PAT 451 INTERACTIVE MEDIA DESIGN I

CONNECTORS

OBJECTIVE: MOVE AWAY FROM BREADBOARD

Our goal is to allow users to focus on their physical interactions, not on the interface itself.

In *Being and Time,* Martin Heidegger distinguishes between the mode of being where *equipment* (entities we use for tasks like cooking, writing, carpentry) are detached from ourselves and available for intellectual study, and a mode where we skillfully manipulate it or act *through* it as opposed to *with* it.

READY-TO-HAND VS PRESENT-AT-HAND

He calls the latter mode

Readiness-to-hand (*Zuhandenheit*).

- When hammering a nail the expert carpenter doesn't think of the hammer as distinct from you're their body. They don't experience the hammer and nail as independent objects; they become transparent and you instead focus on the task.

The former mode

Presence-at-hand (*Vorhandenheit*)

- Entities are removed from the setting of practice, revealed as independent objects. Subject to inspection, measurement, and interrogation as "things."

GOAL: OPERATE *THROUGH* THE INTERFACE

- Breadboard exposes the interface as a “thing”
- By moving it away, it increasingly has the opportunity to be **Ready-to-Hand**

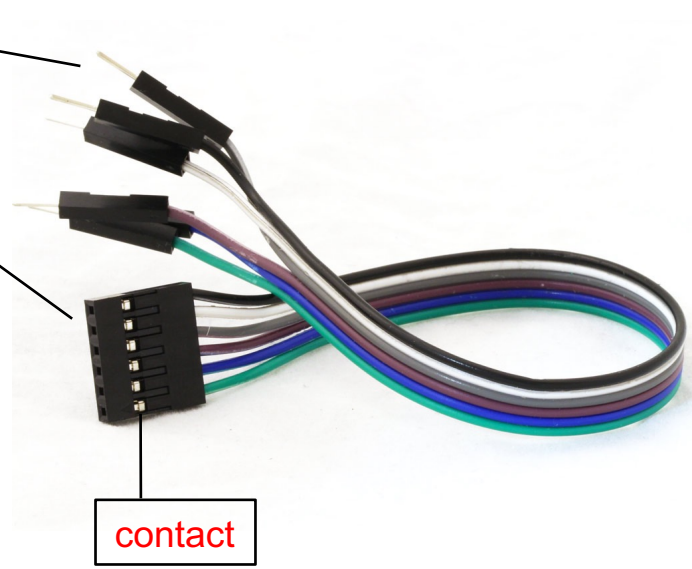
CONSIDERATIONS

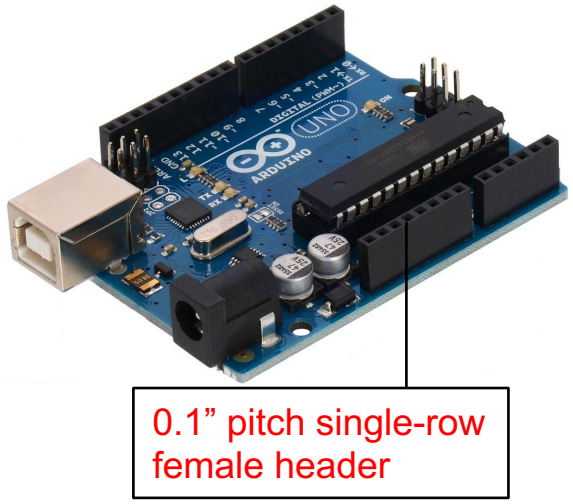
There is no single perfect solution for all interconnect applications. Need to weigh:

- **Number of connections**
- **Length of wire / distance**
- **Rigidity**
- **Force / torque on the connection**
- **Permanence (ability to connect/disconnect)**
- **Modularity**
- **Cost**
- **Time**

SOME TERMS AND FACTS

- **Pin & Socket**
  - Pin: plugs in, has pins (often called ‘male’)
  - Socket: is plugged into, has receptacles (‘female’)
- **Contacts**
  - The part of the connector (almost always metal) where the current flows (sometimes shrouded)
- **Header**
  - An array of equally-spaced identical connectors, in one or more rows, either male or female
- **Pitch**
  - In connectors with an array of contacts (headers), the spacing between centers of adjacent contact
  - Arduino headers and many others we use are 0.1” or 2.54mm pitch





MORE TERMS AND FACTS

- **Mount**
  - Indicates where a component is intended to be mounted, e.g.:
  - **Panel Mount** — attached to the front/back panel of a piece of gear
  - **Board or PCB Mount** — soldered to a circuit board
  - **Cable Mount or Free-Hanging** — attached only to a cable/wire

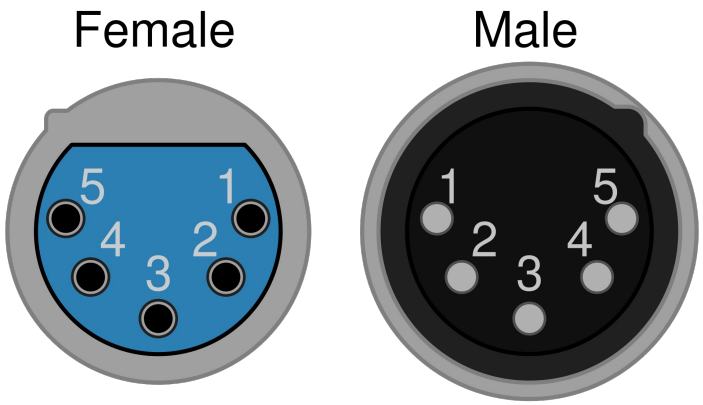
L to R Board-mount, cable-mount, and panel mount versions of the same connector

- **Cable Assembly**
  - A cable that you purchase preassembled with connectors already attached.
  - A normal USB A-to-B cable we use for the Arduino is technically called a cable-assembly.
  - One or both ends may be finished , “single-ended” or “double-ended”

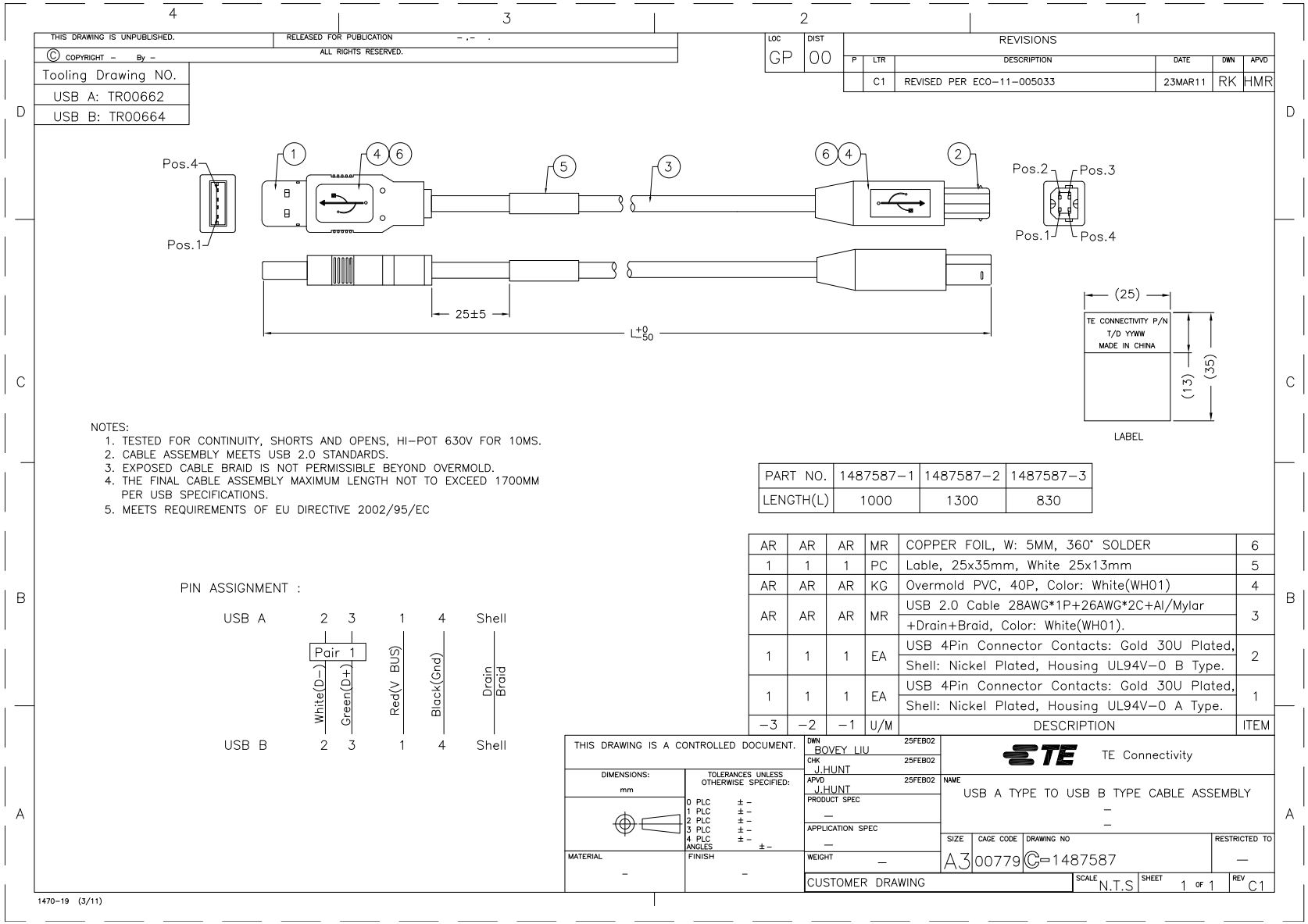
STILL MORE TERMS AND FACTS

- **Position**
  - Numerical identifier to differentiate pins in a header, component, or connector
  - Allows us to relate physical pins to their functionality on schematics or data sheets
  - Physical positions always start at ‘1’ (i.e., not 0-based)
  - Sometime synonymous with “pin”, i.e., “position 1” = “pin 1”
  - Also refers to the number of connections in a connector or assembly

5-position XLR connector



TECHNICAL DRAWING

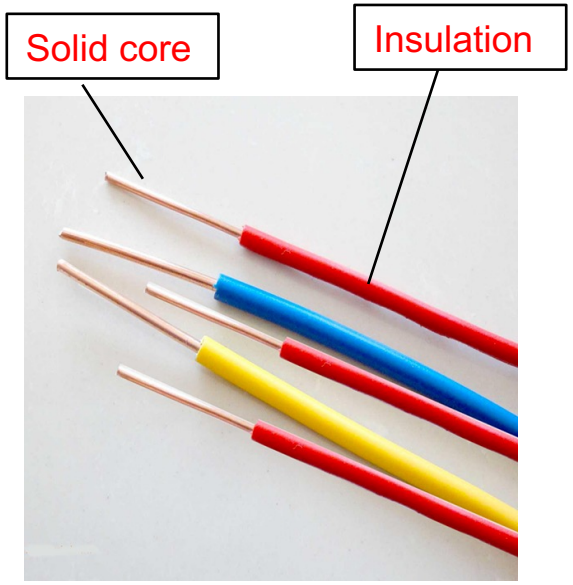


ABOUT WIRE

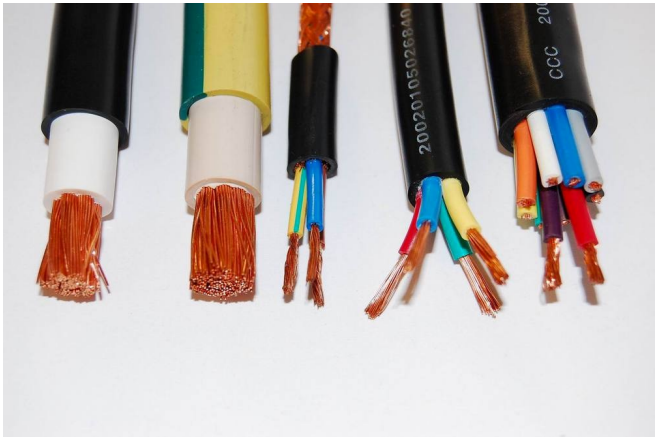
- **Gauge**
  - Refers to the diameter of wire
  - AWG or American Wire Gauge is the standard
  - Diameter **decreases** as gauge increases
  - Some tools are intended for specific wire gauge
  - Higher current applications require lower gauge (thicker wire)
  - We most commonly use 24AWG wire, suitable for low-current, low-voltage applications

Amps @ 12 Volts	LENGTH OF WIRE American Wire Gauge (AWG)						
	3'	5'	7'	10'	15'	20'	25'
0 to 1	18	18	18	18	18	18	18
1.5	18	18	18	18	18	18	18
2	18	18	18	18	18	18	18
3	18	18	18	18	18	18	18
4	18	18	18	18	18	18	18
5	18	18	18	18	18	18	18
6	18	18	18	18	18	18	16
7	18	18	18	18	18	18	16
8	18	18	18	18	18	16	16
10	18	18	18	18	16	16	14
11	18	18	18	18	16	16	14
12	18	18	18	18	16	16	14
15	18	18	18	18	14	14	12
18	18	18	16	16	14	14	12
20	18	18	16	16	14	12	10
22	18	18	16	14	12	12	10
24	18	18	16	14	12	12	10
30	18	16	14	12	10	10	10
36	16	14	14	12	10	10	10
40	16	14	12	12	10	10	8
50	16	14	12	10	10	10	8
100	12	12	10	10	6	6	4
150	10	10	8	8	4	4	2
200	10	8	8	6	4	4	2

WIRE CORE TYPES

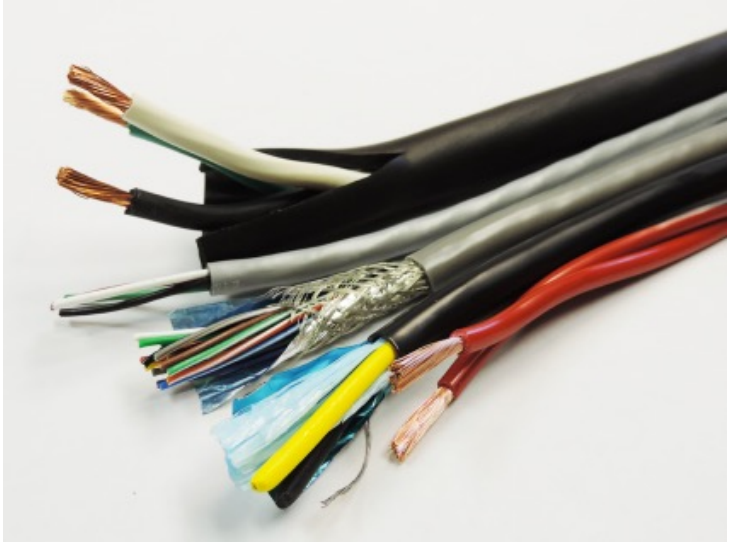


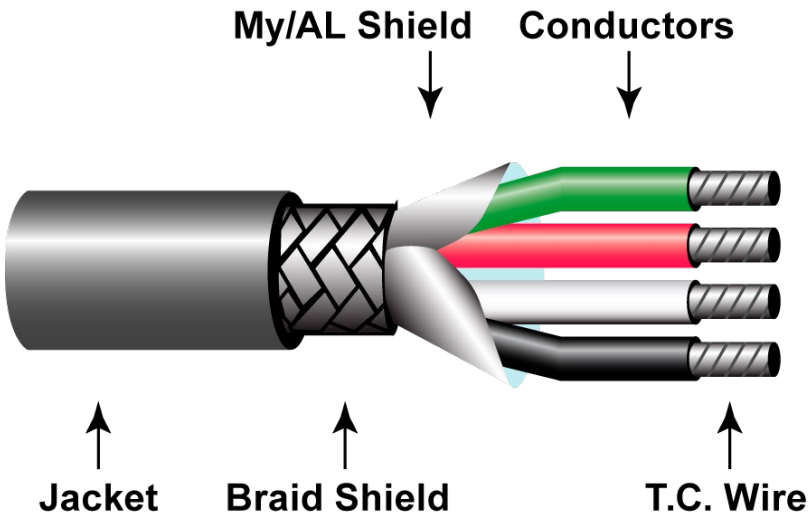
- **Solid core wire**
  - Solid core wire has a single, solid conductor in the center
  - Solid core wire is rigid, appropriate for connections where the wire will never move
- **Stranded wire**
  - The conductive core of stranded wire consists of multiple, closely spaced wire strands
  - For applications where wire will flex or move
  - In addition to wire gauge, stranded wire is specified in the format A/B, where
    - A=number of strands
    - B=gauge of each strand
  - e.g. 24AWG wire may have 7/30 or 19/36 stranding: 7 strands of 30AWG wire or 19 strands of 36AWG wire



CABLE CONSIDERATIONS

- **Multi-conductor cable**
  - Contains multiple insulated wires inside an additional insulated jacket
  - Internal wires are normally color-coded
  - Internal wires are most often stranded to make cables flexible
  - Sometimes wires are paired, and possibly twisted

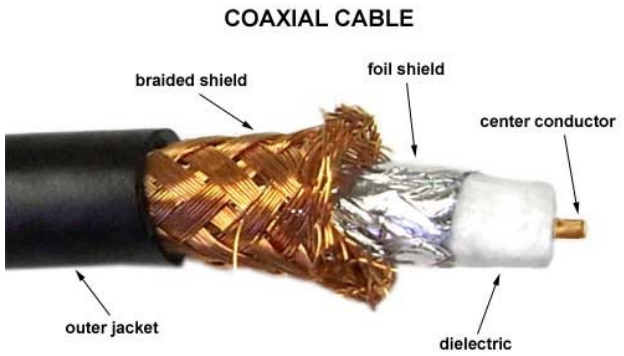




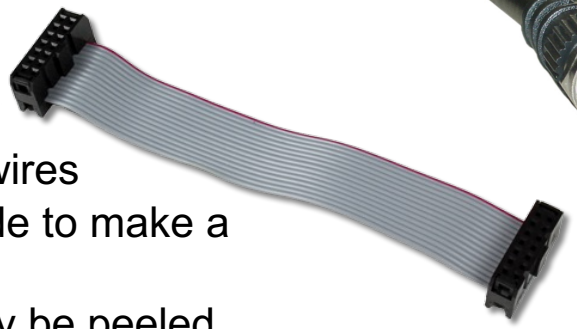
- **Shielding**
  - Multi conductor wire may have a mylar/aluminum foil shield, and/or a copper braided wire shield
  - These either reflect electromagnetic interference or collect it and route it to ground
  - A Drain Wire is sometimes connected to the foil/braid to help connect it to ground

MORE CABLES

- **Coaxial cable**
  - "Coax" wire has multiple conductors (normally just 2) that are concentric, one of which serves as a shield
  - Often used in video (e.g. cable TV), RF transmission (antennas), instrumentation (oscilloscopes)

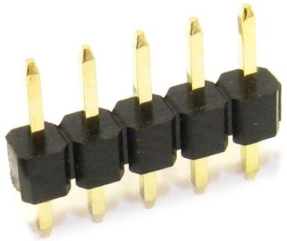


- **Ribbon cable**
  - Multiple, unshielded wires connected side-by-side to make a wide, flat cable
  - Individual strands may be peeled away to separate ends
  - But DO NOT strip away 2-3 wires to make a cable (this is very inefficient/wasteful)
  - Most often used with IDCs: insulation displacement connectors

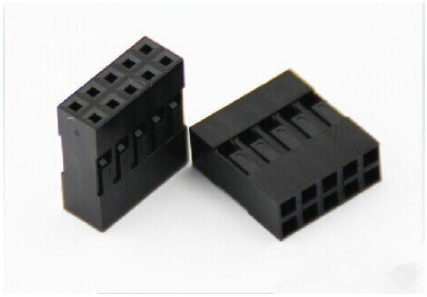


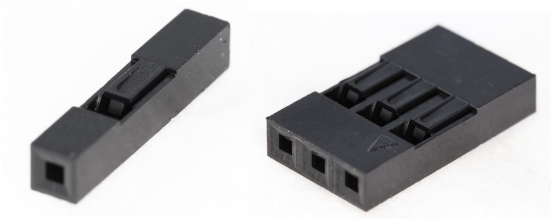
CRIMP CONNECTORS

- **Most common: “DuPont” Connector**
  - A.k.a. “DuPont Mini-PV” or “FCI” or “Berg” connector
  - Commonly copied such that they are a sort of generic standard
  - Most popular (cheapest) version now are “Harwin M-20” series
  - Technically socket-only, mate with square post **pin headers**



- Normally 0.1” or 2.54mm pitch
- Crimp is mechanically connected to a wire using a specialized crimping tool
- Crimp is then inserted into a plastic housing
- Housing may be 1 to 10 pins wide, single- or double-row

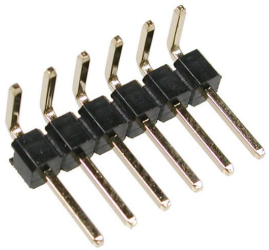


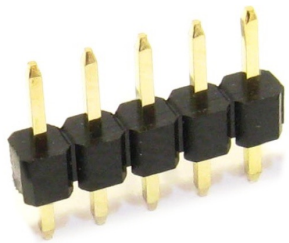


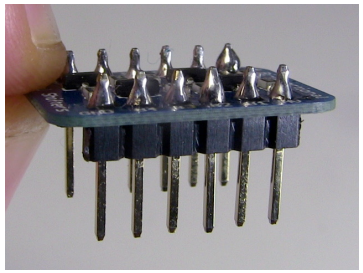
- You can buy pre-made cable assemblies too

MATING TO DUPONT CONNECTORS

- 0.1” pitch breakaway pin headers are ubiquitous
- Single or double row
- Straight or 90º (right angle)

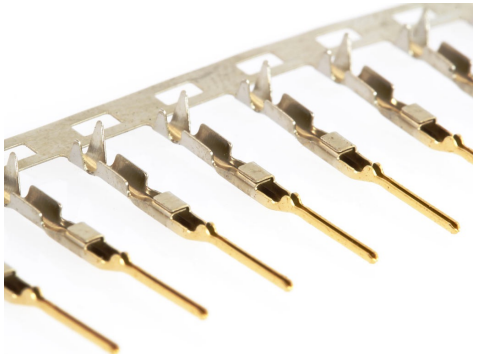


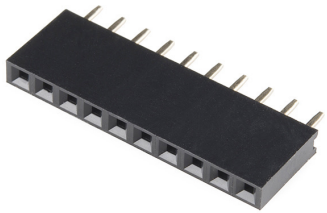




Normally soldered to a PCB

- There are generic crimp pins that mate with Dupont sockets too





- Note that there are also prefab socket strips for PCB mounting, like those on the Arduino

CRIMPING

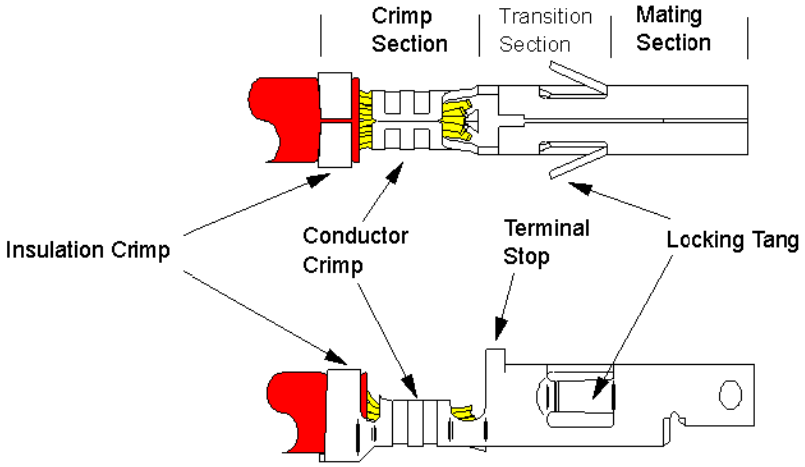
Inexpensive generic crimp tool

ratcheting crimp tool

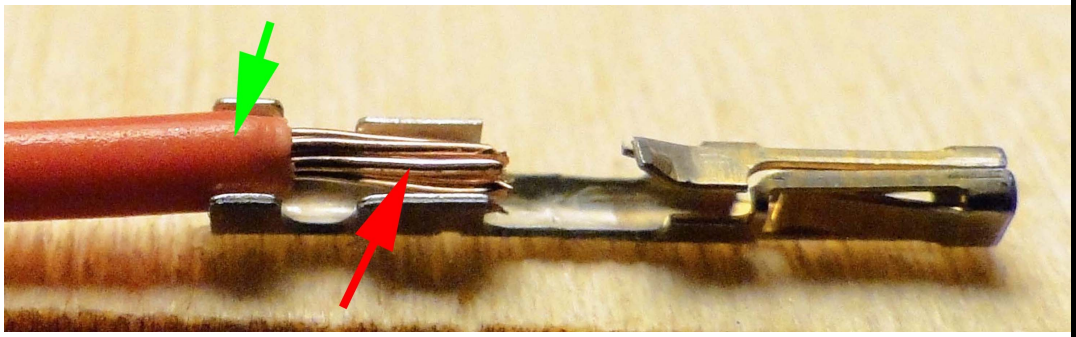
Historic “official” crimp tool (~$1200)

molex

ANATOMY OF A TERMINAL



Insulation crimp



Conductor crimp

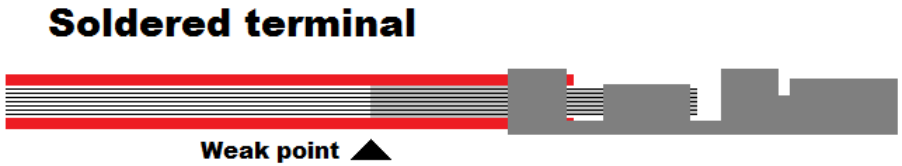
AMAZING WEBSITE OF CRIMPS, CRIMPERS, OTHER CONNECTORS & TRIVIA:

http://www.mattmillman.com/category/crimp-tools-and-connectors/

CRIMP CONNECTORS

- **Why crimp?**
  - When well-done, makes a very robust connection

  - Vs. a solder connection that is brittle and can break when flexed



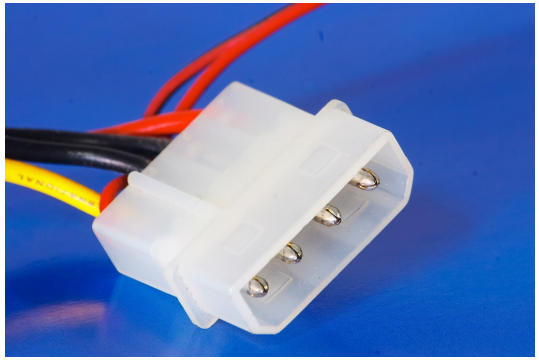
  - When done right, makes a very robust connection
  - Customizable cable length vs a pre-fabricated cable assembly
  - For small numbers of connectors, crimps are often very cost-effective:
    - in quantities we purchase, a crimp connector costs about $0.04 and a 3-pin housing about $0.10
    - BUT an 8-pin housing costs about $0.40, so a double-ended 8-pin crimp cable costs about $1.50 in connectors, plus wire.
    - Worth thinking twice if you are making large quantities of something

CRIMP CONNECTORS

- **Why not crimp?**
  - Can be time consuming
  - Not always most cost effective
  - Not very robust connection, cables can get inadvertantly pulled out easily

- **BEWARE! There are many types of crimps out there. Not all are compatible.**
  - Molex
  - JST

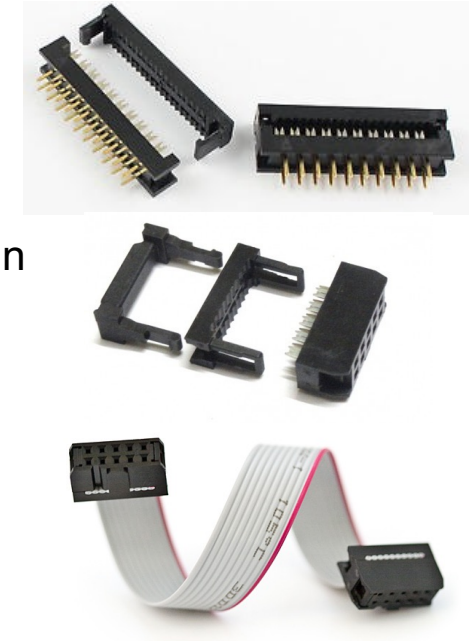
JST



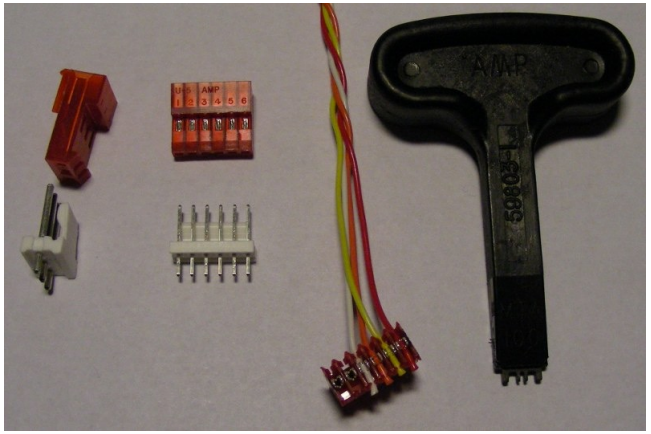
Molex

IDC CONNECTORS

- **Ribbon cable IDC connectors**
  - Insulation Displacement Connector
  - Normally double-row, 0.1” pitch
  - Most often female, mating with double-row male pin header
  - 10, 14, 16, 20 pin are common
  - Very secure
  - Good for short runs of many connectors
  - Not shielded, bad for long runs and expensive for long runs

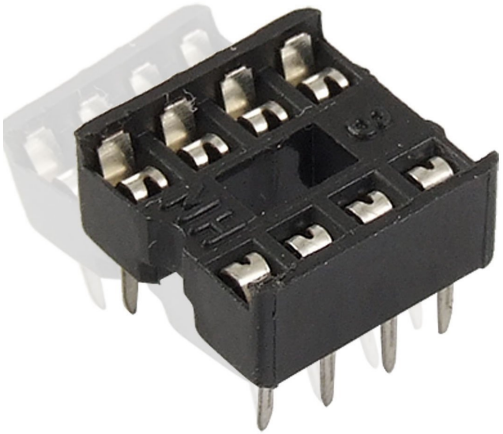


- **MTA Connectors**
  - MTA-100 are 0.1” pitch
  - Pin header may have a locking ramp
  - Socket headers are intended for a specific wire gauge, usually color-coded
  - Our white ones are for 24awg
  - T-handle (cheap) tool or $500+ (fast) mechanical tool
  - Generally for board-mount only
  - Pins are not great for breadboards

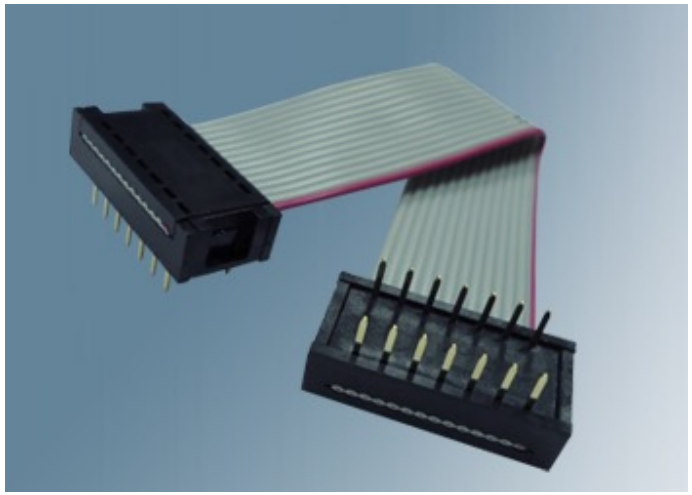


IDC CONNECTORS

- **IDC DIP Plug**
  - Cable-mount connector that copies the pin configuration of a DIP IC
  - DIP: Dual Inline Package
  - Standard width/spacing for integrated circuits
  - Commonly: 8, 14, 16, 18, 28 pins
  - Pins often not long enough for good connection with breadboard
  - Better for plugging into an IC Socket

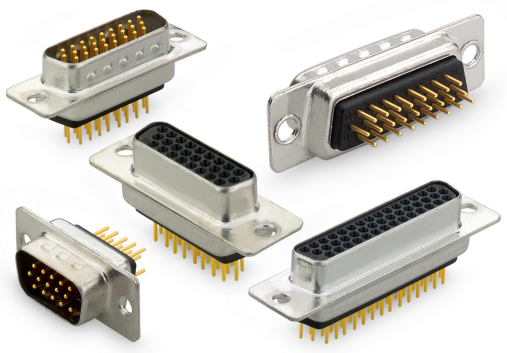


IC Socket



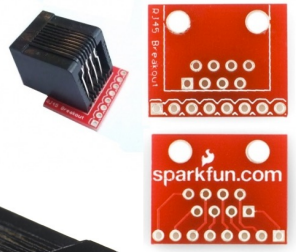
IDC DIP Plug

OTHER CONNECTORS



- **D-SUB**
  - D-subminiature; name from the D-shape of the connector
  - Most often cable-mount and panel-mount
  - Difficult to make, requires specialized tools
  - Good for high-density connections

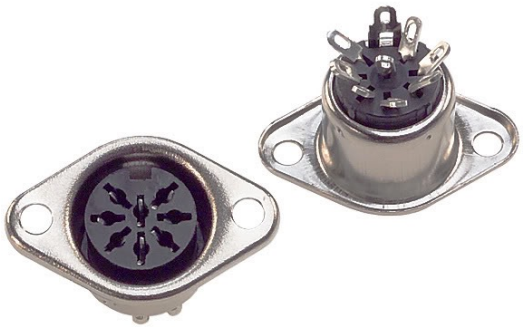
- **“Modular Plug and Jack” or “Registered Jack” (RJ)**
  - Includes telephone jacks and plugs (RJ11, RJ12, RJ25)
  - Ethernet jacks and plugs (RJ45)
  - Specified by the number of positions (P) and the number of actual connectors (C), where C<=P
  - E.g. Ethernet (RJ45) is 8P8C
  - Telephones can be 6P6C, 6P4C, 6P2C. Telephone handset plugs are 4P4C
  - Cable assemblies are very inexpensive
  - Very efficient way to connect 8 signals
  - Sparkfun Breakout Board gives convenient access to 8 pins ($0.75)



OTHER CONNECTORS

- **DIN Connector**
  - “Deutsches Institut für Normung”
  - MIDI connector is a 5-pin DIN connector
  - 3 to 8 pin and even a 13-pin standard connector
  - Female panel-mount connectors are very inexpensive

5-pin DIN Female right-angle board mount



6-pin DIN Female Panel-mount

5-pin DIN Male (MIDI)

GENERAL INTERCONNECT STRATEGIES

- **Arduino -> cable assembly with male pins**
  - Pros:
    - Less connections to debug
    - May be cheap
    - Customizable cables
    - Less space, no breadboard
  - Cons:
    - Not very secure
    - May be time consuming if using crimps
    - No room for external circuitry
    - What to do about multiple power connections?

GENERAL INTERCONNECT STRATEGIES

- **Arduino -> breadboard -> cable assembly with male pins**
  - Pros
    - No strain on Arduino-breadboard connection
    - Breadboard connection may be more secure
    - Modular
    - Power rails available
    - Room for external circuitry/components
  - Cons
    - Extra connections to debug
    - External circuitry/components may not be secure
    - Still potentially time consuming to make crimps
    - Uses more space

GENERAL INTERCONNECT STRATEGIES

- **Arduino -> Panel Mount Connector -> Cable assembly**
  - Pros
    - No strain on Arduino connections
    - No breadboard, less space
    - Panel Mount connectors are most likely secure
    - Can use preassembled cables, save time
  - Cons
    - Need to make/buy an enclosure
    - Often need soldering expertise for panel mount connector
    - Still possibly power rail concerns
    - What to do about external circuitry/components?

GENERAL INTERCONNECT STRATEGIES

- **Arduino -> Perfboard/PCB -> Board-mount Cable assembly**
  - Pros
    - No strain on Arduino connections
    - Perfboard can be custom sized
    - Board-mount connectors are most likely secure
    - MTA cables are very fast to make
    - Secure external circuitry
    - Customize cables
  - Cons
    - Not good for long connections to external devices
    - Often need soldering expertise for panel mount connector
    - Still possibly power rail concerns

GENERAL INTERCONNECT STRATEGIES

- **Arduino -> Perfboard/PCB -> Board-mount connector**
  - Pros
    - No strain on Arduino connections
    - Perfboard can be custom sized
    - Board-mount connectors are most likely secure
    - Secure external circuitry
    - Use standard cables, save time
  - Cons
    - Difficult to design / need the connector to be accessible
    - Board mount connectors not always standard 0.1” pitch

OTHER RESOURCES

- Molex Good Crimps and How to Recognize Them: http://www.molex.com/tnotes/crimp.html
- JST Check-points for Good Crimping: https://cdn-shop.adafruit.com/datasheets/JST_CrinpChart+(English).pdf