UPAMD Single-Wire communications specifications

In the March 22nd, 2011 communications subcommittee meeting the proposal of using single-wire communications (instead of differential) was adopted as an initial working model. To guarantee single-wire communications viability, a model was developed that attempts to satisfy all the requirements of safety, current delivery, and data communications. Given that single-wire communications requires the sharing of the common return wire with power delivery needs, the multiple dynamic and static characteristics of the source, the sink, and the wiring directly affect the communications line.

This first draft introduces a set of possible specifications as a first attempt to address the different physical interface communication requirements. Input is required to refine the specifications and to allow for a viable system implementation.

Basic Assumptions

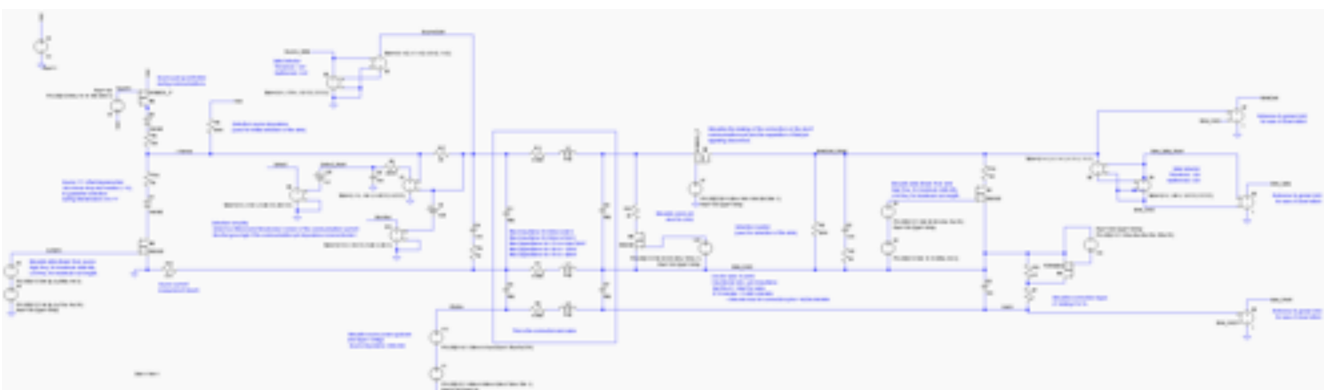
- CAN 2.0B communications (NRZ, dominant/recessive, maximum "0" run-length of 11 bits).
- Desired speed: 100kb/s (up to 500kb/s, no less than 20kb/s)
- Desired future compatibility with differential communications.
- Detection of sink connection & disconnection via the communications pin.
- Detect sink disconnection and remove power within 750μs of event.
- Detect communication pin shorts to GND (avoid powering-up on this condition).
- Capable of handling source and sink power transients
- Compatibility with a 3.3V IO voltage

Required Definitions

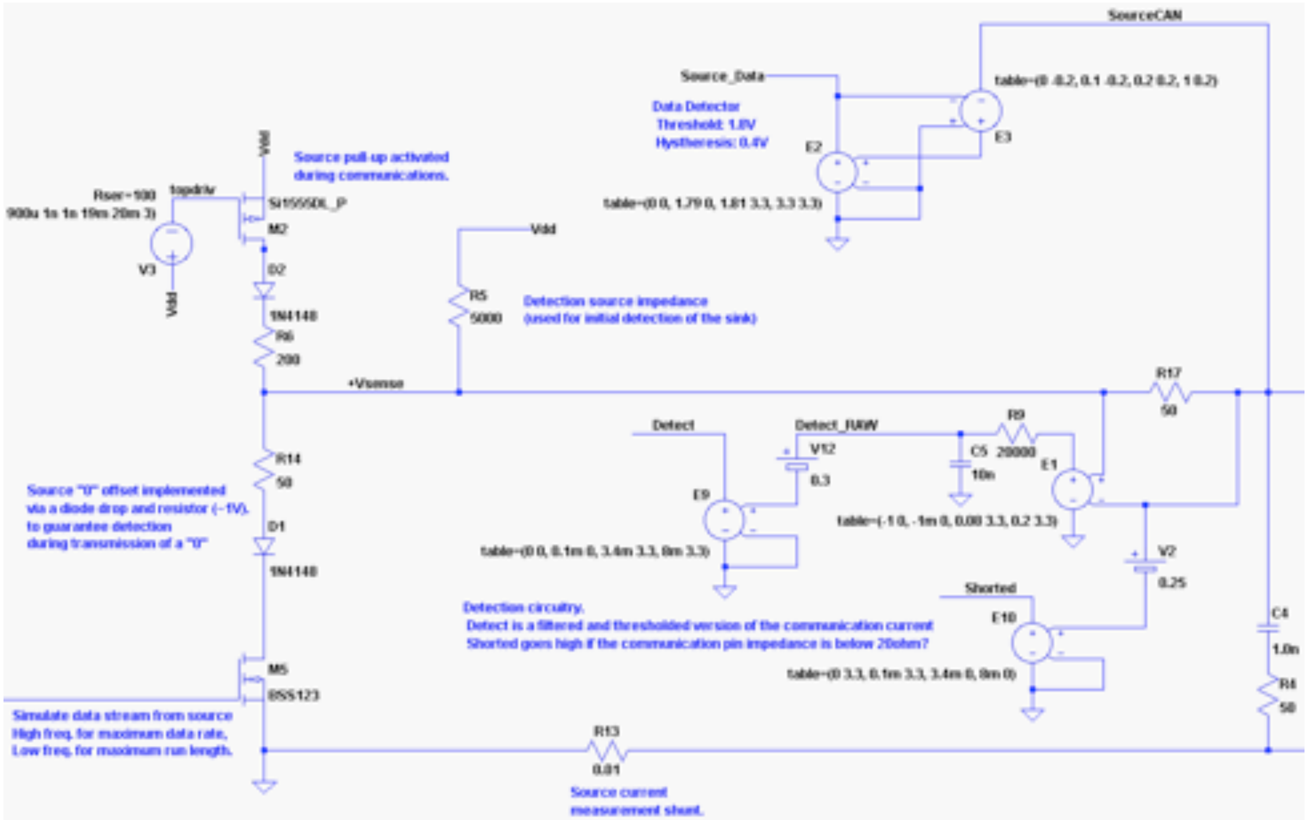
- Sink and source communications
  - Voltage levels for transmission
  - Voltage levels for reception
  - Current levels on communication pins
  - Impedances (pull-up, pull-down)
  - Termination elements (EMI and overshoot control)
  - Source current shaping (EMI control)
  - Protection circuitry
- Source elements
  - Detection circuitry specifications
  - Maximum voltage ripple & dv/dt (source capacitance)
- Sink elements
  - Detection impedance
  - Maximum current transients & di/dt (sink capacitance)

Simulation Elements

The accompanying LTspice simulation (UPAMD_CANcomm20110619.asc) intends to illustrate the multiple issues to be addressed and an initial attempt to address them. Most of the dynamic elements (e.g, amplifiers and comparators) have been idealized to reduce simulation complexity and better illustrate the basic concepts. Proper definition of all the required specifications, and their representation in the simulation parameters, is required to fully define the physical layer for UPAMD.



Source Circuitry



A source pull-up (R6) is activated via M2 and D2 to allow for the desired communications speed. Note that this pull-up (together with D2, D1, R14, and R17) limits communications current to a maximum of 10mA . The transmission of a dominant “0” is achieved via M5, with D1 and R14 limiting the excursion to keep at least 1V of bias in the communications line (for detection purposes). D2 serves to protect M2 in case of a short to the power line.

Line termination is achieved via C4 and R4, these elements have been calculated to provide a common-mode termination of 50Ω at ~4MHz while not considerably reducing rise-time via the source pull-up (for future-proofing this should be in the neighborhood of the expected common-mode impedance of a 120Ω differential line, and the equivalent common-mode termination impedance of such line).

Data discrimination on the *Source_CAN* line (*Source_Data*) is accomplished via a comparator at a threshold of 1.8V with ±0.2V of hysteresis. This ideal comparator has been implemented via the voltage-dependent voltage source elements (VDVS) E2 and E3.

The detection of sink connection and disconnection (*Detect*) is achieved via source current amplification by a 2V/mA trans-impedance (via R17 and E1) and filtering to ~800Hz (R9 & C5) to remove communication transients, followed by a comparator with a 300mV threshold (E9 & V12). This filter directly affects disconnect detection speed. R5 provides the initial detection current when no data transmission is taking place (maximum of ~700μA if shorted). D1 and R14 ensure that a minimum of 1V is present in the communications line during the transmission of a dominant “0” to provide a minimum detection current.

Detection has to be confirmed via the separate detection of a short of the communications line to ground (*Shorted*), this is achieved with a comparator with a threshold of 250mV on the data line (E10 & V2). This detection scheme can detect a up to a 300Ω short to ground when data is not being transmitted or up to a 30Ω short during the transmission of a “0”. This same detection scheme can be realized inside an MCU with two ADC lines connected to the *+Vsense* and *SourceCAN* lines, as long as the ADC is capable of discriminating a minimum change of ~6mV on each (better than 10bits over 3.3V).

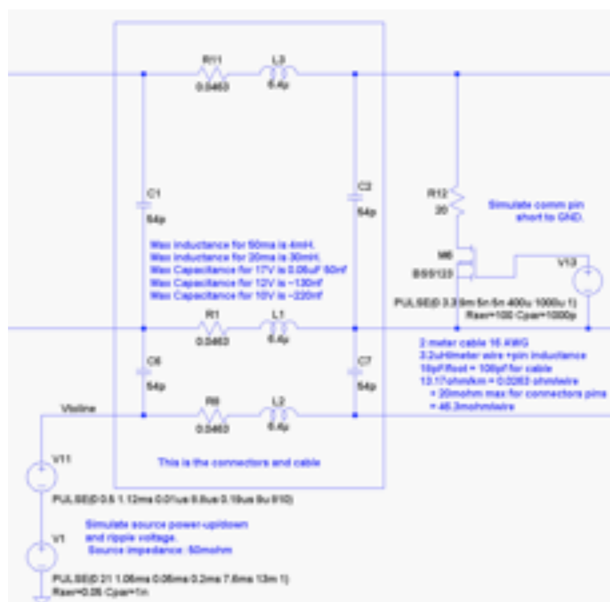
Sink CIrcuitry

Sink dominant “0” transmission is achieved via M1 and R10. While data discrimination in *Sink_Data_RAW* is achieved via a comparator with a threshold of 1.5V and a hysteresis of ±0.1V (E4 & E5). Termination of the data line is done similarly to the source via C3 & R3.

R2 is to ensure a continuous detection current to the source (as a side effect, it reduces the magnitude of the data signal). M3 and V7 serve to emulate sink connection and disconnection.

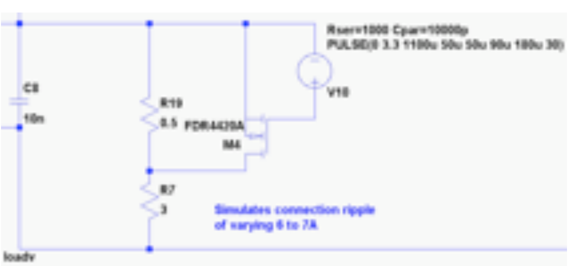
Power and Wiring Simulation

To simulate power delivery, a source (V1) is activated during the detection period. A second source (V11) simulates source ripple. Pogo pin connectors and 2 meters of wiring are simulated by a lumped model consisting of R11, L3, R1, L1, R8, L2, C1, C2, C6 & C7.

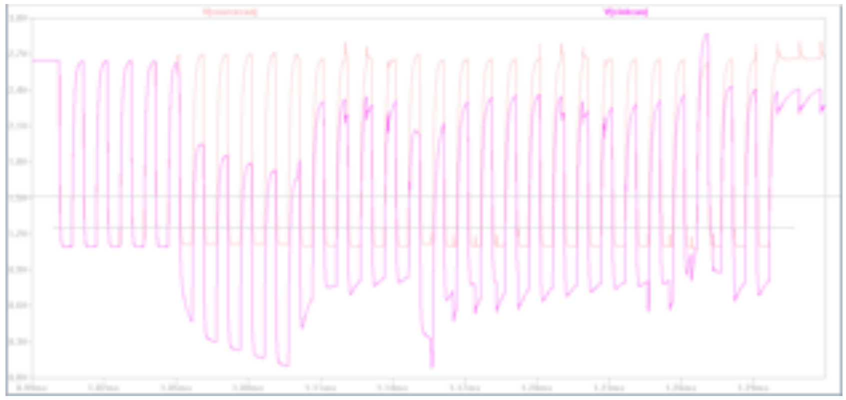


A 3Ω load (R7) simulates 7A of sink current, while a 0.5Ω resistor is switched in and out (R19, M4, V10) to simulate a sink ripple of 1A. Some of this ripple is smoothed-out by C8.

R12, M6, and V13 are used to emulate shorting of the communications line to GND.



Worst-case data discrimination



The traces on the right show the main challenge of the current set of simulation parameters. Sink-side and source-side view of the same source transmission during initial source start-up. Movements on the signal baseline are due to transitions on the power-lines and the induced ground currents.

Note that on the sink-side the eye is a very narrow 300mV at best, which is not easily discriminated with a fixed-threshold detector (within normal tolerance boundaries).

Tentative specifications

The following specifications have been put together based on the accompanying simulation, no major effort to optimize these, to define testing conditions, or to find the most reasonable simulation corners has been carried out.

Source communications	
Guaranteed voltage, transmission	Dominant “0”: 0V to 1.1V, Recessive “1”: 2.6V to 3.3V
Guaranteed voltage, reception	Dominant “0”: 0V to 1.6V, Recessive “1”: 2.0V to 3.3V
Shorted current level on communication pins	15mA max
Impedances (pull-up / pull-down)	500Ω to 200Ω / 50Ω to 200Ω
Termination elements (EMI and overshoot control)	50Ω (real) @ 10MHz ?
Source current shaping (EMI control)	?
Protections	Short to Gnd, Short to power (60V).
Sink and source communications	
Voltage & current levels for transmission	Dominant “0”: 0V to 1.1V, 5 to 15mA
Voltage levels for reception	Dominant “0”: 0V to 1.4V, Recessive “1”: 1.6V to 3.3V
Current levels on communication pins	15mA max
Impedance, active pull-down	50Ω to 200Ω
Termination elements (EMI and overshoot control)	50Ω (real) @ 10MHz ?
Source current shaping (EMI control)	?
Protection circuitry	Short to Gnd, Short to power (60V).
Source elements	
Detection circuitry specifications	Sink detection: 1kΩ to 6kΩ min., disconnect <300μs
Communication short to gnd detection	15Ω max, 25mA max, <100μs
Maximum voltage ripple & dv/dt (source capacitance)	Ripple: ±500mV, 50V/μs max. Ramp-up: 200V/ms max
Sink elements	
Detection impedance (pull-down)	2kΩ to 5kΩ
Maximum current transients & di/dt (sink capacitance)	Ripple: ±500mA, 50mA/ms maximum

PLEASE SEND ANY COMMENTS TO THE UPAMD COMMUNICATIONS SUB-COMMITTEE OR TO EDGAR BROWN EBROWN@AXIONBIO.COM.