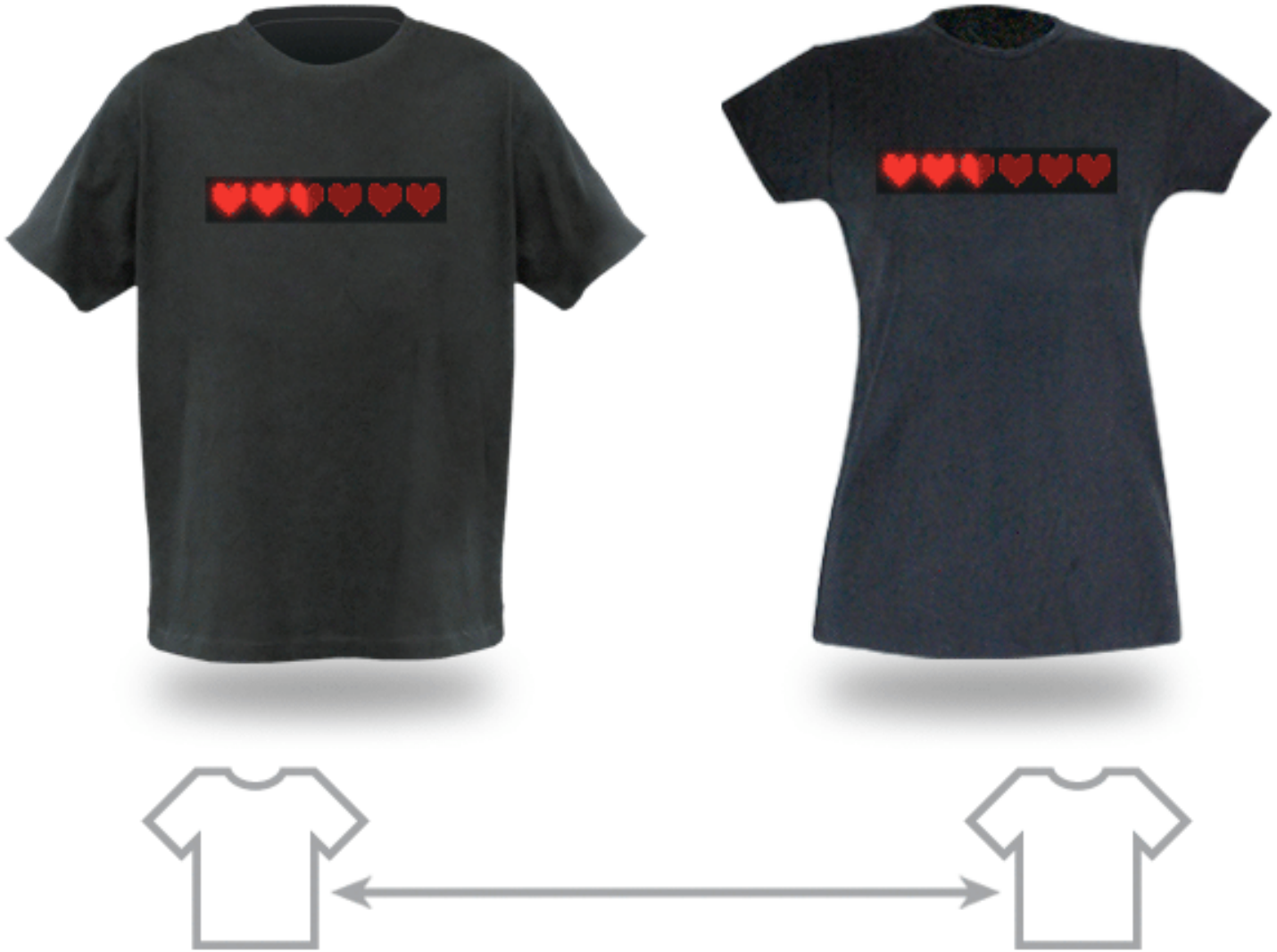
Perform-o-shoes

Andrew Schneider

Twitch Set

Andrew Schneider

Wireless Wearables



8-Bit Dynamic Life Shirts

ThinkGeek

Tools

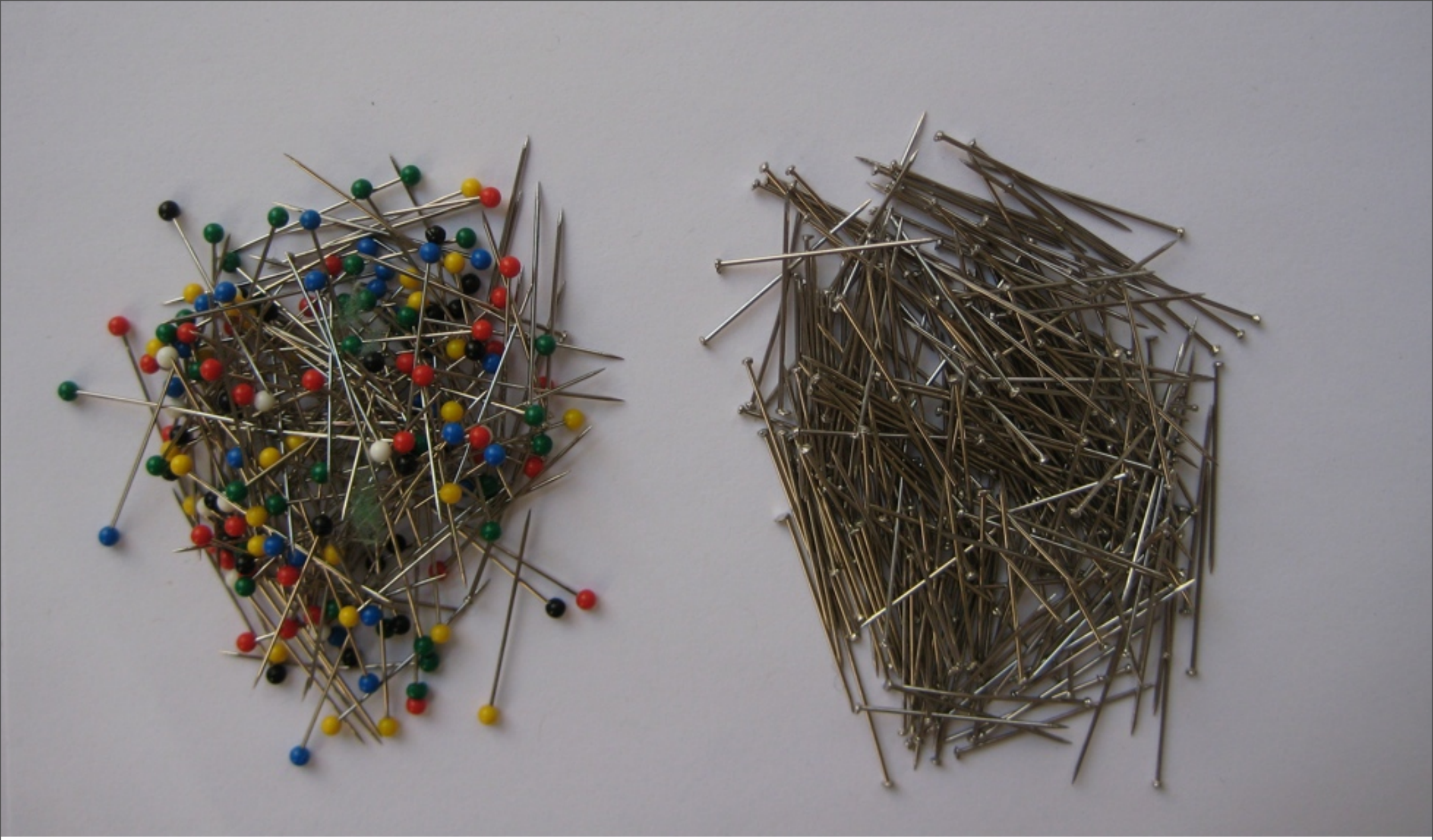

Disappearing Ink Marking Pen
Marcador con Tinta Invisible
• Air & water soluble ink
• Marks can be removed with damp cloth


WARNING: USE EXTREME CAUTION IN THE USE OF THIS DEVICE. IMPROPER USE OF THIS DEVICE CAN RESULT IN INJURY OR DEATH. FOLLOW SAFE-GUARDS SUGGESTED IN THE OWNER'S MANUAL IN ADDITION TO NORMAL SAFETY PRECAUTIONS IN DEALING WITH ELECTRICAL CIRCUITS. DO NOT USE THIS DEVICE IF YOU ARE UNFAMILIAR WITH ELECTRICAL CIRCUITS AND TESTING PROCEDURES.
Q.C.
09A07
TEC
RadioShack
CAT II
200mA
500V
MAX
SELECT
OFF
mA
OPEn
AUTO-RANGE DIGITAL MULTIMETER
AUTO POWER OFF

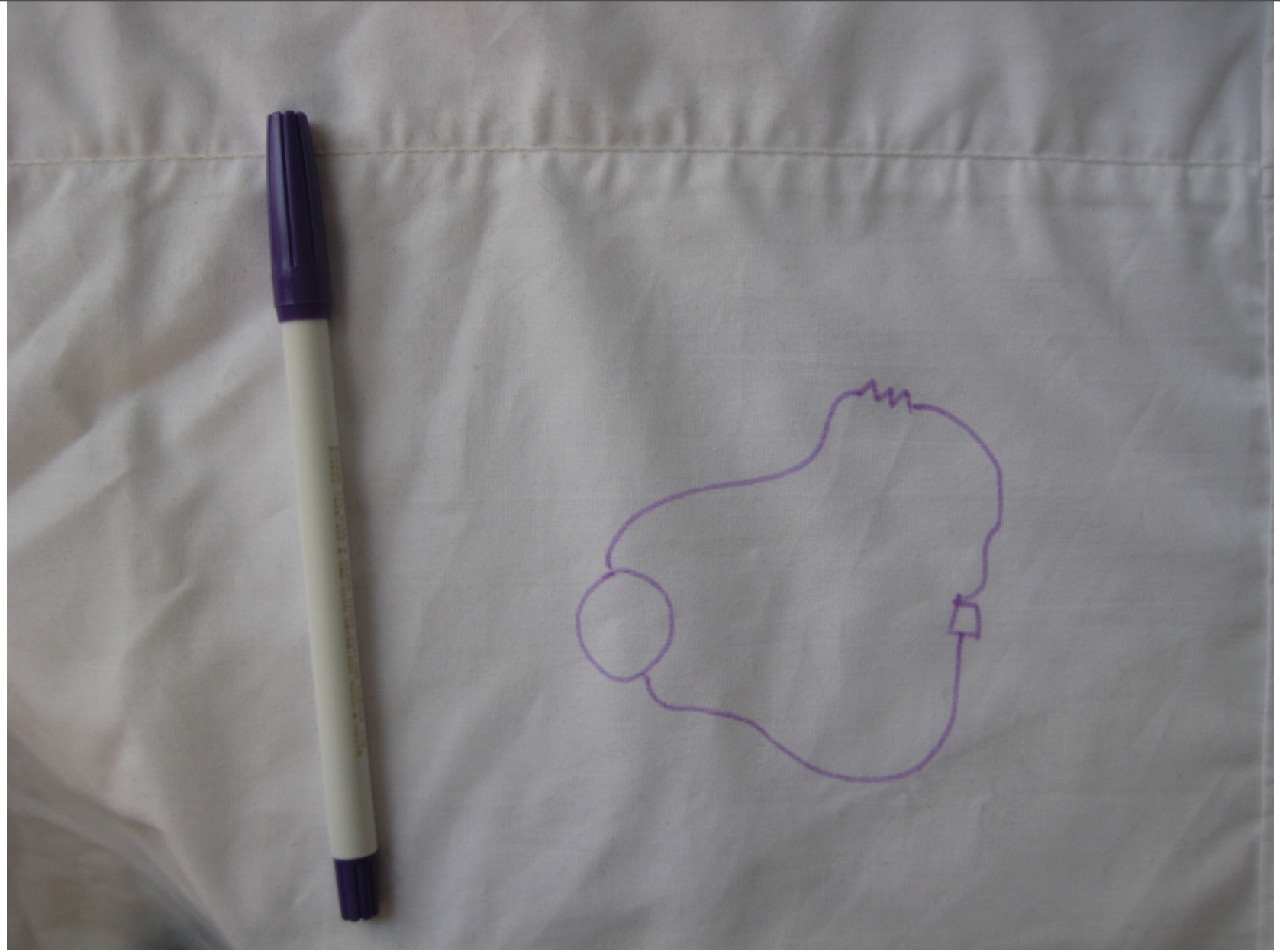
Multimeter

Alligator Clips

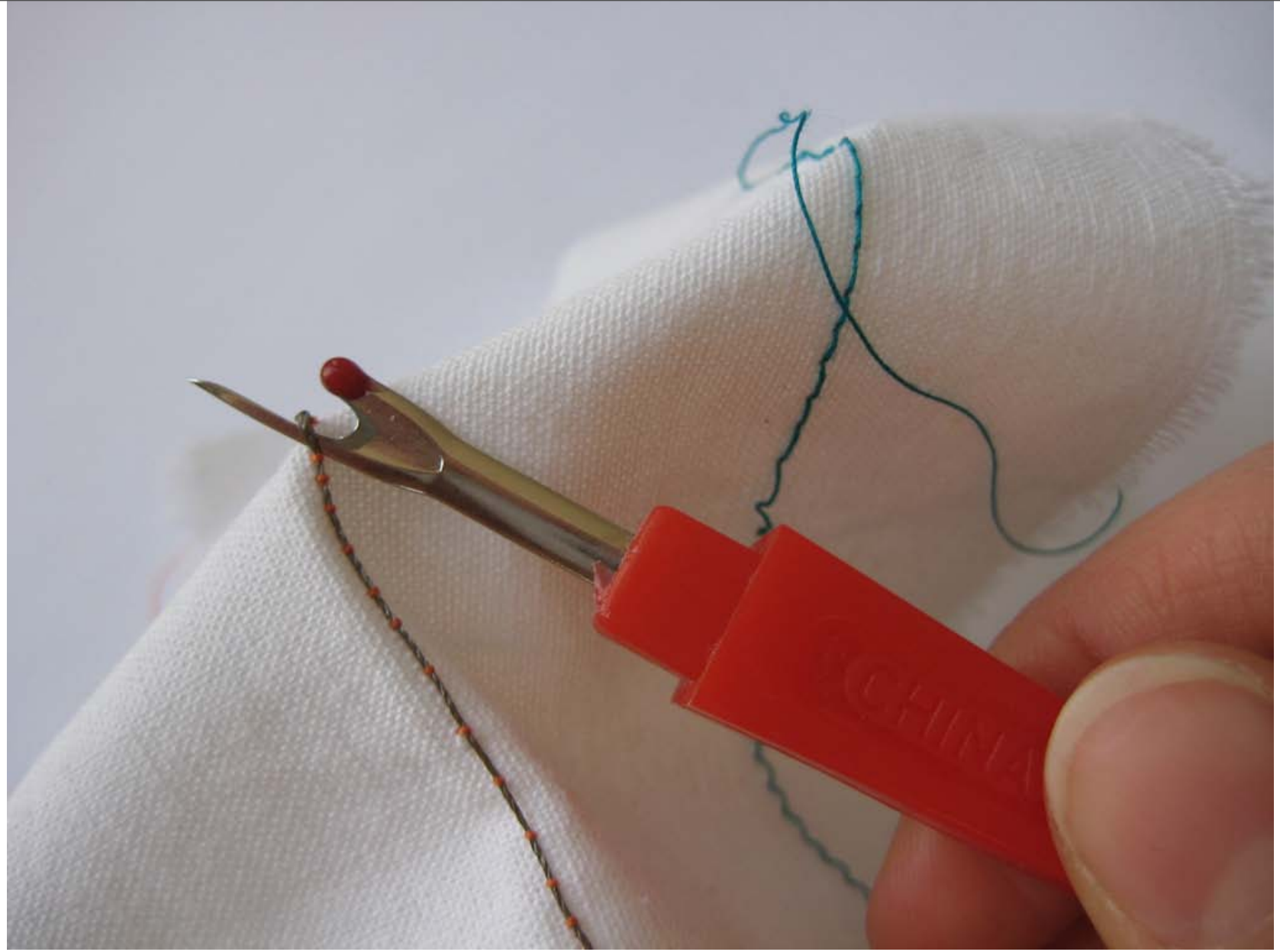
Sewing Needles



Pins



Fabric Pens



Seam Ripper

Measuring Devices

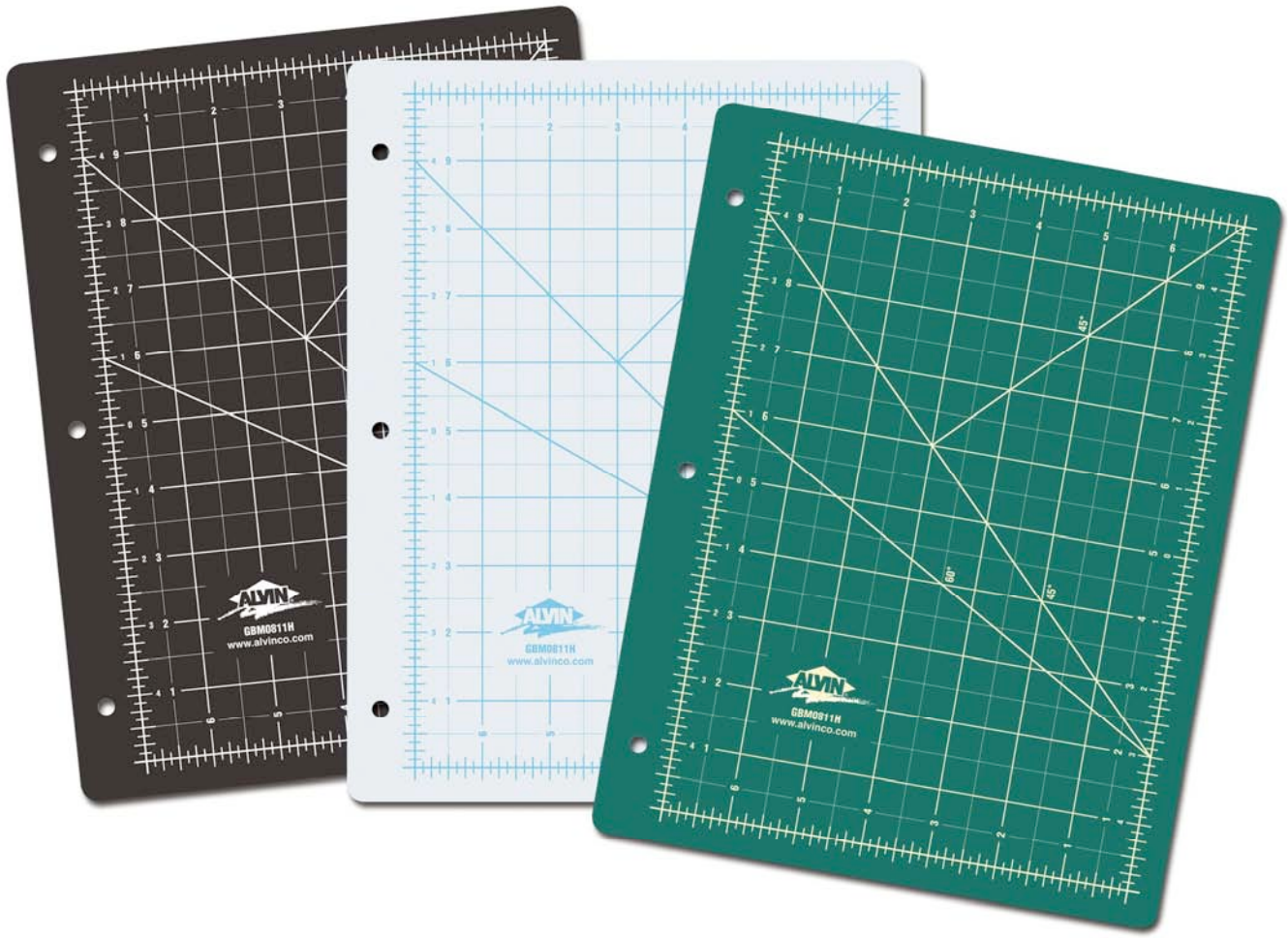
Tape Measure

Yard Stick

Transparent Ruler

Fabric Scissors

Pinking Shears



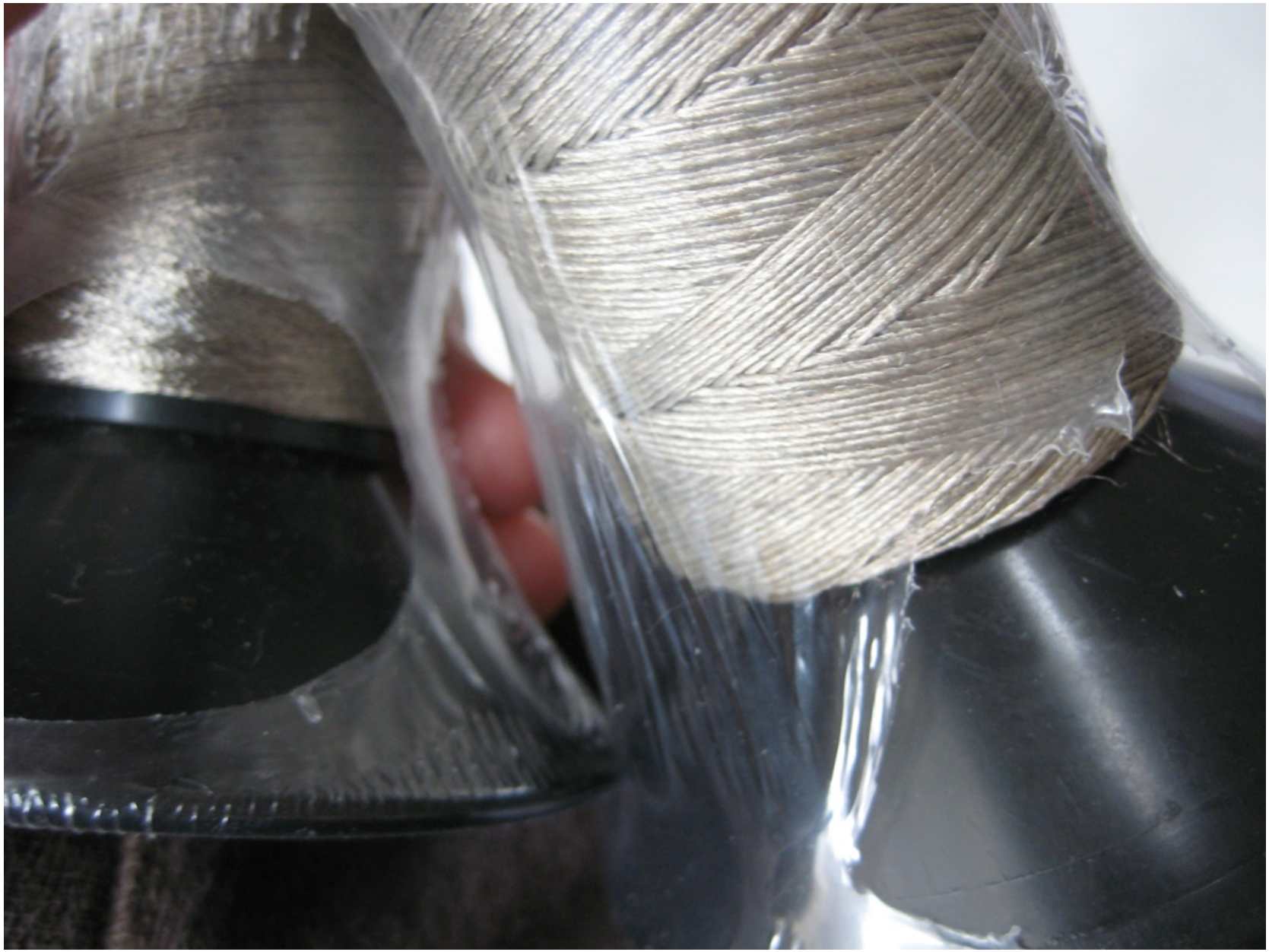
Self-Healing Mat & Rotary Cutters


BEACON
MAGNA-TAC
809™
PERMANENT ADHESIVE
PERFECT FOR BRIDAL & OTHER SPECIAL OCCASIONS
GREAT FOR HEADPIECES, FAVORS, COSTUMES, HANDBAGS, & MORE
BONDS FABRIC, LACE, BEADS, GLASS, METAL, WOOD & LEATHER
El Adhesivo Perfecto para Trajes de Novias y Quinceañeras — Para Decoraciones Como Cuero, Capas, Coronas, Recuerdos, Disfraces, etc.
DANGER:
EXTREMELY FLAMMABLE WHEN LIQUID
8 Fl. Oz. (226.8 mL)
Dritz
Fray Check
Stops Fraying on Fabric!
WARNING
FLAMMABLE LIQUID & VAPOR
Made in USA
MAGNA-TAC 809™ quickly dries to a
washable bond.
DIRECTIONS:
Pre-wash fabrics to remove sizing.
Always test on sample fabric first.
Apply glue to item and position
Washable after 24 hours. Do not dry
Keep covered when not in use.
Can be thinned with acetone.
Do not use varnished furniture as a
even if protected. Surface may
INSTRUCCIONES:


Easy Squeeze Bottle
Sobo
Premium Craft & Fabric Glue
by Delta
4 FL. OZ.
8 FL. OZ. (240 ML)

Fabric Glue

Materials



Conductive Thread

	Lame Lifesaver lame repair	approximately 40 ohm/ft	$15 CDN / 200-yard spool
	Bekitex BK50 (Bekaert) originally designed for conductive backing of carpeting for computer rooms and offices	approximately 500 ohm/ft	$30/1-lb cone
	Bekinox VN (Bekaert) Anti-static textiles Intelligent Textiles Signal transfer Power transfer	?	$36 - $244 / 1-lb cone
	Conductive Thread - 117/17 2ply finer thread that can be used in standard sewing machines	82 Ohms per foot	$16.95/Spool contains 1 oz of thread, about 1200 yards.
	Conductive Thread - 234/34 4ply “thicker thread with a lower resistance that can be used with hand sewing”	14 Ohms per foot	$16.95/Spool contains 2.5oz of thread, about 670 yards.

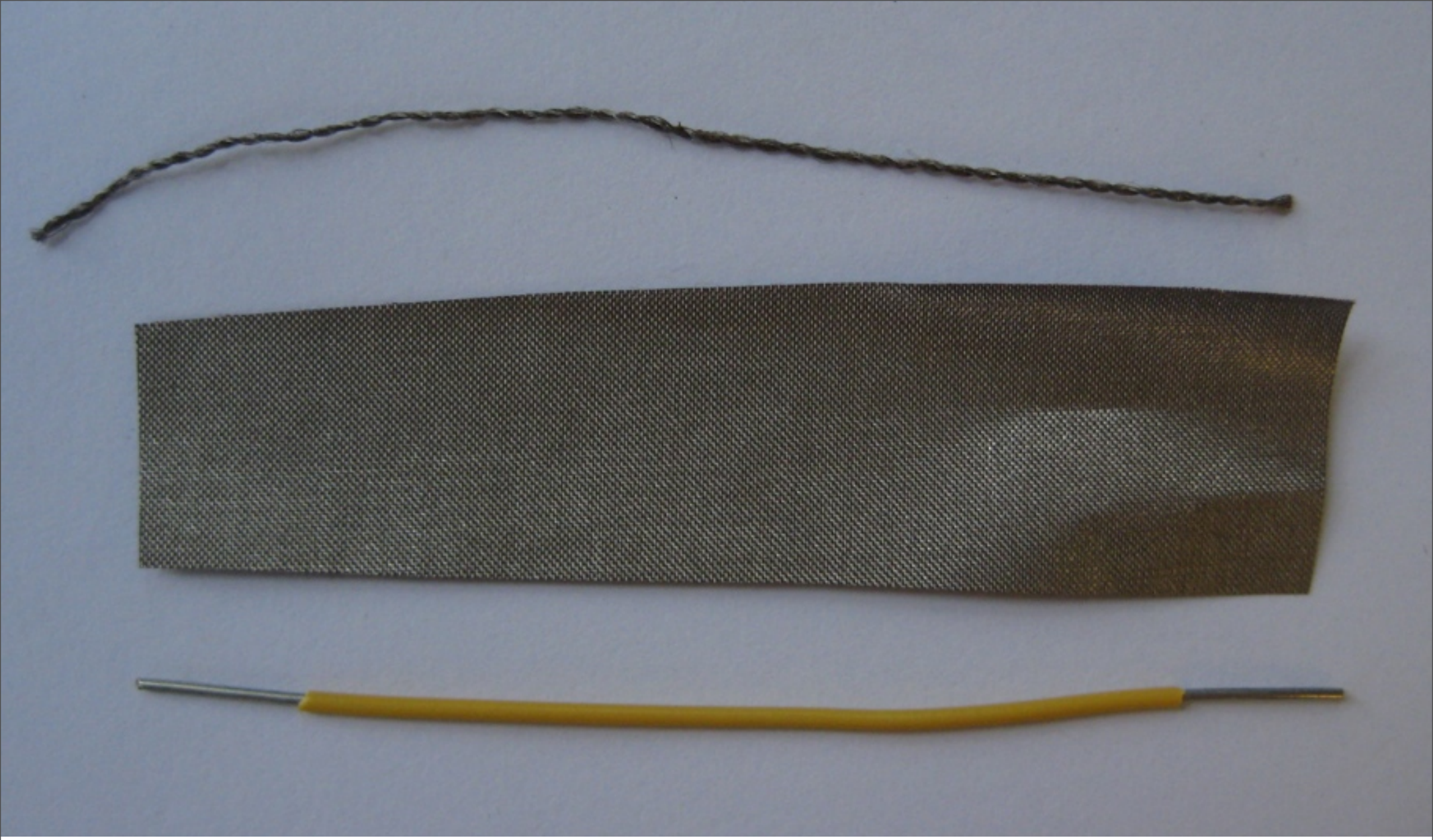

RadioShack
CAT II
200mA
500V
MAX
SELECT
OFF V Ω mA
015.4
AUTO-RANGE DIGITAL MULTIMETER
AUTO POWER OFF
INCHES
1
2
3
4
American Discovery
• George Washington • John
John Quincy Adams • Andrew
• John Tyler • James K.
Thom

Conductive Threads

Sparkfun 117/17 2ply

Sparkfun 234/34 4ply

Lamé Lifesaver

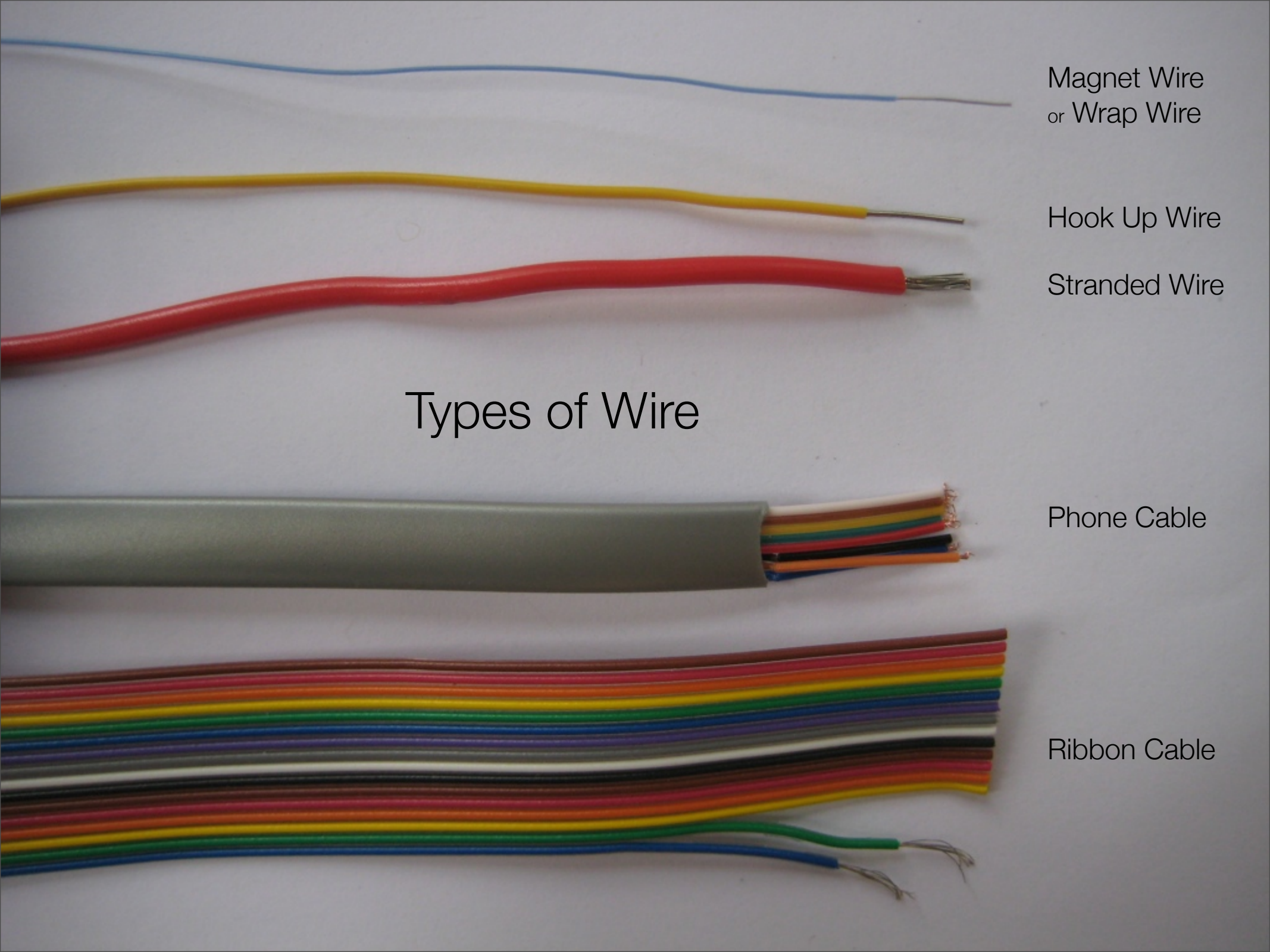


Choosing Materials

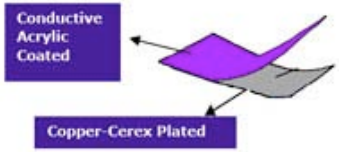
for your application

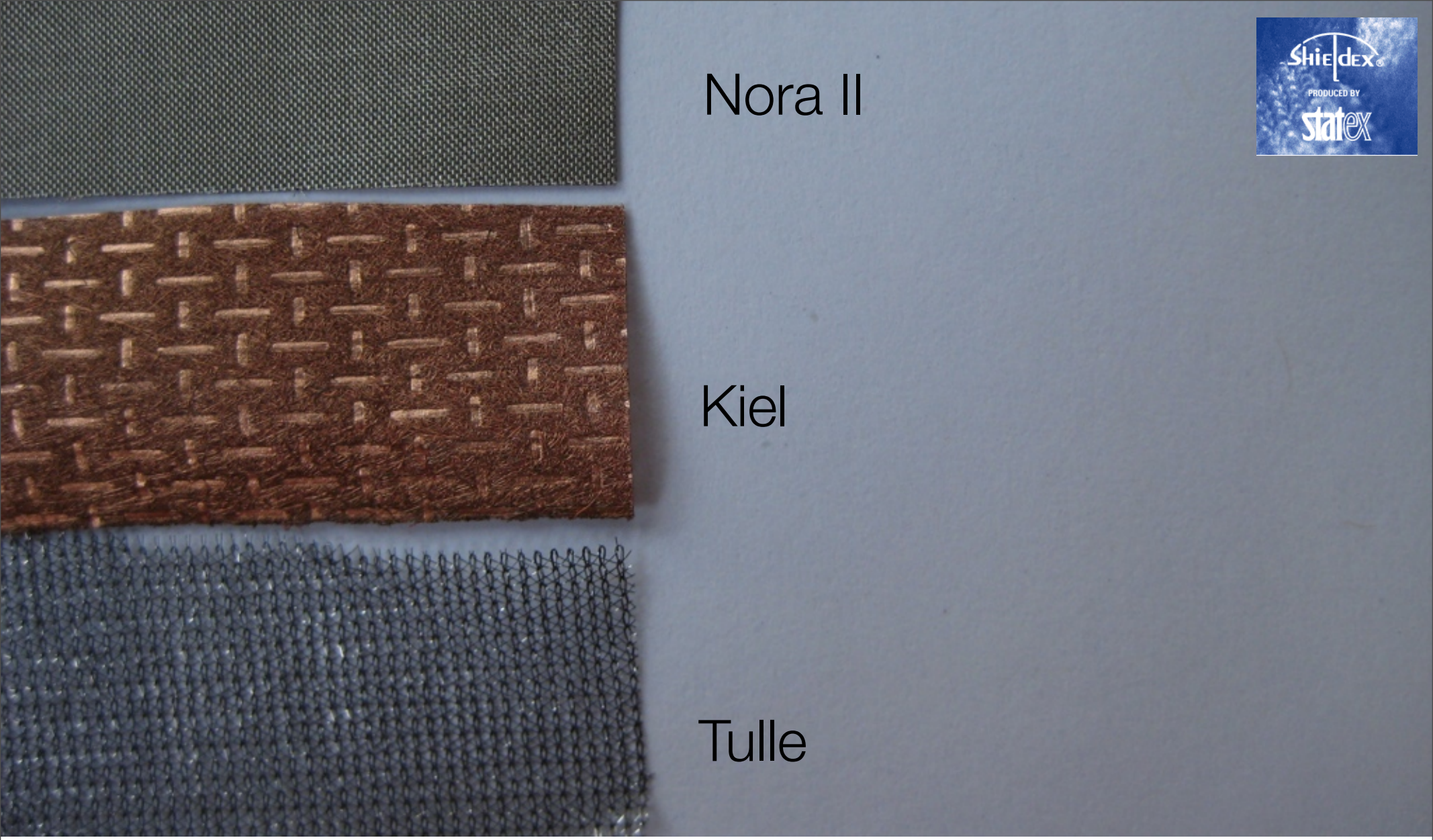
Factors to consider:

- Insulation
- Resistance
- Flexibility
- Durability
- Washability
- Cost


Magnet Wire
or Wrap Wire
Hook Up Wire
Stranded Wire
Types of Wire
Phone Cable
Ribbon Cable

Conductive Fabric

	Bremen	Silver plated nylon fabric	Conductive fabric for general use	$20.97/yd
	Kassel		Conductive fabric for general use	$32.07/yd
	Koln		Conductive gasket skin	$23.90/yd
	Nora Dell		Conductive fabric for general use	$35.62/yd
	Tulle	Polyamid monofilament	theatrical drapery medicinal material general use	$24.73/yd



Conductive Fabric

Shieldex Fabrics from Fine Silver Fabrics

Conductive Fabric

Shieldex Fabrics from Fine Silver Fabrics

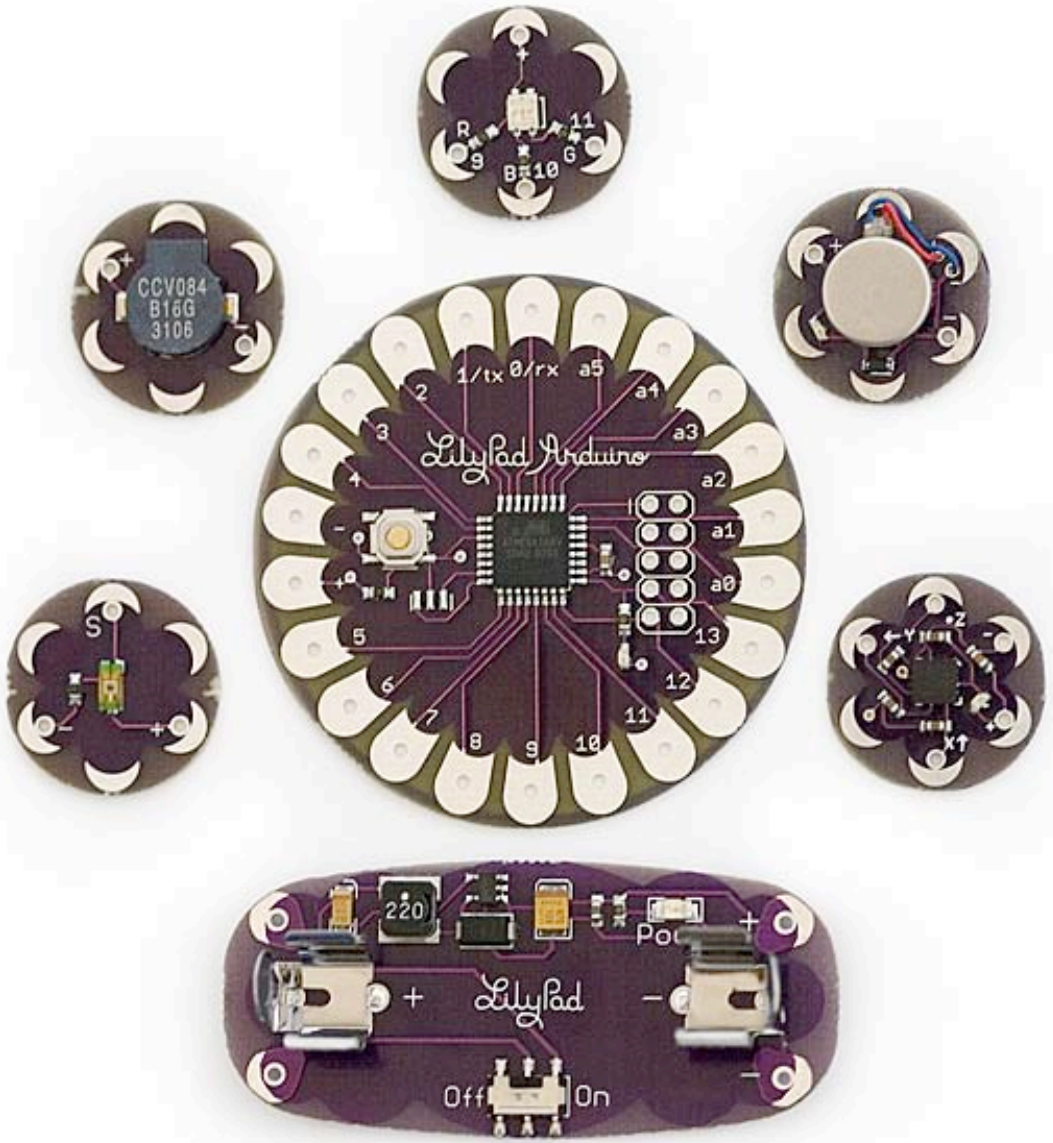
Organza

(available at your local fabric store)

conductive fibers run only in one direction

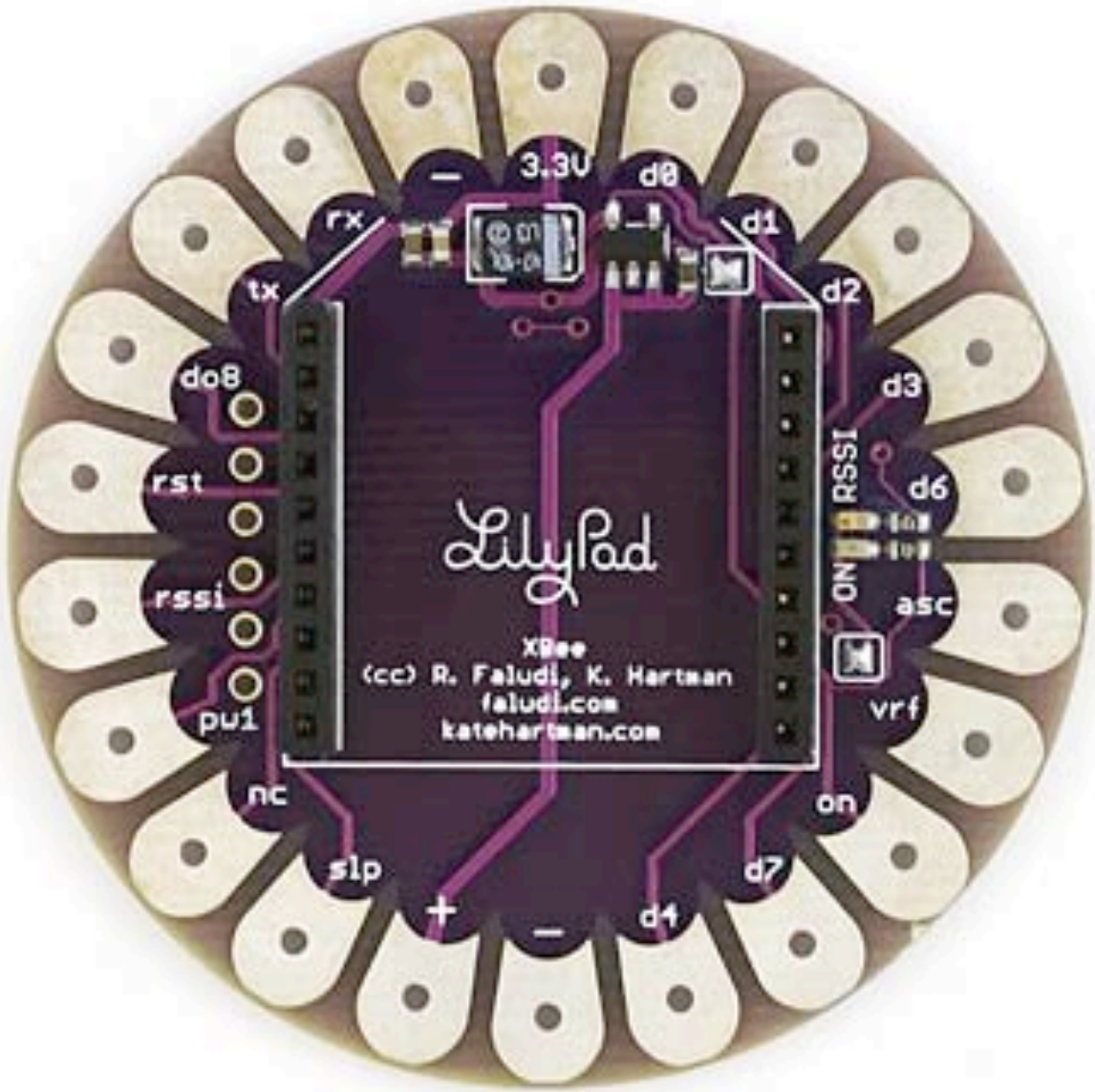

RadioS
OPEn
AUTO-RANGE DIGITAL MULTIMETER
AUTO POWER OFF


Radio
Shrt
AUTO-RANGE DIGITAL MULTIMETER
AUTO POWER OFF



Lilypad

Leah Buechley & Sparkfun Electronics



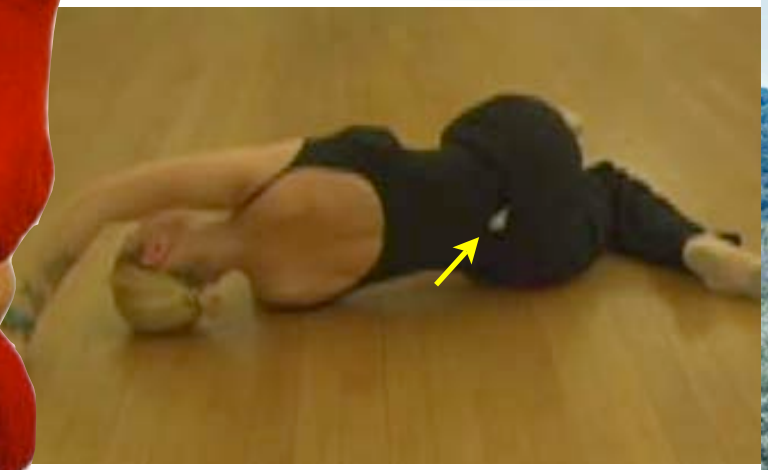
Lilypad XBee

Rob Faludi & Kate Hartman

Lilypad Embroidery

Becky Stern

Moving Data by Radio

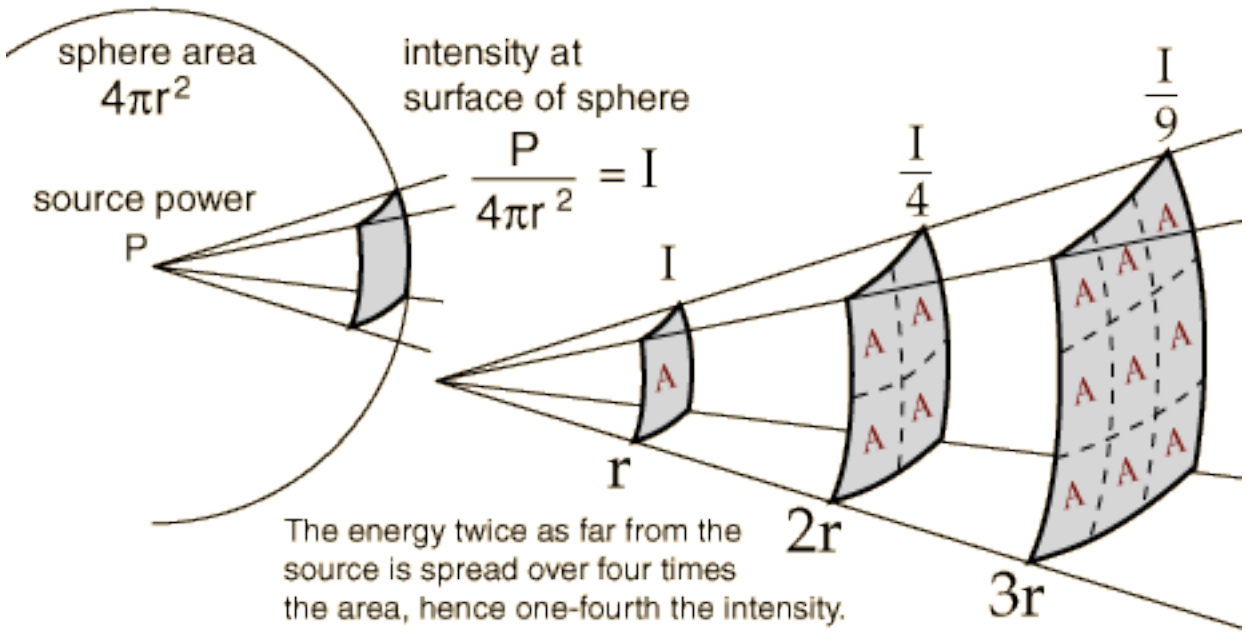


Radio Communications

- electromagnetic waves
- no medium required
- modulation
- well-described mystery: “air waves” “wireless” “ethereal communication”
- cool posters: http://faludi.com/2007/09/15/spectrum-posters/

Inverse Square Law

- power needs increase exponentially with distance



What Do We Want?

- wireless
- easy communication
- reliability
- low power
- addressing
- small
- standardized
- cheap
- bandwidth
- speed
- routing
- broadcasting
- transparency
- easy to learn

Some Methods for Device Communication

- Transmit/receive pairs
- Proprietary transceivers
- Ethernet
- WiFi
- Cell phone data
- Bluetooth
- Cell modules

802.15.4

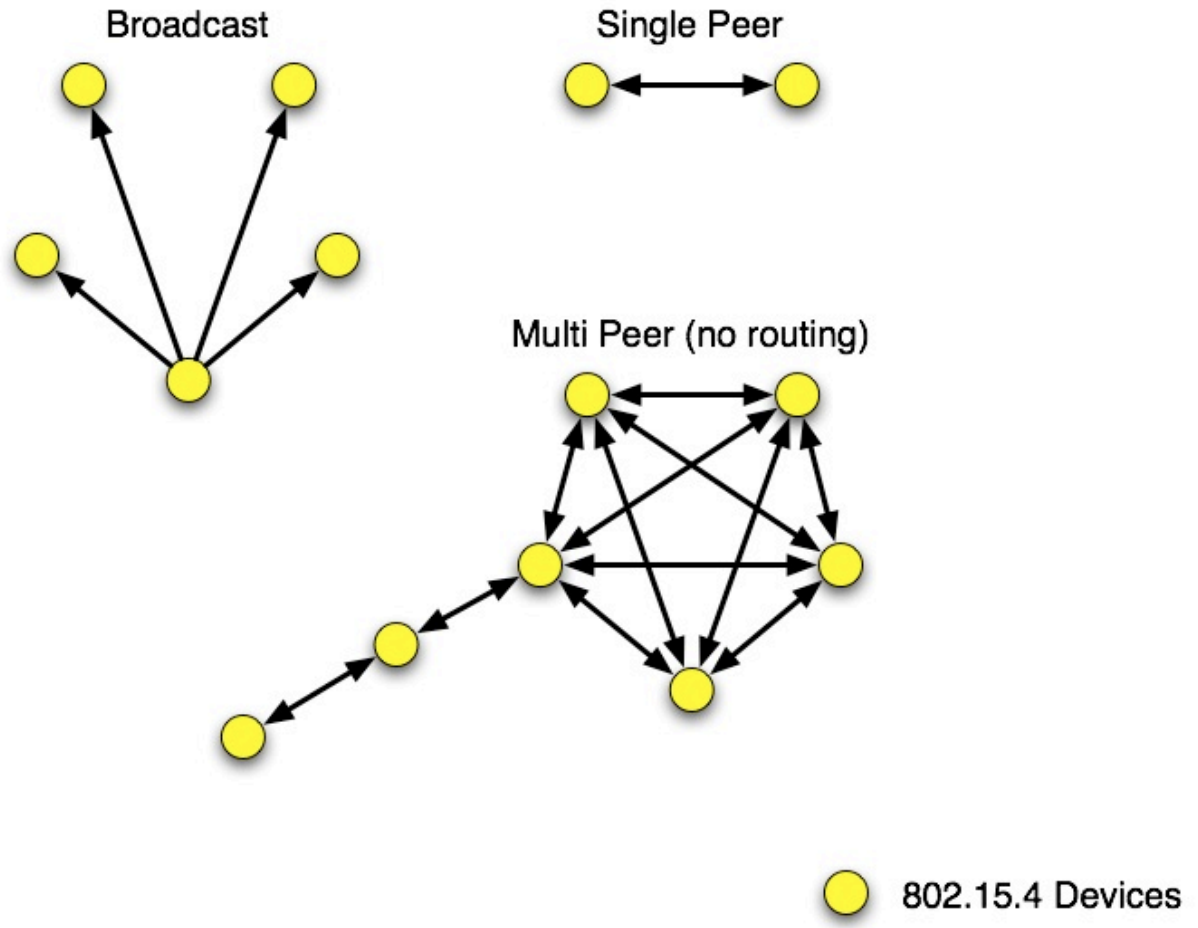
- low power
- addressing
- cheap
- wireless
- small
- standardized

ZigBee & 802.15.4

- ZigBee is built on top of the IEEE 802.15.4 protocol
- XBee radios are available with or without ZigBee
- XBee 802.15.4 vs. ZNet 2.5 vs. ZB Pro vs. DigiMesh
- All ways are useful

802.15.4 Topologies

- single peer
- multi-peer
- broadcast



ZigBee

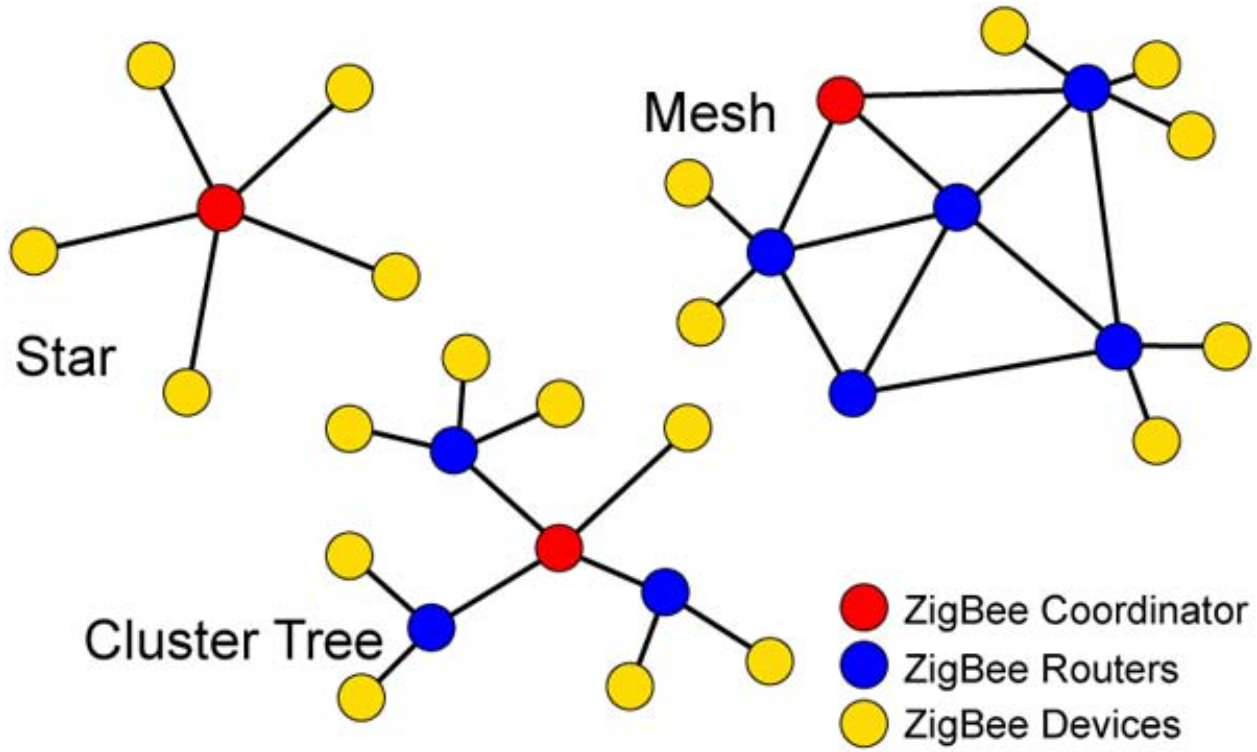
- routing
- self-healing mesh
- ad-hoc network creation

ZigBee™ Alliance

- ZNet 2.5 older
- ZB Pro better density, frequency agility

ZigBee Topologies

- peer
- star
- mesh
- routing



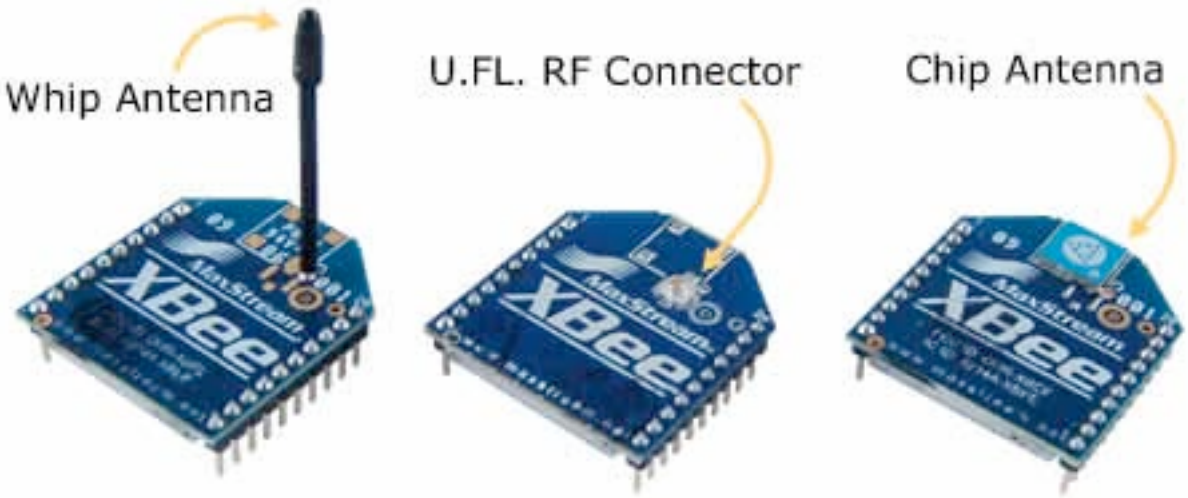
How Do I Make One?

LilyPad XBee

Materials

- XBee 802.15.4 OEM Module, Chip Antenna (30-100 m range) $23
  XBee Pro 802.15.4, Chip Antenna (100m - 1.6 km range) $36
    - Digikey: http://www.digikey.com
- LilyPad XBee, http://faludi.com/lilypad
- Alligator clips
- 9 Volt battery or 3.3 - 3.7 Volt battery
- FTDI cable for programming with angle headers

Antennas



Chip Antenna on Pro

FTDI Cable

Remember!

- Never send more than about +4 Volts to the 3.3 pin. Use the + pin instead
- Conductive thread may be too resistive for power and ground, try fabric or wire
- XBee TX goes to Arduino RX and vice versa

Instructions

- XBee Practical Example: Paired communication between two microcontrollers. Includes building, wiring and code for PIC and Arduino
- Making Things Talk by Tom Igoe
- I/O Example on faludi.com, or in the XBee manual section 2.2
- faludi.com/lilypad

Serial Terminal Programs

- Processing: http://rob.faludi.com/teaching/cmn/code/XBee_Terminal.pde
- Z-Term: http://homepage.mac.com/dalverson/zterm/
- HyperTerm: Windows Start Menu, Accessories, Communication
- screen: Terminal program on the Mac (or Linux)
- X-CTU: http://www.digi.com/support/productdetl.jsp?pid=3352&osvid=57&tp=4&s=316
- plenty of others

Baud, Bits and Parity

- Default baud rate: 9600
- Bits: 8
- Stop bits: 1
- Parity: None
- Flow control: none for now...

Data Mode vs. Command Mode

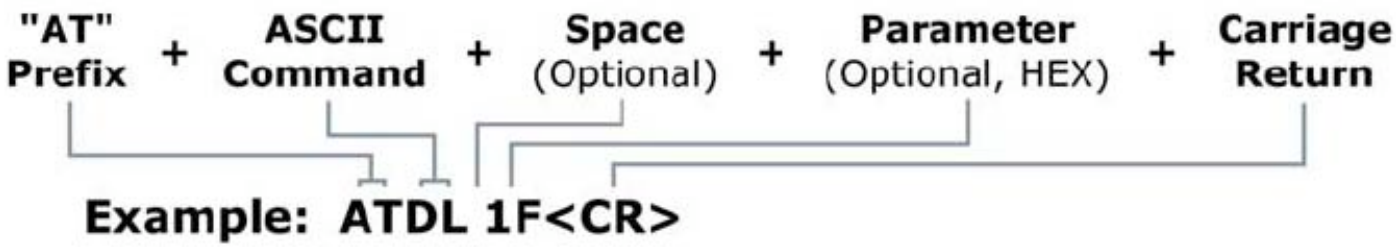
- Idle Mode, transmit and receive data
- Command Mode, talk to the XBee itself
  - +++ "*Yo, XBee*"
  - AT "*Attention!*" (Hayes command set)

Some AT Commands

- AT -> OK
- ATMY -> my address
- ATDH, ATDL -> destination address hi/lo
- ATID -> personal area network ID
- ATCN -> end command mode

AT Command Format

Figure 2-08. Syntax for sending AT Commands



Method 1 (One line per command)

Send AT Command	System Response
+++	OK <CR> (Enter into Command Mode)
ATDL <Enter>	{current value} <CR> (Read Destination Address Low)
ATDL1A0D <Enter>	OK <CR> (Modify Destination Address Low)
ATWR <Enter>	OK <CR> (Write to non-volatile memory)
ATCN <Enter>	OK <CR> (Exit Command Mode)

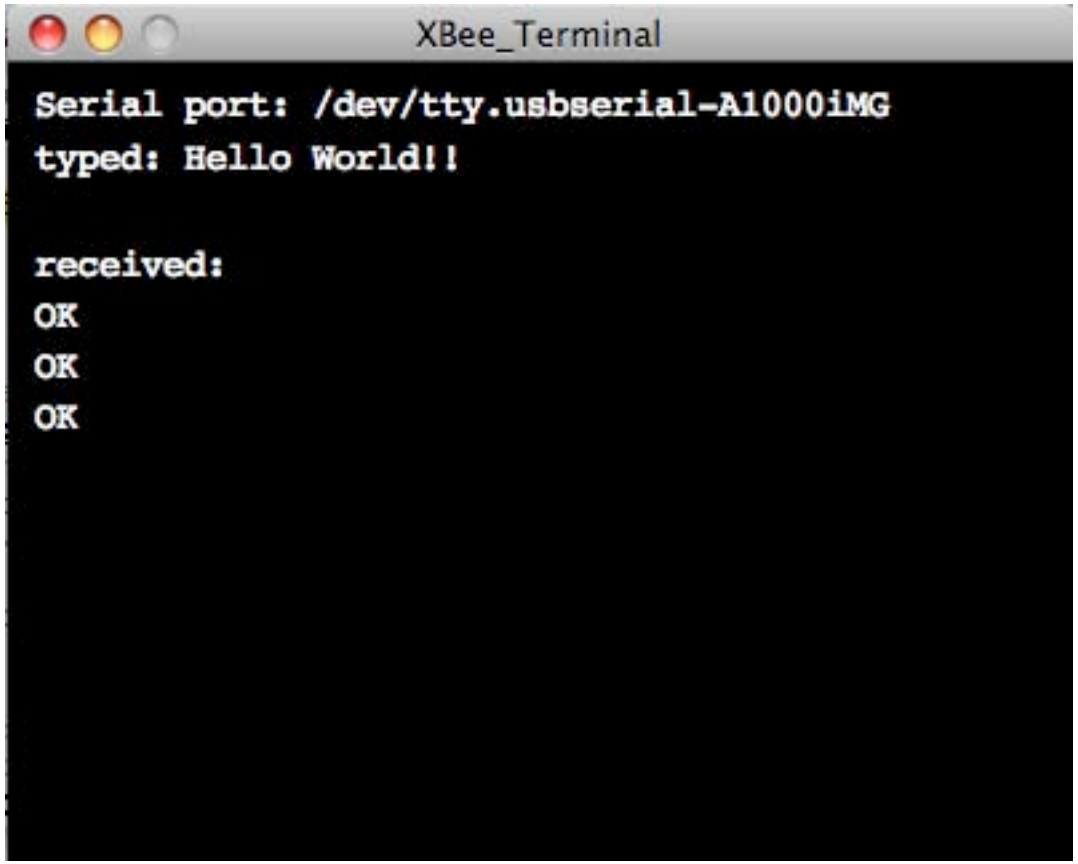
Method 2 (Multiple commands on one line)

Send AT Command	System Response
+++	OK <CR> (Enter into Command Mode)
ATDL <Enter>	{current value} <CR> (Read Destination Address Low)
ATDL1A0D,WR,CN <Enter>	OK, OK, OK <CR> (Command execution is triggered upon each instance of the comma)

Hexadecimals

- Just like decimals, but count from 0 to 15 in each position
- Since there's no existing single numeral representing 10 - 15, use A - F instead
- A = 10, B=11, C=12 ... F=15
- A1 = 161, common notation: 0xA1
- What does BFF equal? What does it look like?
- Calculators on Mac & Windows

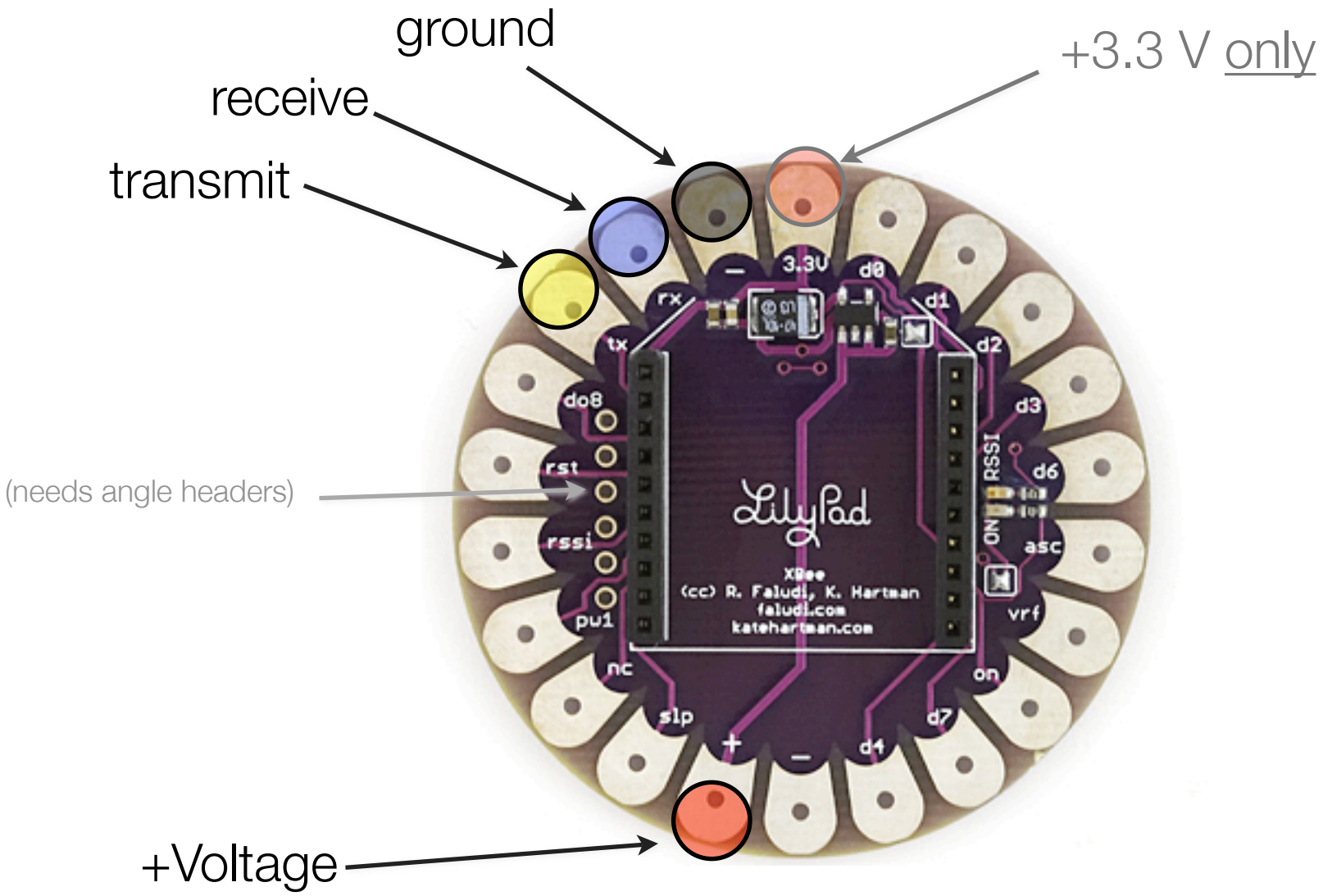
Exercise: Setup



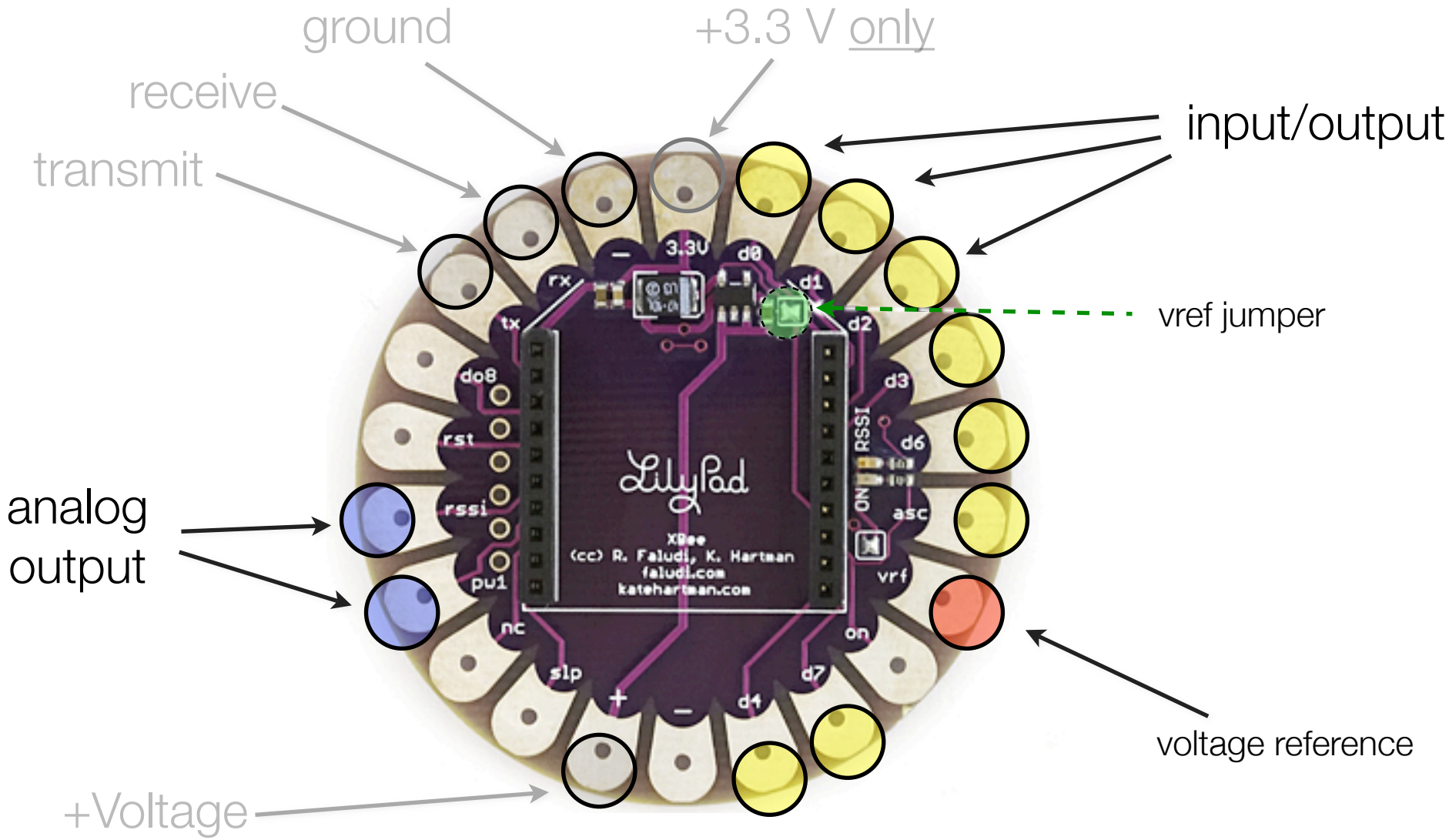
I/O Why

- Why:
  - Save space, save power, save weight and save money
  - Reduce complications
- Why not:
  - Limited inputs/outputs
  - No access to logic
  - Each radio must be manually configured

Wiring


ground
receive
transmit
+3.3 V only
(needs angle headers)
+Voltage
3.3V
d0
d1
d2
d3
d6
asc
vrf
on
d7
d4
slp
nc
pu1
rssi
rst
do8
tx
rx
RSSI
ON
LilyPad
XBee
(cc) R. Faludi, K. Hartman
faludi.com
katehartman.com

Input/Output Wiring



I/O AT Commands

- ATD0...D8 -> configure pins for I/O
- ATIR -> sample rate
- ATIT -> samples before transmit
- ATP0...P1 -> PWM configuration
- ATIU -> I/O output enable (UART)
- ATIA -> I/O input address

Example Configuration

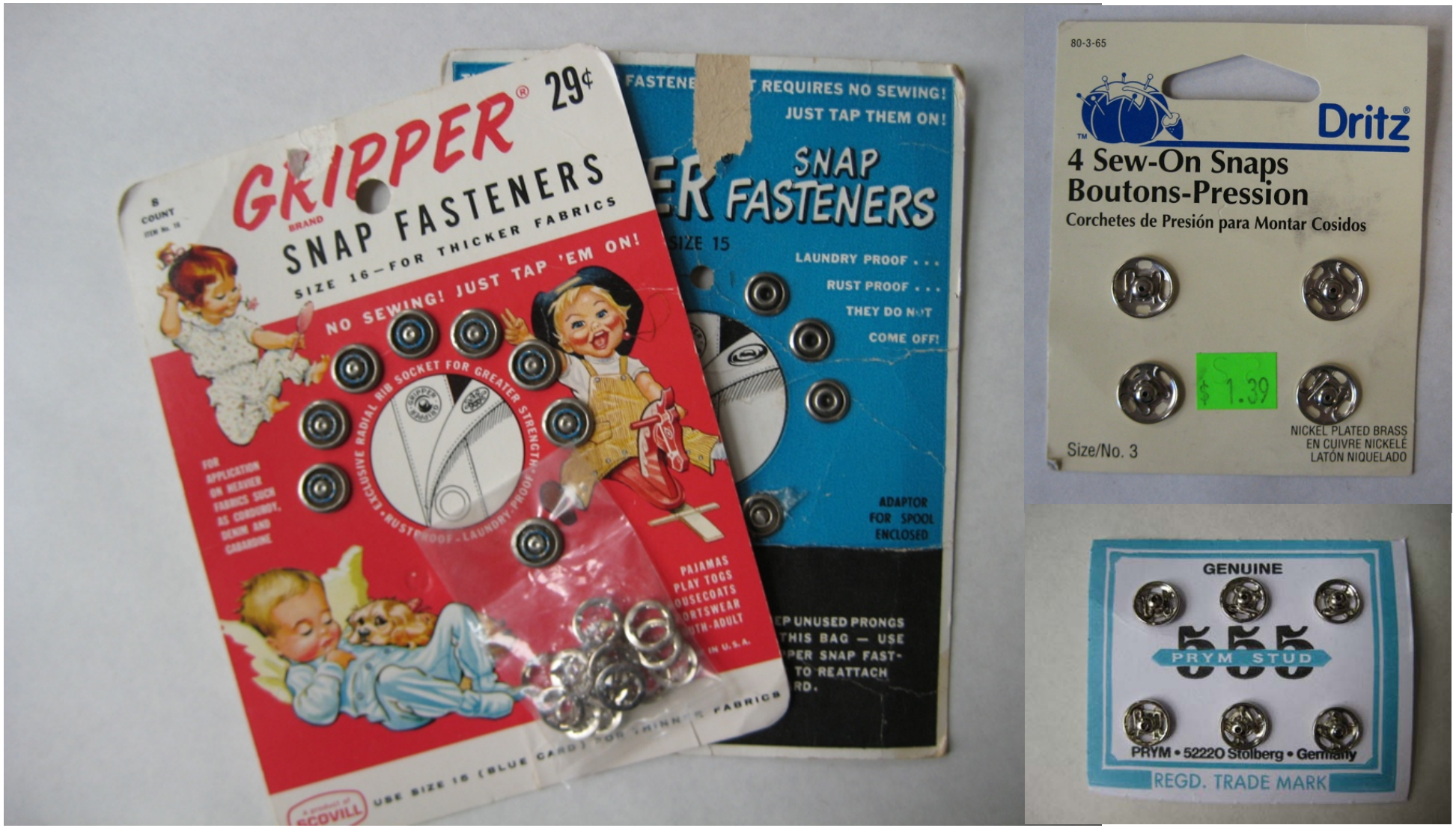
- ATID3456 (PAN ID)
  ATMY1 my address 1
  ATDL2 destination address 2
  ATD02 output 0 in analog mode
  ATD13 output 1 in digital out mode
  ATIR14 sample rate 20 milliseconds (hex 14)
  ATIT5 samples before transmit 5

- ATID3456 (PAN ID)
  ATMY2 my address 2
  ATDL1 destination address 1
  ATP02 PWM 0 in PWM mode
  ATD15 output 1 in digital out high mode
  ATIU1 I/O output enabled
  ATIA1 I/O input from address 1

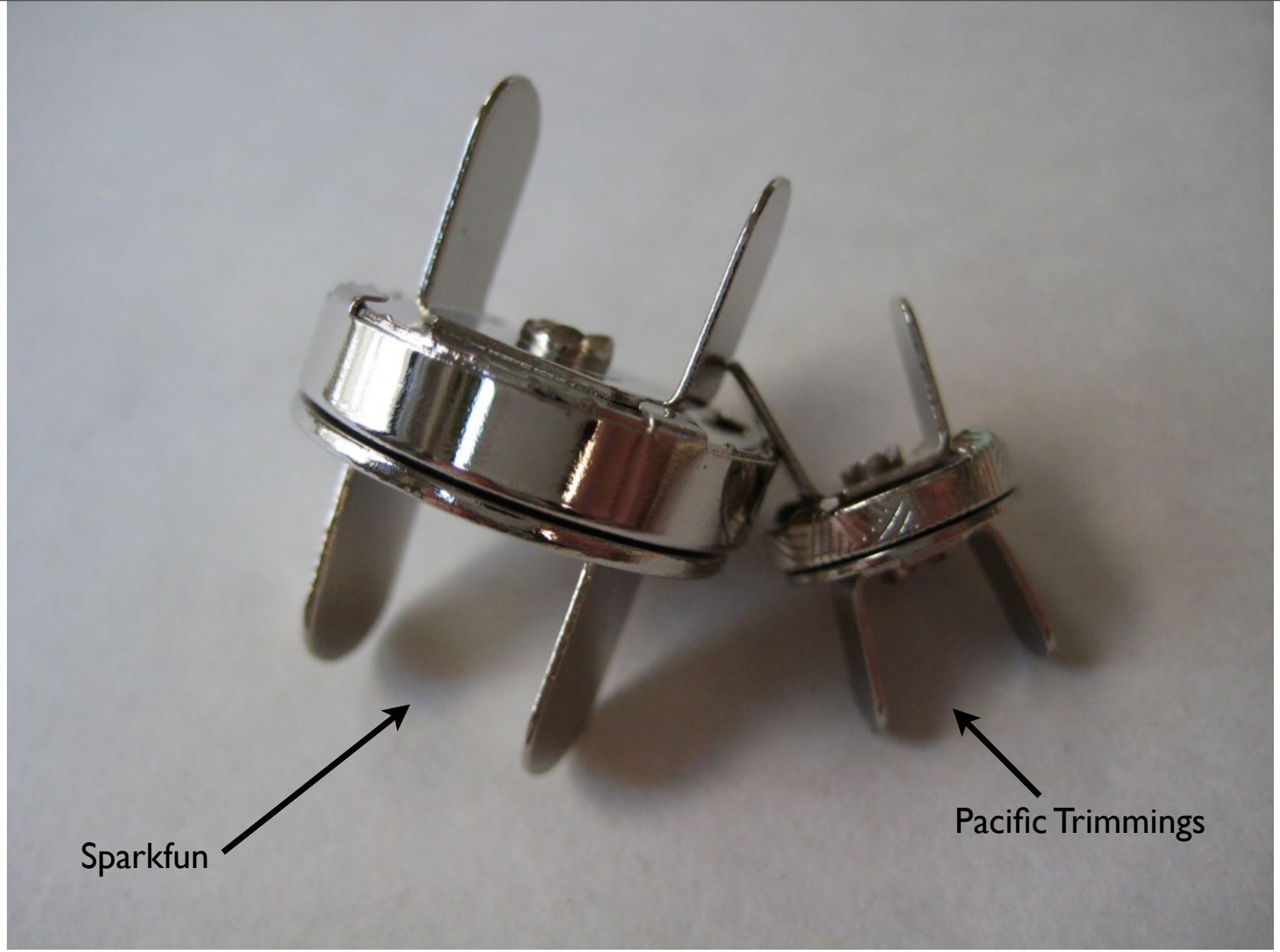
Exercise:
Circuit Test with Alligator Clips

Techniques

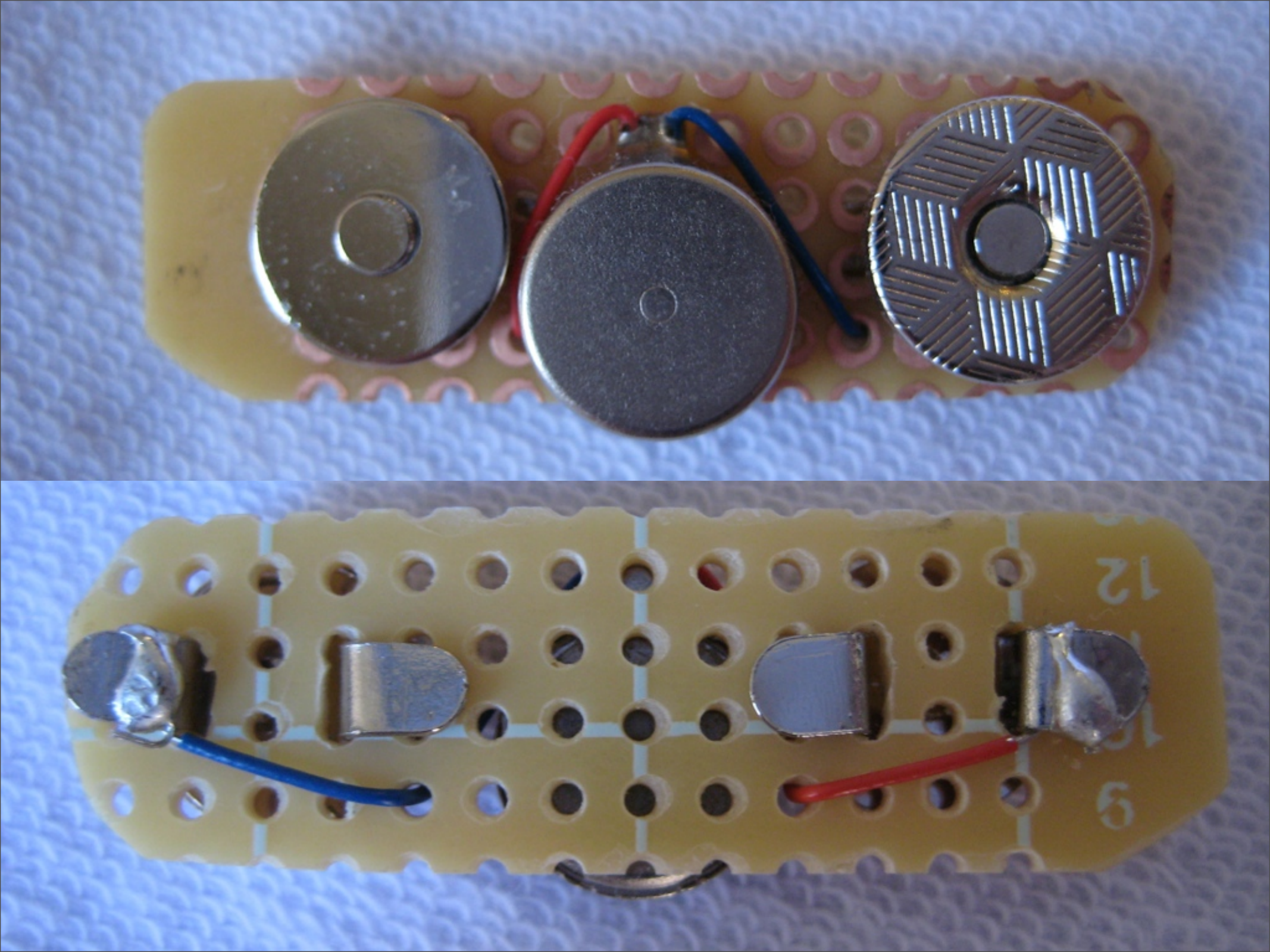
Sewing Notions as Connectors and Switches



Snaps



Magnetic Snaps

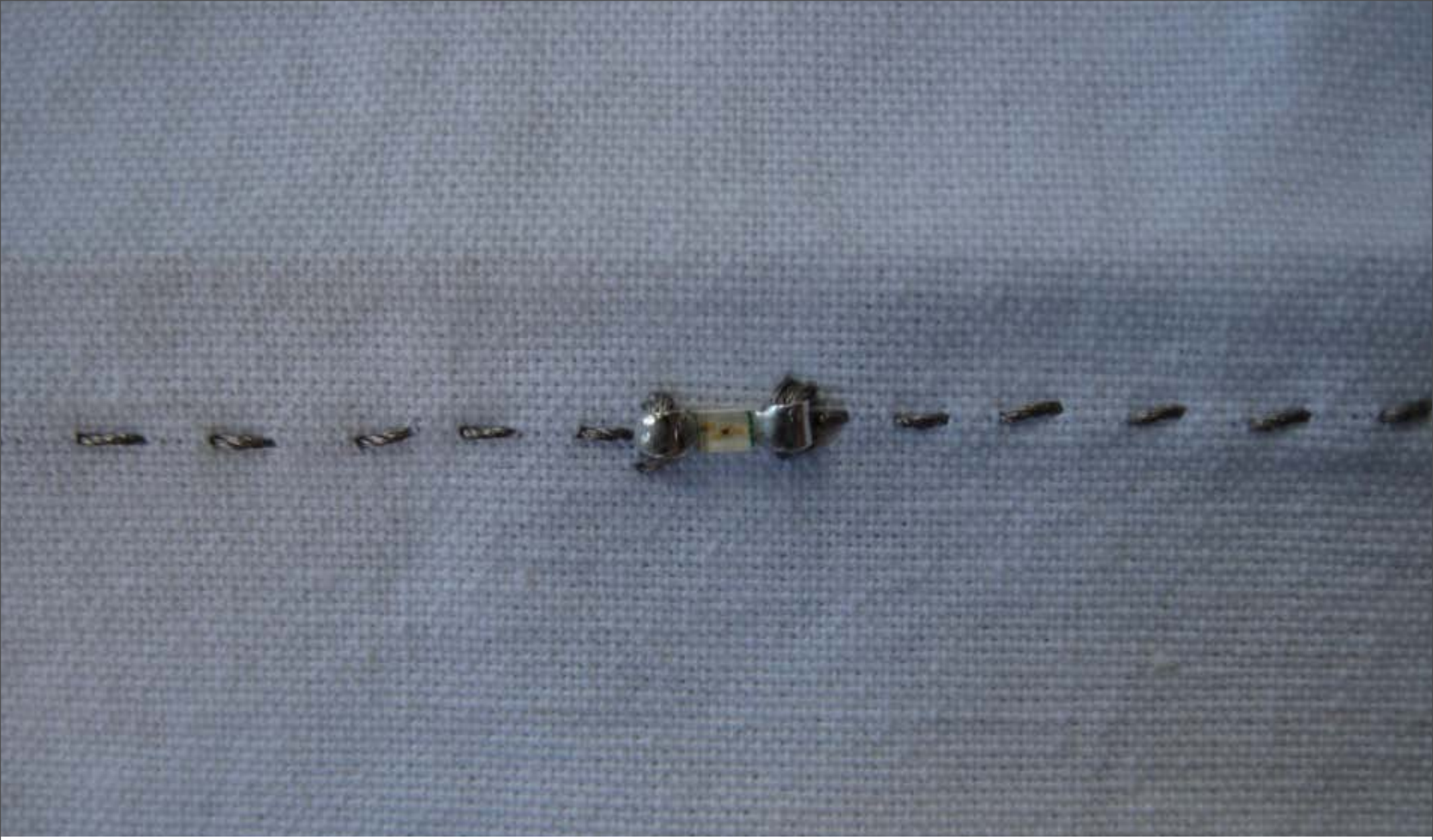


Sewable LEDs

Through-Hole LED

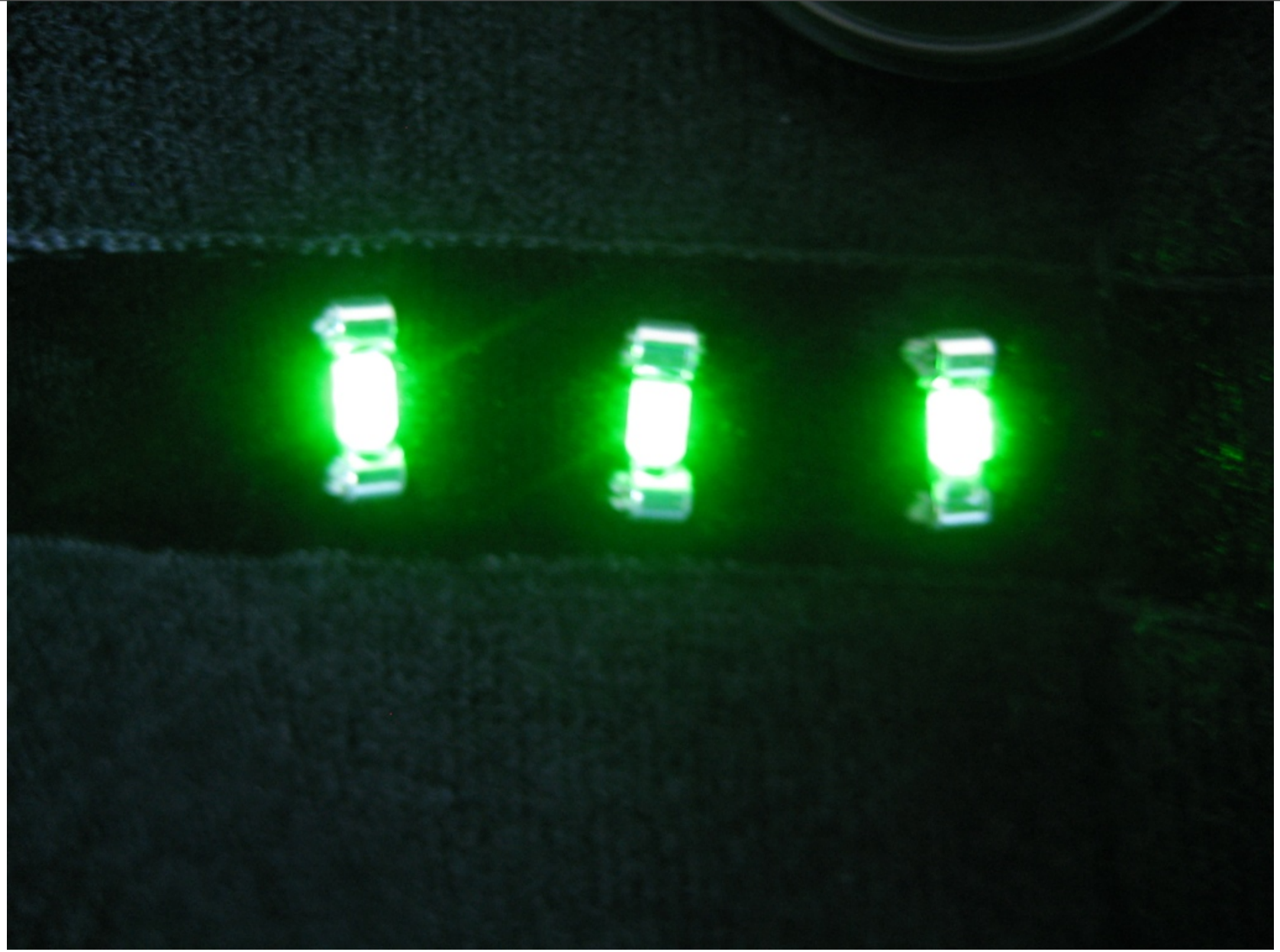
with looped legs


crimping beads
Metalliferous
surface-mount LEDs
Digikey part #160-1402-1-ND



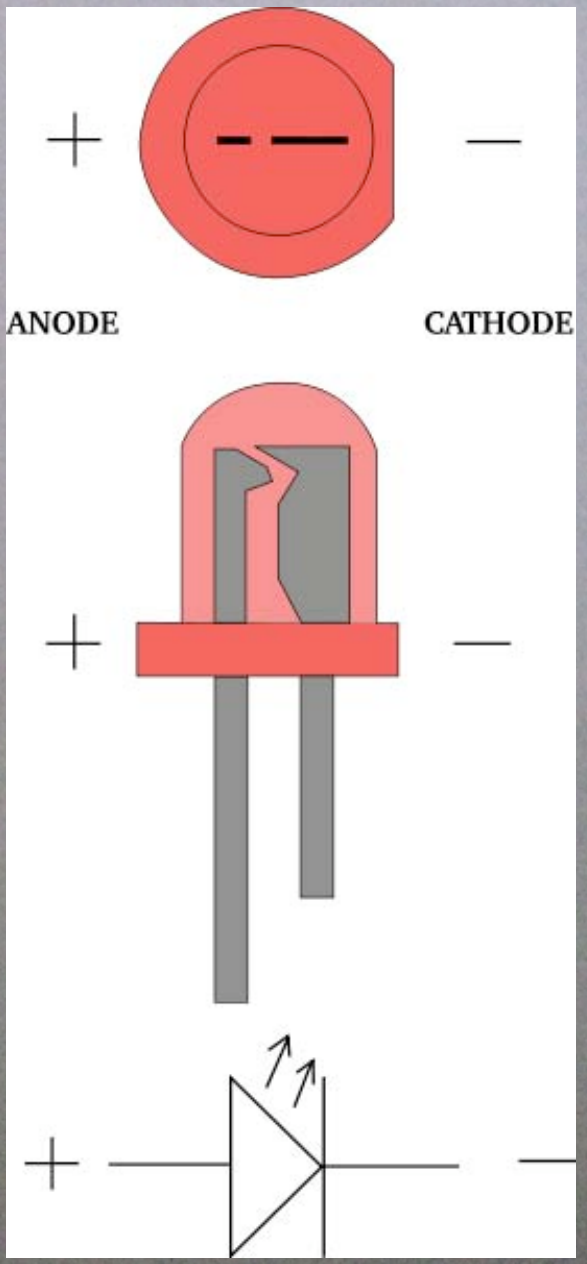
Surface Mount LED

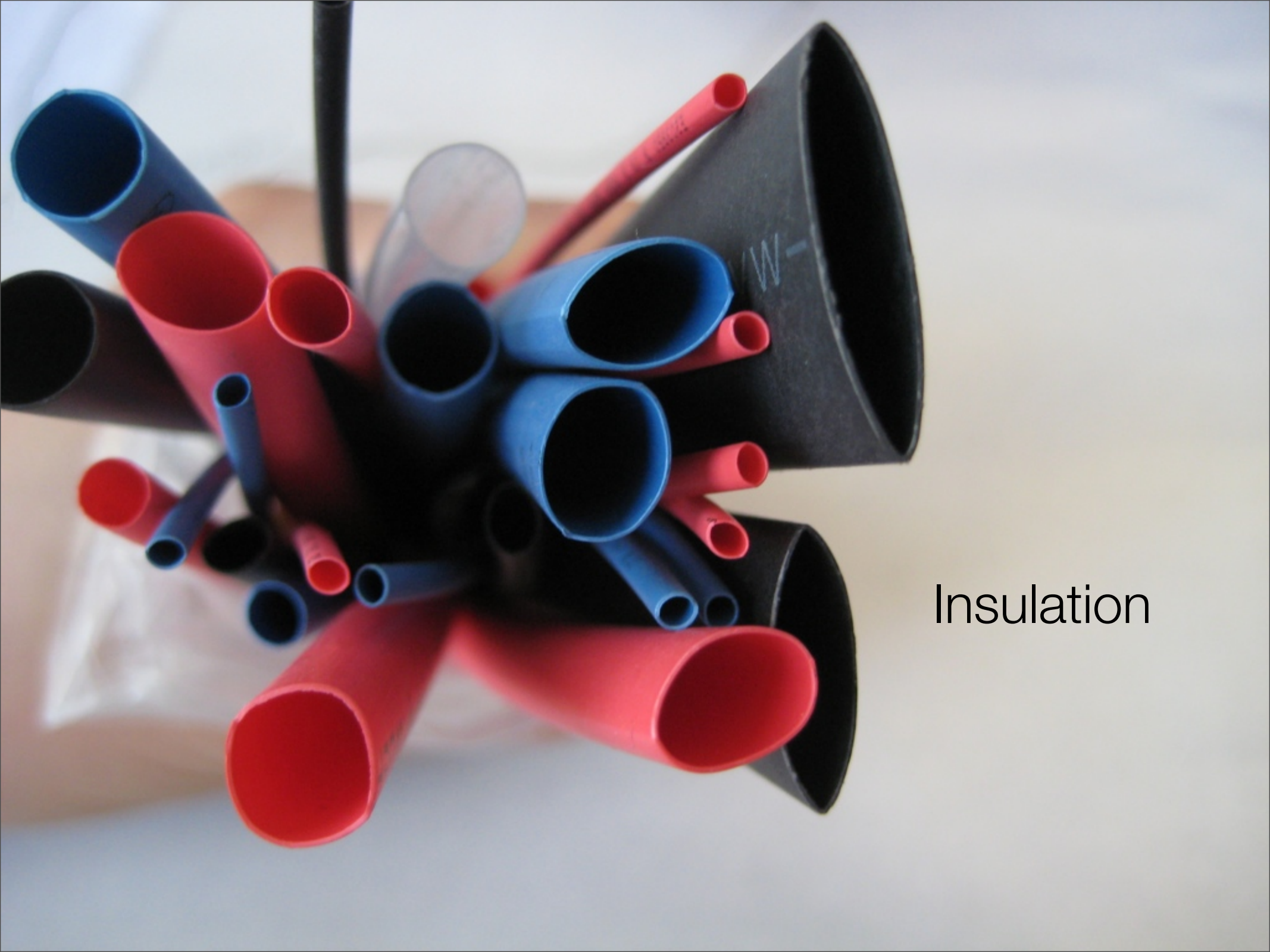
with Crimp Beads



Sewable LEDs

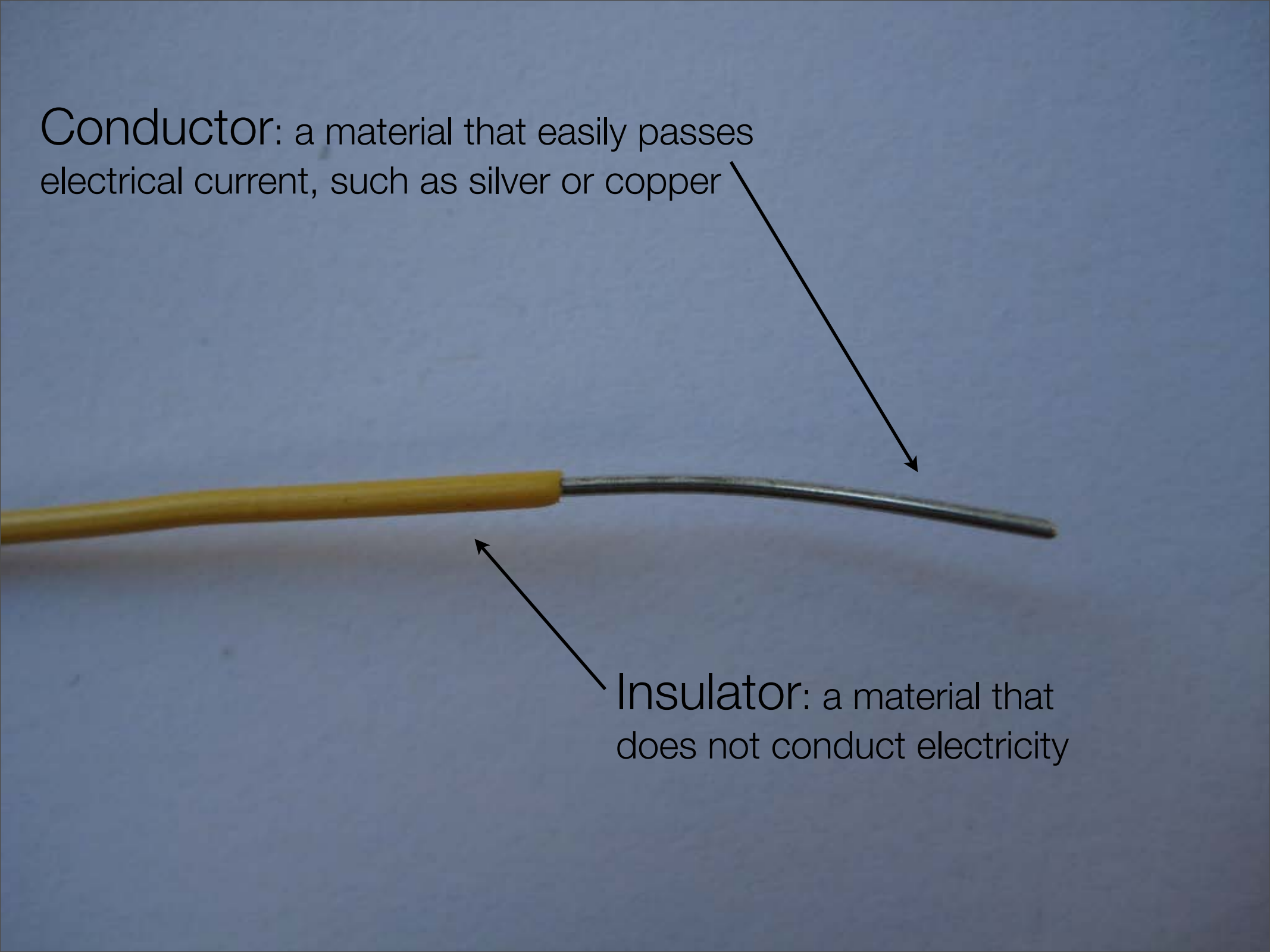

+
−


+
−
ANODE
CATHODE
+
−
+
−



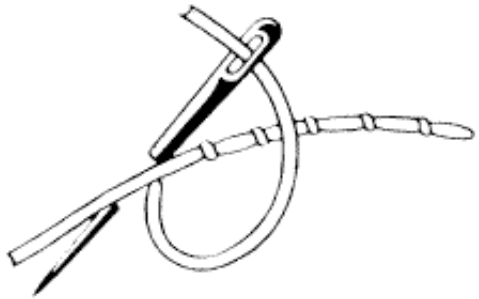
Insulation

Why do soft circuits need a different approach?

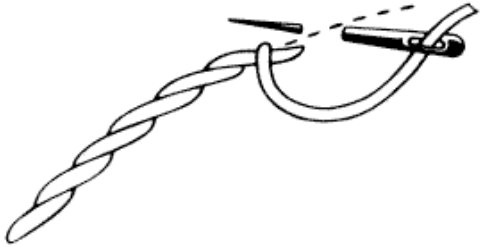

Conductor: a material that easily passes electrical current, such as silver or copper
Insulator: a material that does not conduct electricity

How do you insulate soft conductive material?

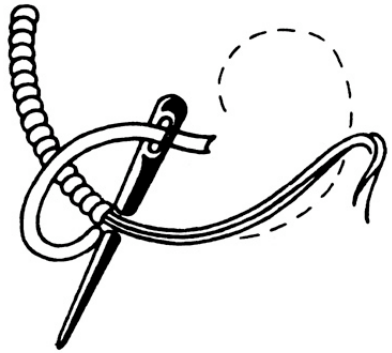
Stitching



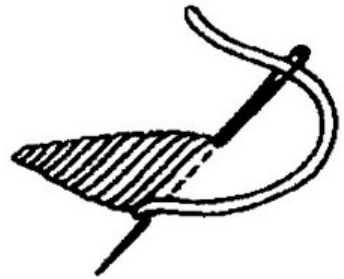
Couch Stitch



Stem Stitch

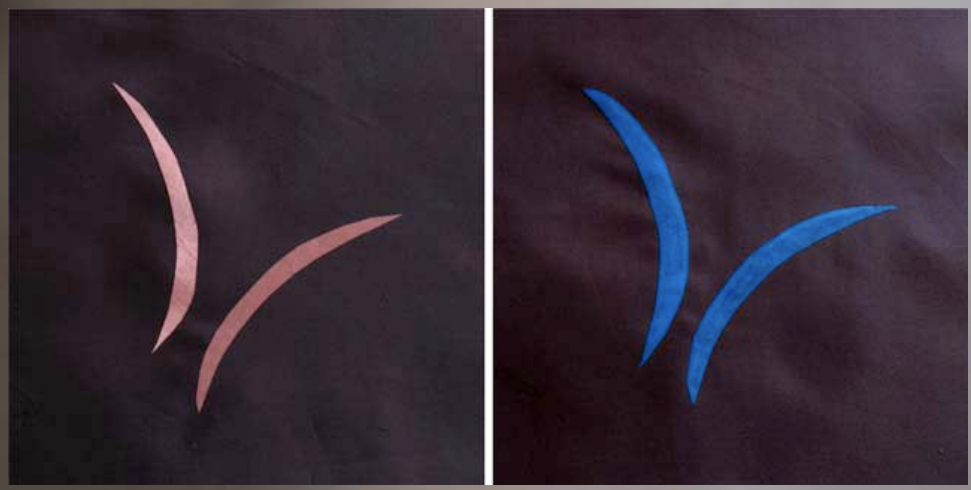


Overcast or
Trailing Stitch

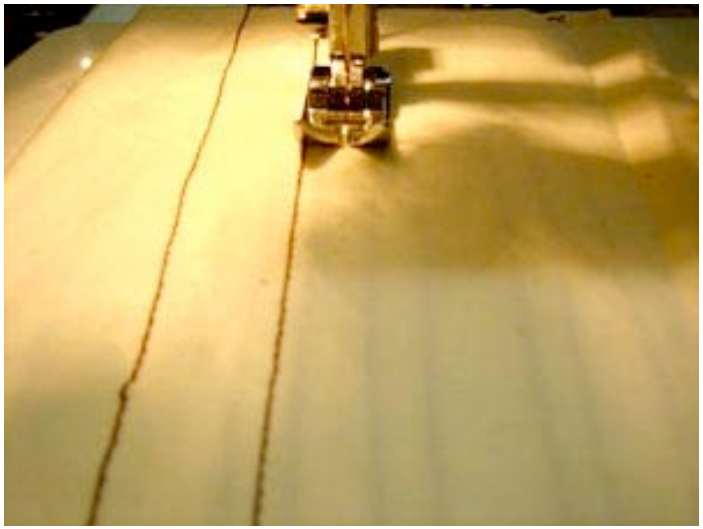


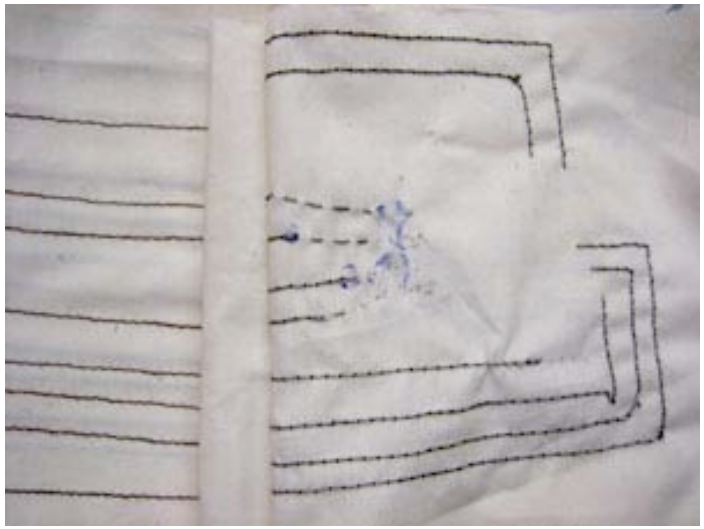
Satin Stitch

Iron-on patches

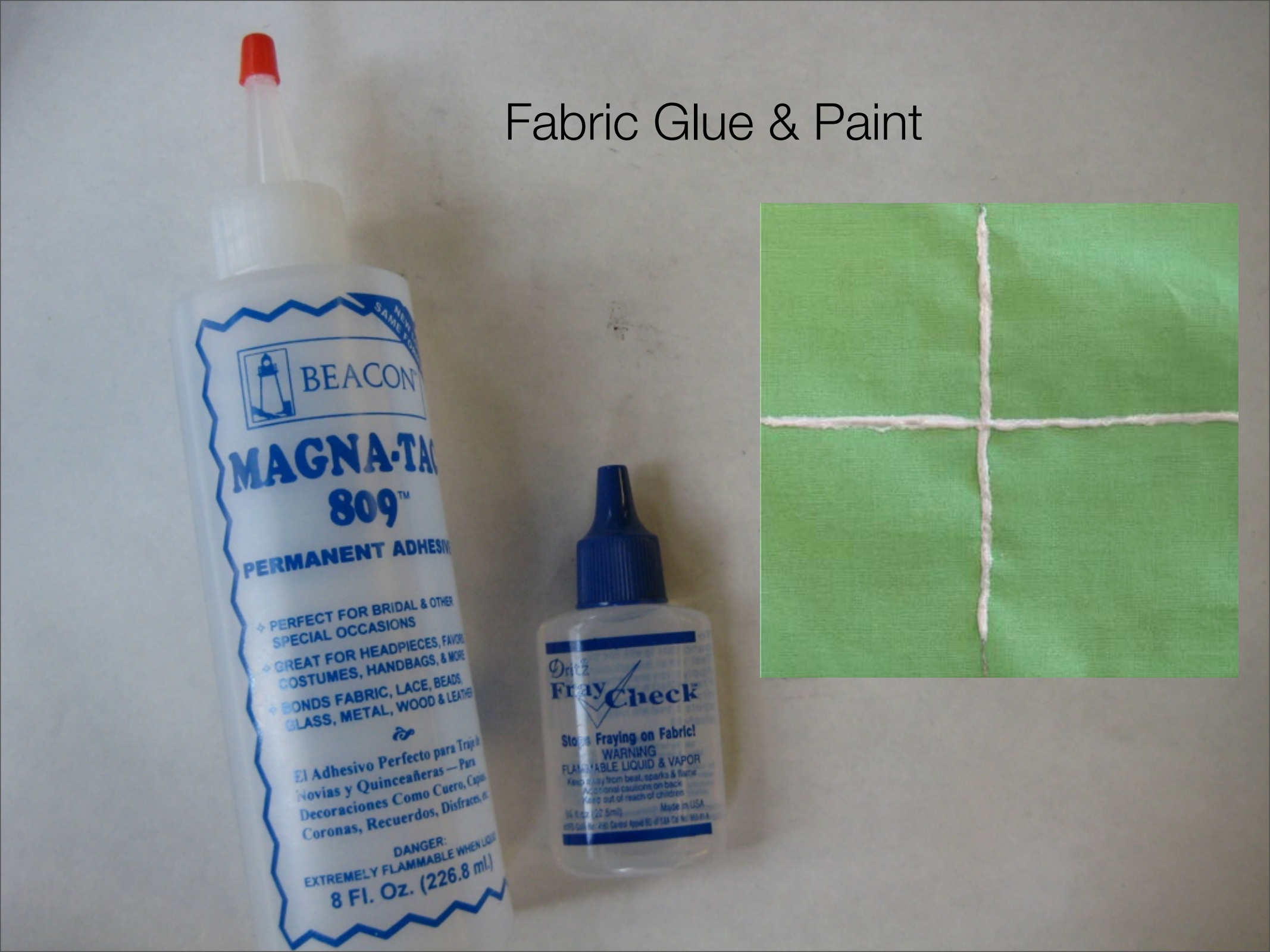


Insulating Layers of Fabric



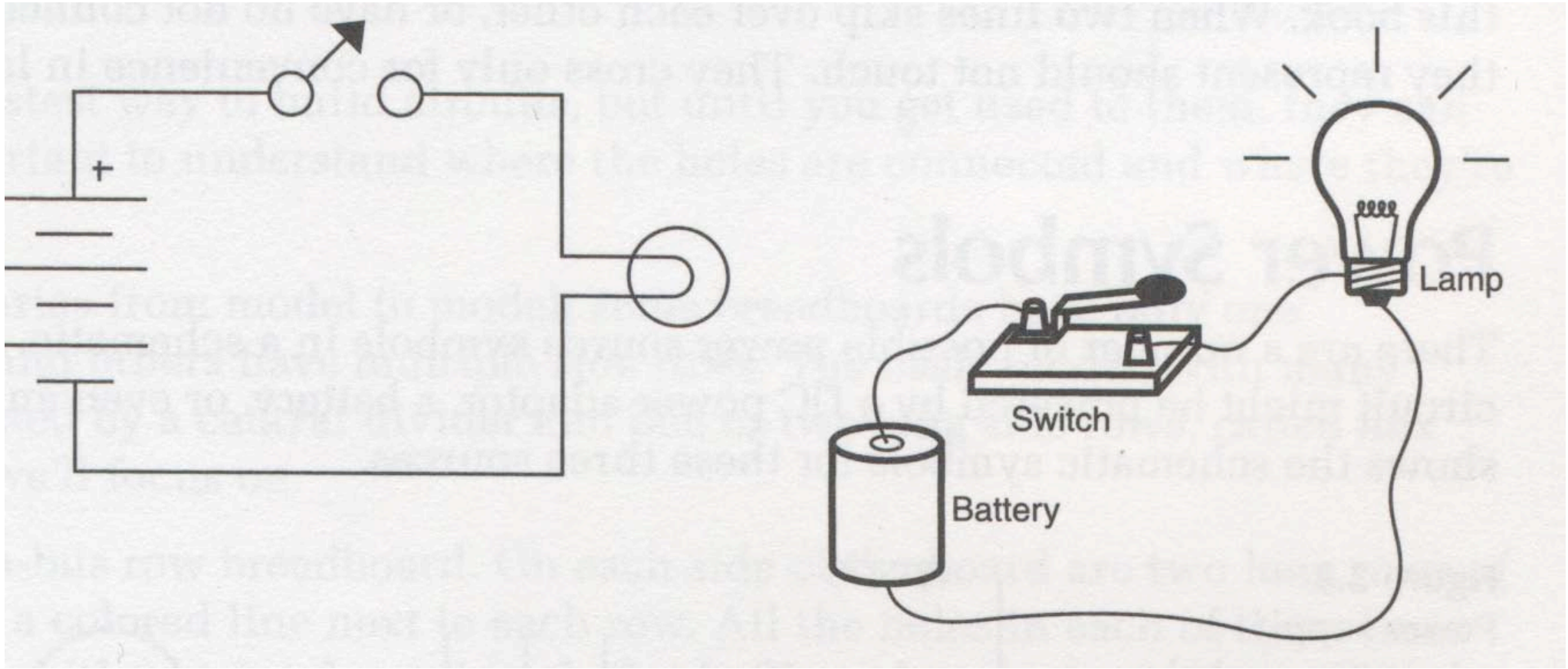


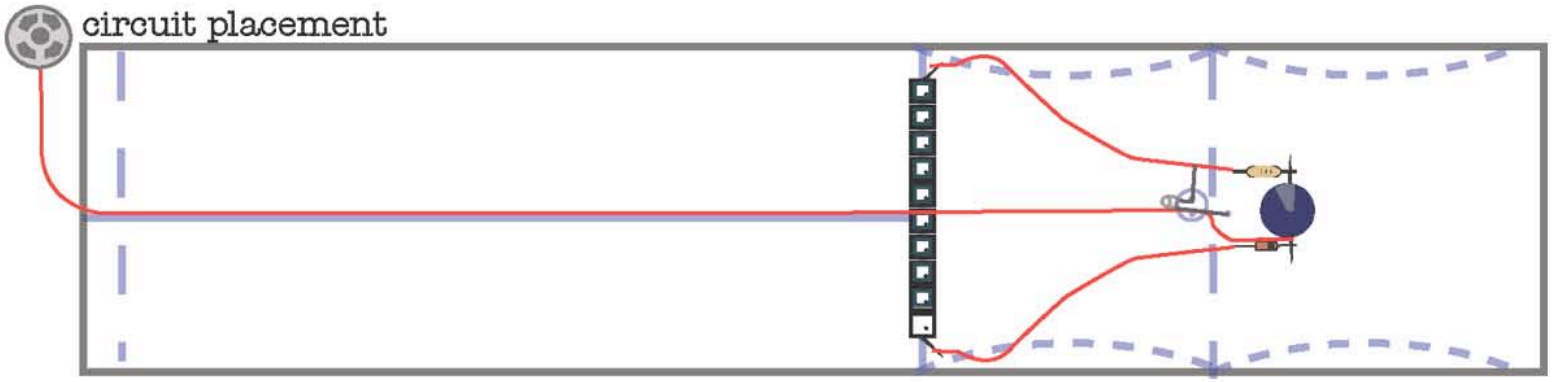
Fabric Glue & Paint



Why is it important to plan the layout of a soft circuit?

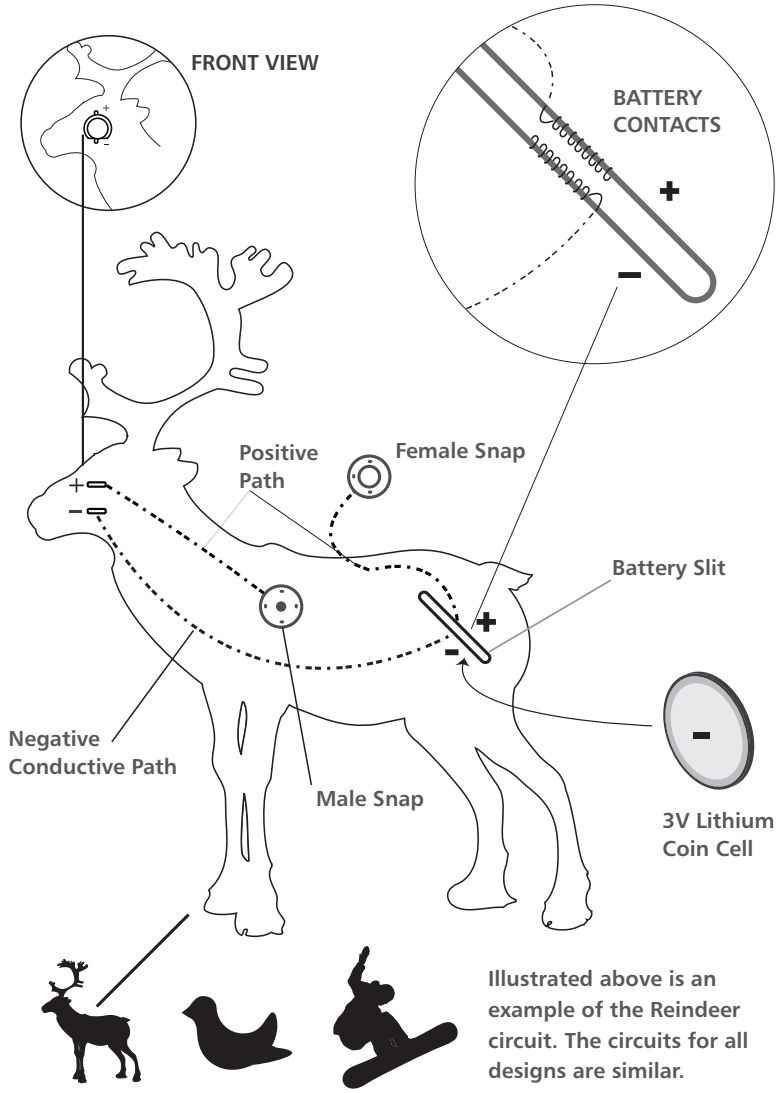
- get a sense of materials needed
- anticipate feasibility (power needs, etc.)
- plan for insulation (possibly layers)
- tool for troubleshooting


+
Lamp
Switch
Battery



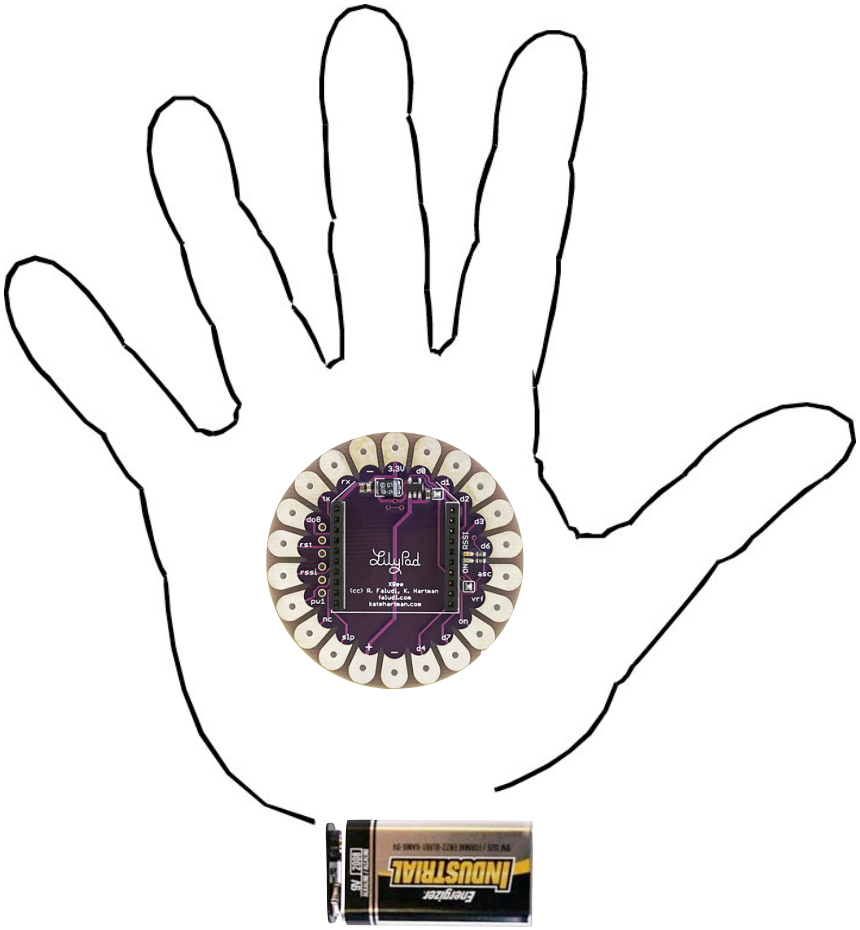
from “Solar Jewelry” by Hatti Lim & Alice Planas (CRAFT Issue 06)

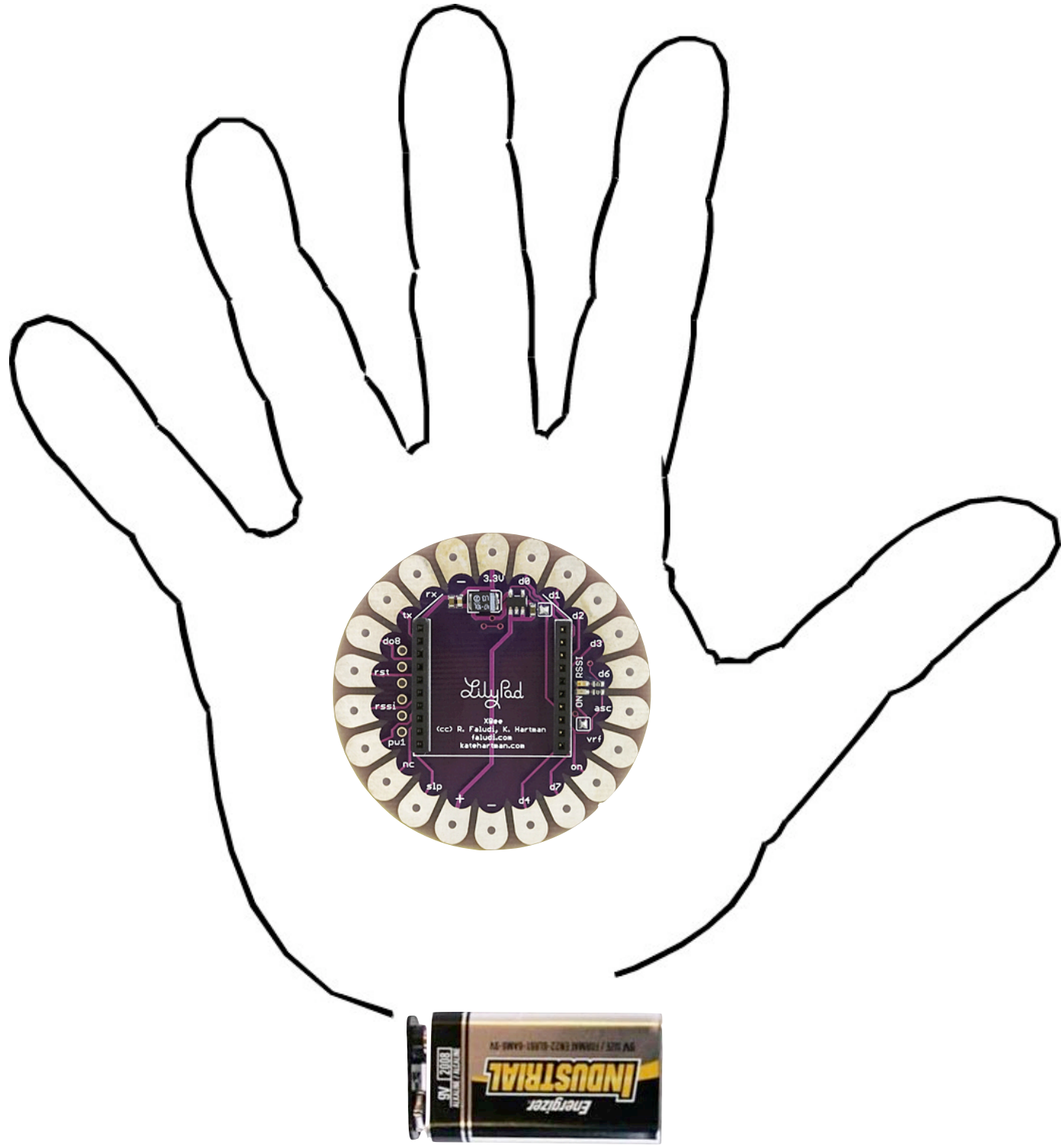
REVERSE SIDE OF ORNAMENT



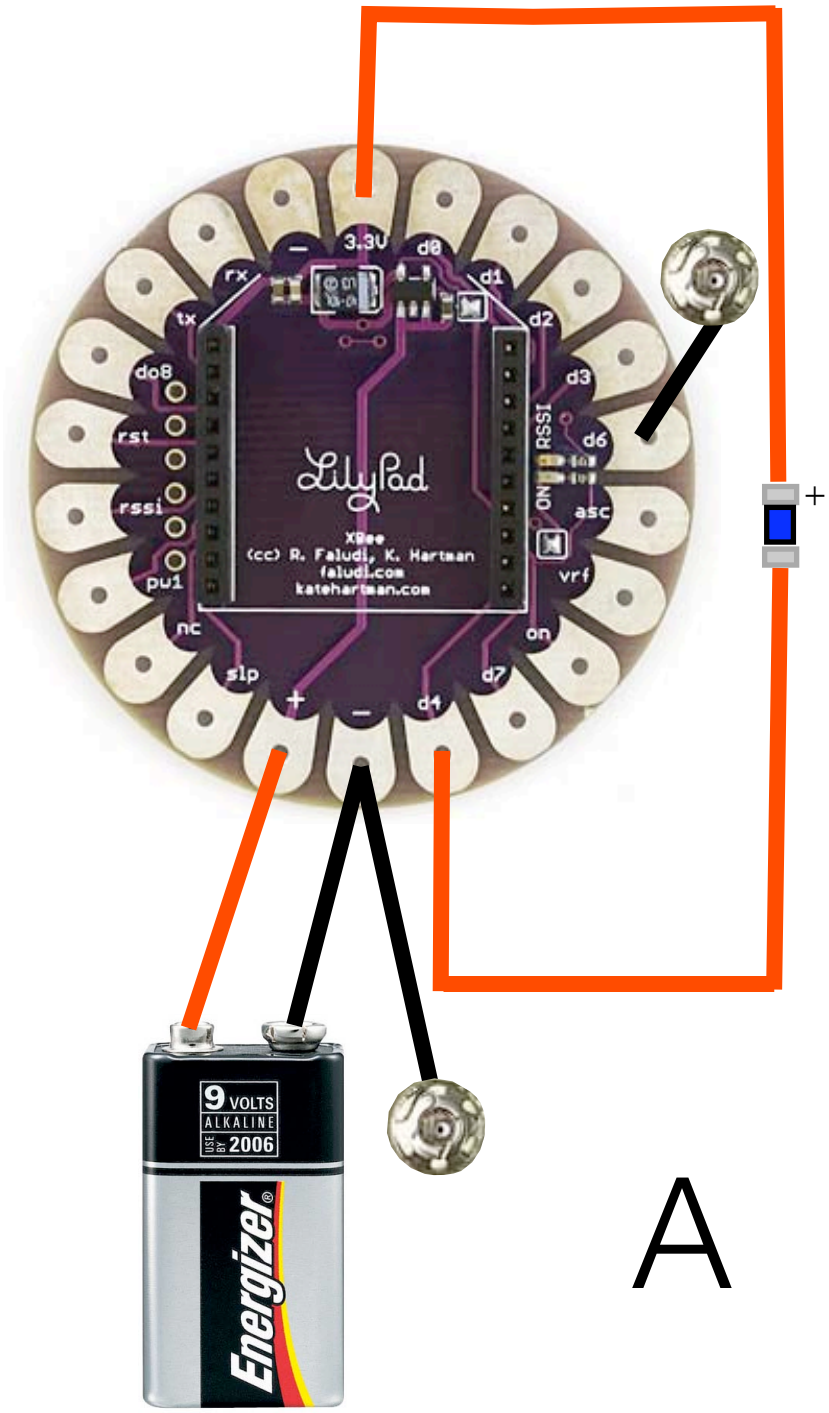
from “Felt Ornament Tutorial” by SparkLab

Exercise: Circuit Layout




LilyPad
(cc) R. Faludi, K. Hartman
faludi.com
katehartman.com
3.3V
d0
d1
d2
d3
d6
asc
vrf
on
d7
d4
slp
nc
pu1
rssi
rst
do8
tx
rx
RSSI
ON
Energizer
INDUSTRIAL

Exercise: *espionage gloves*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tx
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rssi
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slp
d7
d4
d6
asc
vrf
on
RSSI
ON
LilyPad
XBee
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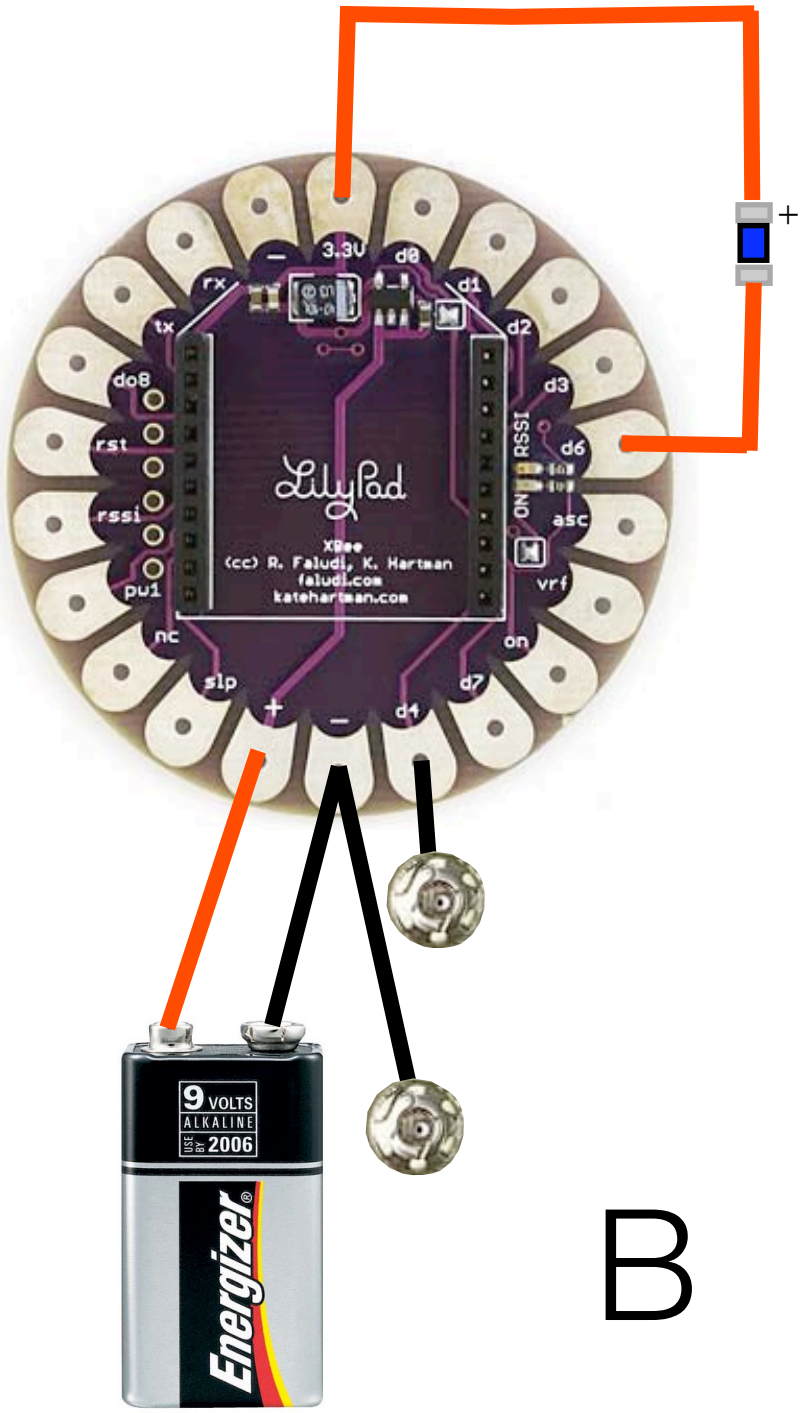
9 VOLTS
ALKALINE
USE BY 2006
Energizer

A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LilyPad
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Energizer

B

Common XBee Mistakes

- http://www.faludi.com/projects/common-xbee-mistakes/