NIM to TTL, TTL to NIM,

— etc, etc, ... —

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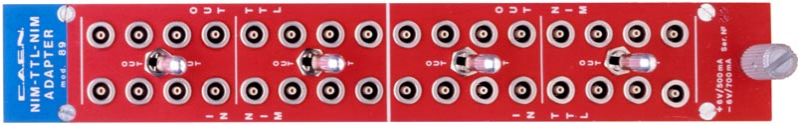
Motivation

The old problem

- Nuclear physics instrumentation - often NIM inputs/outputs (LEMO jacks)
- interface it with general purpose devices - often with TTL inputs/outputs
- Experiment groups have old converter modules, some from the 70s ... and they're falling apart - so these people come to us
- You can buy new modules from the usual vendors - but they cost a fortune
- We want to implement *our own* NIM/TTL IO into our modules



www.caen.com

TTL, LVTTL, CMOS

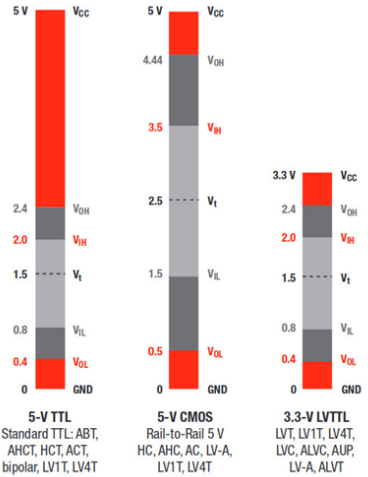


Figure: Texas Instruments Logic Guide 2017

What is "TTL"?

- **T**ransistor **T**ransitor **L**ogic
- Voltage signal - driver sends defined voltage into an undefined (high) impedance
- Used for IC to IC communication
- *misused* for device to device communication
- Compare variants: TTL (5V), LVTTL (3.3V) and LVCMOS (3.3V)
- TTL and LVTTL $\rightarrow$ same $V_{th} = 1.5V$
- CMOS logic has V_{th} at $VCC/2$
- 3.3V CMOS and 3.3V LVTTL compatible

What is NIM?

- **N**uclear **I**nstrumentation **M**odule
- Current signal - a defined current (16 mA) into a defined impedance (50R, LEMO jacks)
- Used for device to device communication - over several meters of 50R lab cables
- Negative polarity. Logic HI = -0.8V in 50R, Logic LO = 0V
- Negative? - Yeah, logic signal intended comparable/compatible with a decent PMT pulse
- In NIM crate you always get -6V for free, so negative logic is not an issue

NIM vs TTL - HI level power needed

TTL/NIM in 50R

- assume driving constant **HI** into line termination
  remember: $I = U/R$, $P = U^2/R$
- TTL 5V,50R $\rightarrow$ 100 mA, 500 mW
- LVTTL 3.3V,50R $\rightarrow$ 66 mA, 218 mW
- LVTTL 2.5V,50R $\rightarrow$ 50 mA, 125 mW
- NIM -0.8V,50R $\rightarrow$ 16 mA, **12.8 mW !**

Best of both worlds

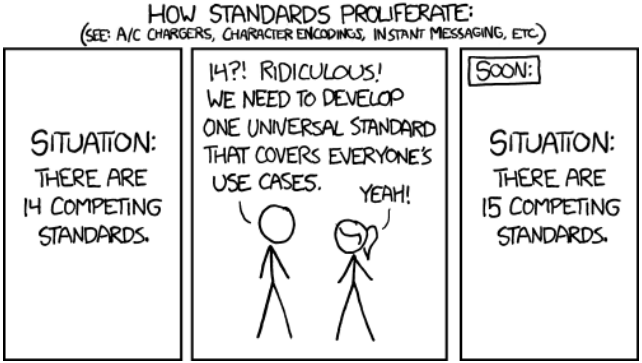


Figure: xkcd.com

- I propose positive logic NIM :)
- HI $= +0.8$V in 50 R
- Technically best solution - works with no existing equipment
- Better not ...

oldschool NIM driver/receiver example

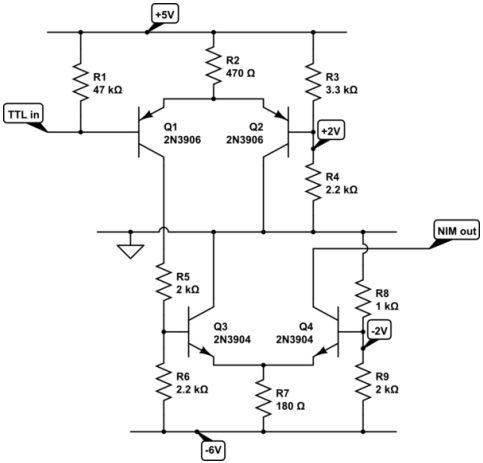
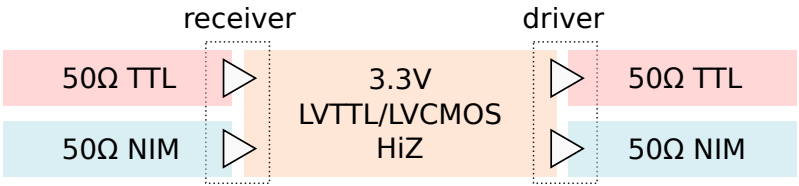


Figure:
https://electronics.stackexchange.com/questions/456969/ttl-to-nim-logic-translation-logic-gate-issue

legacy tech

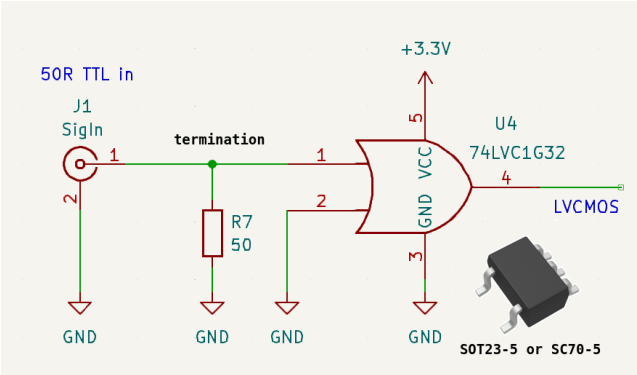
- "oldschool example" of a NIM driver
- uses discrete BJT transistors
- negative power comes from NIM crate -6V
- draws significant current when idle
- asymmetric reaction to rising/falling edges
- we don't need to build it like this anymore

What we need



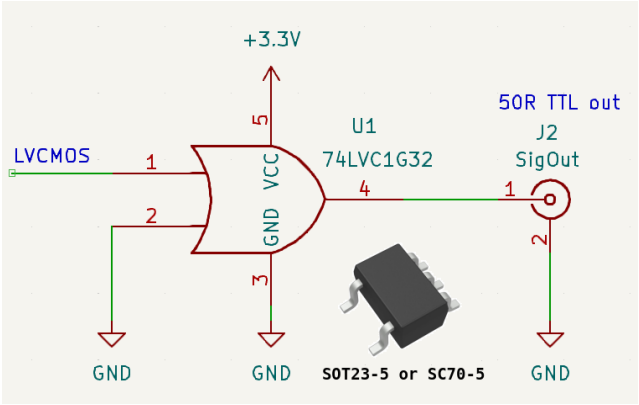
- If we have a circuit for all four cases ...
- ... we can build all sorts of active converters and I/O on our own boards
- If possible compact/cheap/reliable/reusable building blocks
- easy to power with e.g. a single 5V source
- something you could give to a colleague

TTL to LVCMOS



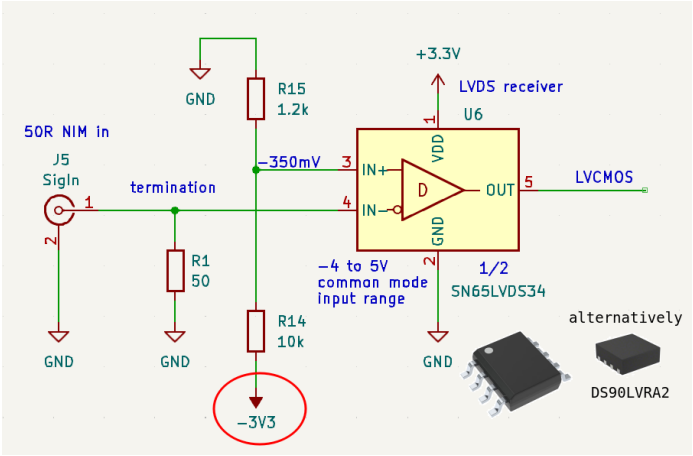
- Okay, that was trivial
- $V_{th} = VCC/2$
- TTL/LVTTL is compatible with LVCMOS anyway

LVCMOS to TTL



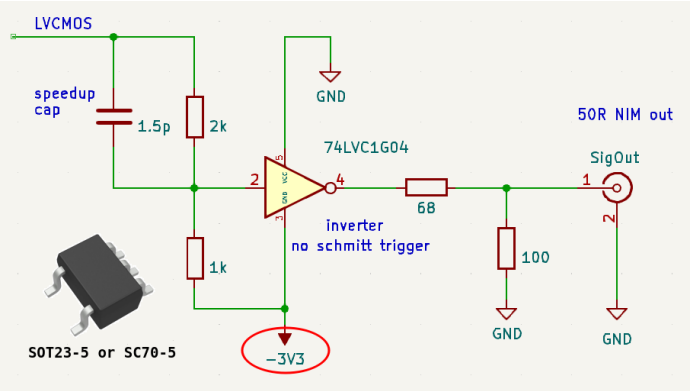
- Pretty easy as well. Driver output only reaches 2.5V in 50R, but complies with TTL and LVTTL levels!
- Edges are nice and steep ($\leq 800ps$)

NIM receiver



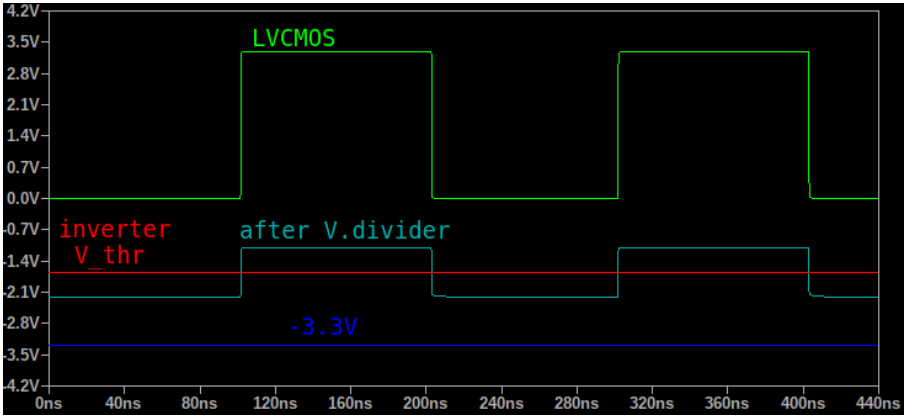
- Use LVDS receiver as comparator/inverter with negative threshold

NIM driver



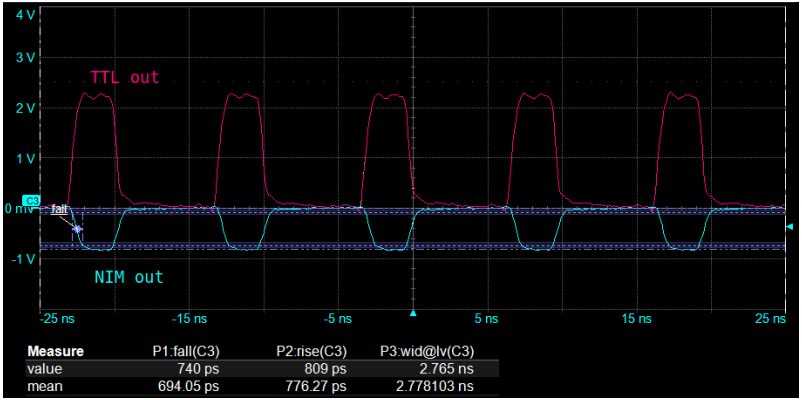
- speedup cap and inverter input cap ($\approx 3pF$) build a (capacitive) 1:2 voltage divider, too

NIM driver - voltage divider



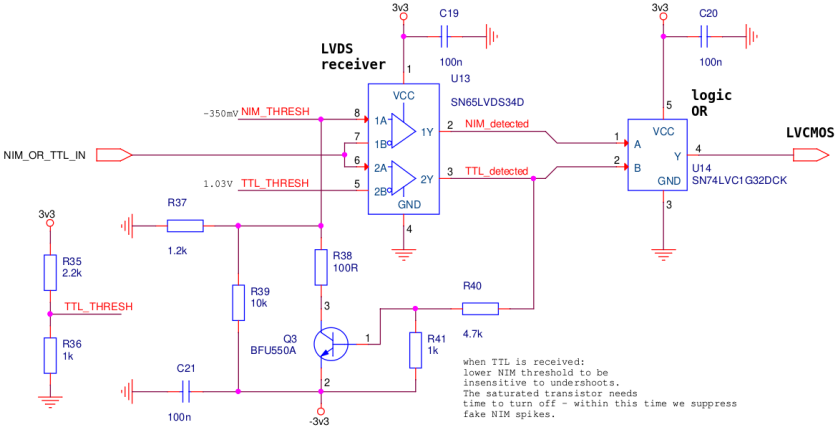
- both resistive and capacitive divider achieve level conversion while preserving edge steepness

output driver performance



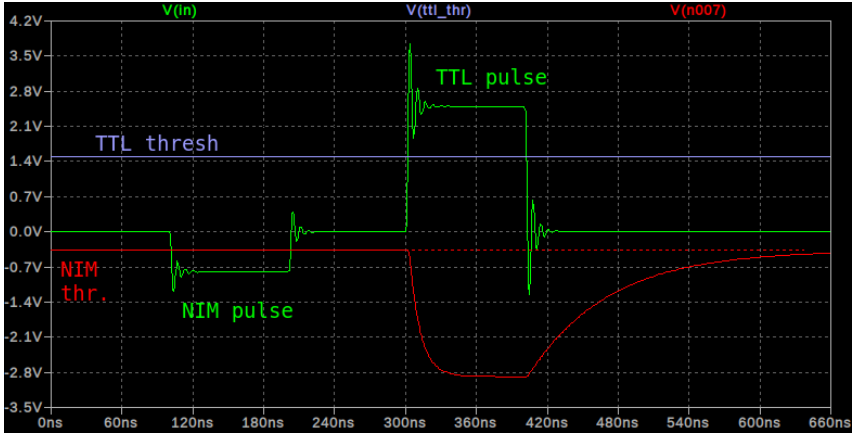
- No pulse width distortion
- both, rising and falling edges are steep, for NIM and TTL

NIM/TTL combo receiver - with undershoot rejection



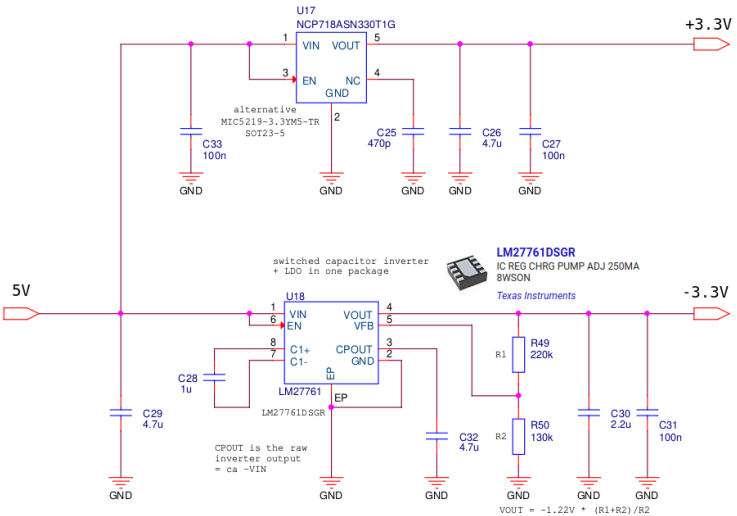
- Remember: LEMO Jacks are more expensive than ICs :)

Combo input - undershoot mitigation



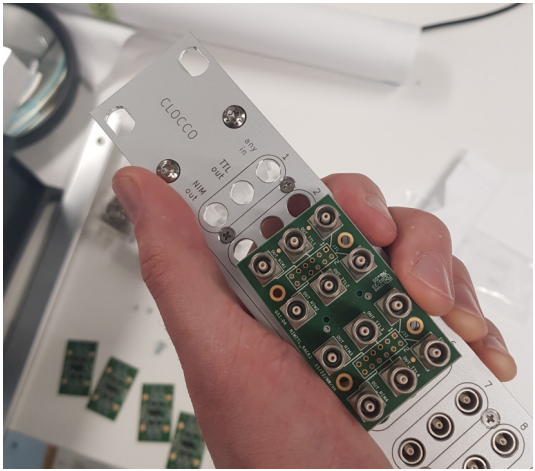
- an additional transistor helps ignoring ringing/fake NIM pulses

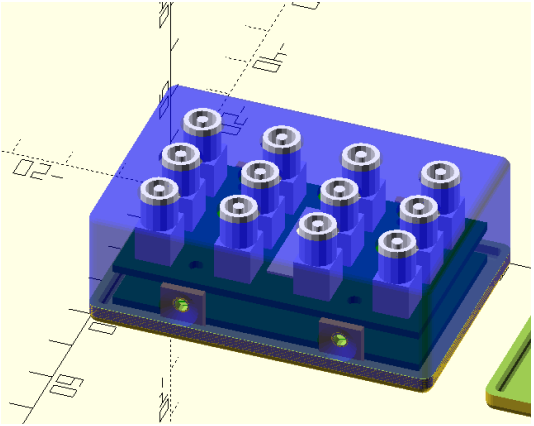
-3.3V power rail from a charge pump



- where do I get my negative power from?
- charge pump LM27761
- switched capacitor, no coil, low EMI
- includes -3.3V LDO
- easily powers at least four NIM drivers
- low cost, 1.5€ in single qty
- alternatively LM27762 - has neg AND pos LDO

The finished stand-alone product





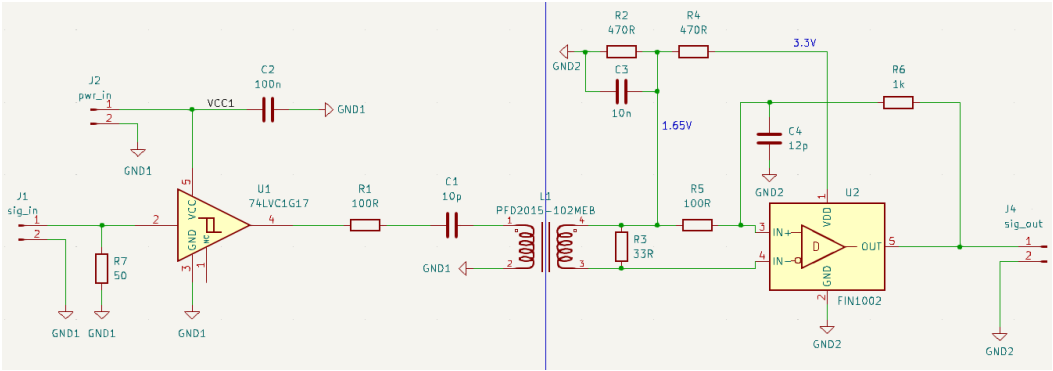
- Either 20 ch in 19" Rack, or a 4 ch module powered by USB

The End

That's all

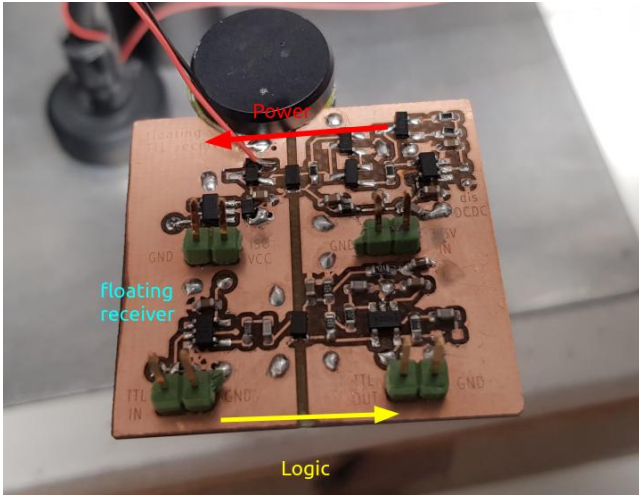
- Thank you

Bonus: Galvanic Decoupler - work in progress

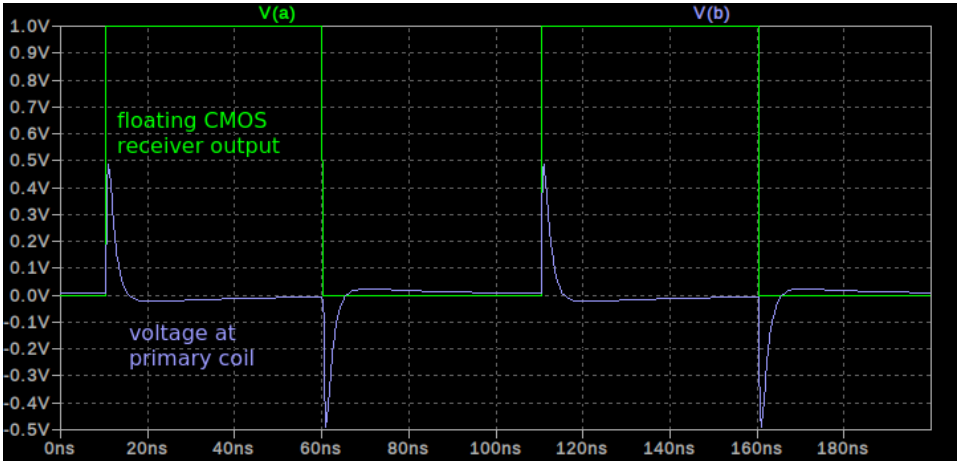


- LVTTL over a gap
- works like a charm
- pulse lengths from 3ns to seconds, edge precision $\leq 20ps$
- transmits clocks up to 200 MHz

Galvanic Decoupler - the demonstrator



Galvanic Decoupler



Galvanic Decoupler