# Digital TIPS and TIDBITS

TTL vs CMOS

The 74LS series TTL chips are very useful for most applications:
- Fast, ~10 ns gate delay
- Fairly low power consumption, ~1 mW/gate
- Widely established standard

The 74HC CMOS series eliminates many old objections to CMOS
- Slightly Faster than 74LS TTL ~< 10 ns
  - much better than older 4000 and 74C chips
- Power consumption less than LS TTL at 1 MHz
  - but power exceeds LS as frequency increases above 1 MHz
- More robust against abuse (static electricity etc)
- Logic thresholds not consistent with standard TTL
  - Can use HCT chips which have TTL logic thresholds
  - Can Run HC CMOS at 3.3V supply for level compatibility, 40% slower

4000 and 74C CMOS allow wide range for supply voltage: $3\ V \le V_{CC} \le 13\ V$
- performance better at higher voltages, 9V recommemded

Interfacing TTL and CMOS

CMOS to TTL
- If $V_{CC}$ is +5V, then one CMOS output can drive one LS TTL input
- CMOS logic levels are close to 0 V or 5 V, so no threshold incompatibility
- If CMOS is run at $V_{CC}$ ~3.3 V, thresholds are still compatible with TTL

- Sometimes 4000 series or 74C chips are run at $V_{CC} > 5\ V$ for improved speed
  - Need level-shifter chip to interface to TTL
    - 4049/50, 74C901/2

TTL to CMOS
- TTL output thresholds are inconsistent with 74HC, 74C and 40' CMOS inputs
- When CMOS is run with $V_{CC} = 5\ V$
  - Use a 74HCT buffer between them
  - Use an open collector buffer with pullup to 5 V

- When CMOS uses $V_{CC} = 3.3\ V$ (Usually 74HC only)
  - Direct connection from TTL to CMOS possible

- When CMOS uses $V_{CC} > 5\ V$ (Usually 4000 or 74C series
  - use level shifter buffer chip
    - 40109, LTC1045, 14504
  - use open collector buffer with pullup to 5 V

Common Precautions

*Noisy supply and ground lines can cause troubles that take hours to find.*

Make $V_{CC}$ wire very large so that current surges don't cause much voltage drop
make a large bus wire, don't daisy chain $V_{CC}$ or ground lines

Be very careful with grounding. Typical precautions are
Ground all devices at one single point
Use a ground plane
one side of pc board a solid conductor for gnd connections

Both $V_{CC}$ and ground lines should be wide traces or #14 or #16 wire
to minimize both inductance and resistance

Quirks with TTL

Draws a lot of current when switching. Put despiking capacitors between $V_{CC}$ and gnd on every 2nd or 3rd chip to supply large current surges momentarily
0.01 µF to 0.1µF, ceramic
1 to 47 µF tantalum cap between where$V_{CC}$ and gnd comes on board.

Noise immunity to low level is very bad with TTL
always check for noise on gnd

Quirks with CMOS

Input FET very easy to ruin
Be very careful of static charge
Discharge yourself before touching
store and transport in conductive foam or pouch
never put belly up
Never plug in or unplug them with supply on

Will "latch up" if an input is driven above supply $V_{CC}$
$V_{CC}$ shorts to ground, chip gets hot, pretty soon it's belly-up

Unconnected inputs are indeterminate
Connect all inputs of all gates on a chip, even if the gates aren't used.
Failure to do this could make both complementary FETS conducting
Draws a lot of current messing up other gates and chips

If you forget to connect $V_{CC}$, or gnd, chip will still work as long as at least one pin is at $V_{CC}$ or gnd.

Unconnected inputs and unconnected supply lines can cause intermittent and unreproducible failures that drive you up a wall.

Driving External devices:

CMOS and TTL are designed to sink more current than source
Put any device that draws current between $V_{CC}$ and the output
Use a current limiting resistor for LEDs (220Ω to 1k)
For 5 V relays, always use diode to protect against inductive spike

If you need more current (>10 mA) use gate output to drive a transistor
If large transients are apt to come from a device, use optoisolator
Open collector or drain outputs can be used for nonstandard voltages

Sending signals over a distance
use an output buffer on sender and input Schmitt trigger on receiver
Open collector or special line driver senders ensure clean levels
Terminate line just before Schmitt trigger
eliminates reflections
180Ω to 5V, 390 Ω to gnd is standard (H&H Fig 9.32)
Twisted pair line with differential input (H&H Fig. 9.34)
Higher voltage signals using twisted pair (RS232)
RS422 combines differential signal and higher signal voltages
Current sinking drivers
uses current sources to drive line
(H&H say works real good, see Fig 9.35)
Coaxial cable
good interference immunity
data rates up to 100 kb/s over 1 mile (1.6 km)
well standardized
See H&H Fig 9.40,41,42 for examples

Fibre optic cable
Standardized senders, receivers and cables available
Cheap
infrared LED sender ($1)
phototransitor receiver ($1)
1mm plastic step-index cable (cheap)
1Mb/s over 30 ft
Better system
200µm glass step index fibre
detectors have builtin amps
5Mb/s over 1 km
Current record (old?)
4 GHz over 120 km, no repeaters