Protocol for Communications Between Devices on SigNet™

This document applies to SigNet™ devices from:
NCE Corporation (Webster, NY)

Overview of SigNet

SigNet connects up to 2047 devices related to signaling of a model railroad for the purposes of controlling signals. It is intended that the SigNet bus provide the physical layer of a Producer/Consumer network. Each device connected to the network is assigned a unique address to differentiate it from other devices on the network. The basic communications scheme uses collision avoidance and short (3 and 6 byte) packets to provide high throughput at low data rates.

Physical configuration of the bus:

The bus is configured to be driven by a 'bit banged' UART through an open collector transistor. A 250uA pull-up resistor (47K to a nominal 12 volts) on the open collector is provided by each receiving node on the network. A 47 Ohm resistor is placed in the common leg of the transmit transistor allowing about 70 devices on the network before a simple bus repeater is necessary. Data polarity is chosen to make it easy to feed the bus (with simple conditioning) directly into the UART pin of a microcontroller or MAX232 type interface chip. Transmit data follows the normal hardware UART output polarity. A start bit on the bus is low and a stop bit is high. Data is transmitted least significant bit first. Data on the bus runs standard asynchronous format at 9600 bps with 8 data bits, no parity, 1 stop bit.

Bus Wiring:

As there are only two wires for SigNet there is no specified connector. It is recommended that two clearly marked screw terminals be provided for connection of devices to the bus. The markings should be "COM" (or "COMMON") and "SIG" (or "SIGNAL"). The COM is always negative with respect to the "SIG" terminal. For noise reduction on the relatively high bus impedance it is suggested that twisted pair (#26 AWG or larger) be used for interconnection of bus devices.

Collision avoidance:

For a collision to be detected in time for a colliding device to remove itself from the bus without corrupting data it is required that all transmissions must be 'bit banged'. A bus low condition represents a '0' bit and a bus high condition represents a '1'. A device may not start transmission until it ensures that the bus has been idle (high) for at least 2.0mS. Taking the bus low for the period of the start bit and any following '0' bits starts transmission. When a '1' is transmitted (bus high) the state of the bus is continually sampled during the bit time to make sure the bus is actually high. If the bus goes low while our device is sending a high we must immediately cease transmission and begin again after the required bus idle period of 2.0mS has been completed. A device shall receive its own transmitted and verify, via checksum, that the transmitted data has not been corrupted. In the case of corrupted data it will re-transmit the packet after the appropriate bus idle time has elapsed.

Bus packet data:

Packets are transmitted with the 8 least significant bits of the device address followed by the 3 most significant bits of the device address in the 3 lsb of the following byte. The 5 msb of the second byte are the packet header payload. An XOR checksum of all packet bytes follows the packet data.

See examples below.

3 byte packet and example:

[device addr low byte] [5 bit payload, device addr 3 msb] [XOR checksum of bytes 1 and 2]

Example:
device address 257 (0x102) with a payload of 31 (0x1F)

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00000010   11111   001  11111011
Addr lsb   payload msb  checksum
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6 byte packet and example:

[device addr low byte] [5 bit payload, device addr 3 msb] [loco address high] [loco address low] [loco data] [XOR checksum of bytes 1 through 5]

Example: device address 255 (0x0ff) with a payload of 15 (0x0F) detects feedback of data from a loco with the short address of 127 (0x7f). The data is 85 (0x55)

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11111111  01111   000    00000000  01111111   01010101   10101101
Addr lsb  payload msb    short loco address     data     checksum
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Locomotive addresses and data are transmitted in 6 byte packets with the following format:
Long address: <11aa aaaa> <aaaa aaaa> (numerical format is the same as DCC loco address)
Short address: <0000 0000> <0aaa aaaa> (numerical format is the same as DCC short loco address)

Timing Of SigNet bus

At 9600, N, 8, 1 each byte takes 1.041 mS. The bus must remain at idle for 2.0mS after completion of any transmission before the next transmission can start. A transmitting device must not allow more than 300uS between the stop bit of one byte and the start bit of another byte.

Normal Bus Operation

In normal operation sensor/detector devices on the bus produce and transmit data when they have a change of state. Other devices such as signal controllers, computers, etc. monitor the bus and act on the data produced by the various sensors. Signal controllers may elect to send change of aspect information over the bus.

SigNet may be used several ways to control signals:

- Stand alone DC mode – signal controllers use internal logic as they monitor SigNet detectors to set the proper aspect for their signal heads.
- Computer controlled DC mode – a computer monitors detector and turnout position via SigNet then issues aspects for signal heads via SigNet.
- Stand alone DCC mode – signal controllers use internal logic as they monitor detectors and turnout position (either by inputs on the controller or listening to accessory packets) via SigNet to set the proper aspect for signal heads.
- Computer controlled DCC mode – a computer or command station monitors detector and turnout positions via SigNet then issues DCC signal packets to control signal head aspects.
- SigNet can also be used to report locomotive location and data feedback to a computer or command station monitoring SigNet.
- A CTC panel can monitor occupancy or turnout position information via SigNet and display this data.

It is suggested that signal controllers/decoders using DCC signal packets from the track use the same SigNet address as their DCC address. This will simplify control of signals by a computer that monitors SigNet and sends DCC signal packets to signal decoders. Advanced feedback detectors may also provide data to the network in the form of locomotive addresses or locomotive feedback data. The device address of 0x000 is the broadcast address and may be used with the payload code of 0x0d to force all devices to report status which is useful for detecting which device addresses are connected to the network.

Exception Operation of Bus

If a device becomes defective, is misadjusted or has some other reason for continuously transmitting it is possible for another device to 'step in' and tell it to stop transmitting. This is accomplished by violating the 2.0mS idle time between packets by 500uS and sending a packet to the device with the payload code of 0x0b after only 1.5mS idle time.

Power Up Operation of Bus

At power up, all devices report their status. This accomplishes two things.

1) The current state of all detectors and switch positions is now known so signals can be set to their proper aspects.
2) Any computers used for monitoring the layout status are updated with the proper occupancy and signal aspect data.

Power up reporting may take several seconds if the bus is heavily populated.

Bus Packet Data

The first two bytes of data form a packet header with payload. In most circumstances this will serve as a complete packet (along with the checksum). The header consists of an eleven-bit address followed by five bits of packet payload. With certain 5 bit payload configurations three additional data bytes follow the header.

Packet Header payloads

0 0000	Block unoccupied
0 0001	Block occupied
0 0010	Turnout normal
0 0011	Turnout reverse
0 0100	Reserved
0 0101	Reserved
0 0110	Reserved
0 0111	Reserved
0 1000	Reserved
0 1001	Reserved
0 1010	Block shutdown due to short circuit
0 1011	Block power restored
0 1100	Device must stop all reporting (used to 'shut up' bus hogs)
0 1101	Device can resume or start status reporting. Also used to "force" a status report
0 1110	Detected locomotive address follows (loco address is always 2 bytes followed byte 1 dummy byte of 0x00)
0 1111	Address and Data feedback from loco follows (2 bytes loco address then 1 byte data)
1 nnnn	Change to signal aspect 'nnnn' (values range from 0000 to 1111). If a signal driver sends this packet it is announcing it has changed to aspect 'nnnn'. If an addressed signal driver receives this packet it must change aspect to 'nnnn'.

Bold text indicates a 6 byte packet. All other packets are 3 bytes

