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Space data and information transfer systems - CAN data bus communication protocol on spacecraft

空间数据与信息传输系统 航天器CAN总线通信协议

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3 Terms and definitions

3 The terms and definitions given in GB/T 5271.9 and GB/T 42041 together with the following apply to this document.

3.1 node: A device connected to a communication network that is able to communicate over the network according to a communication protocol.

3.2 master node: A node used during the communication process to control and manage the other nodes.

3.3 slave node: A node controlled by the master node during the communication process.

3.4 polling: The process of asking each slave node in turn whether it has data to send.

3.5 selecting: The process of requiring one or more nodes to receive data.

3.6 dominant: Characterizes the logic 0 state in CAN bus communication.

3.7 recessive: Characterizes the logic 1 state in CAN bus communication; it can be overwritten by the dominant state.

4 Abbreviated terms

4 The following abbreviated terms apply to this document.

CAN, controller area network; CRC, cyclic redundancy check; DLC, data length code; IDE, identifier extension; OSI, open system interconnect; RTR, remote transmission request; SJW, synchronization jump width.

5 General principles

5.1 Protocol stack. The CAN bus network is a local area network that contains a single network segment. Compared with the seven layers of the OSI protocol stack, the controller area network itself is described with three layers of protocol: the physical layer, the data link layer and the application layer. Figure 1 shows how the CAN bus communication protocol specified in this document maps onto the OSI layering.

5.1 In that mapping the CAN application layer stands against the OSI application, presentation, session, transport and network layers, its function is the user information exchange protocol and it belongs to the task protocol rather than to this document. The CAN data link layer is divided into the logical link control sub-layer (LLC), whose functions are receive filtering, overload notification and recovery management, and the medium access control sub-layer (MAC), whose functions are data encapsulation and de-encapsulation, frame coding, error detection, error signalling, acknowledgement, serialization and deserialization. The CAN physical layer is divided into the physical coding sub-layer (PCS), whose functions are bit encoding and decoding, bit timing and synchronization, and the physical medium attachment sub-layer (PMA), whose function is the driver electrical characteristics. The data link layer and the physical layer are the part covered by this protocol.

5.2 Bus topology. In a space data and information transfer system, a CAN bus is used inside the spacecraft to connect several computers and so form an on-board network. A dual redundant bus-type topology made up of the two CAN buses A and B is recommended for the spacecraft CAN bus. Figure 2 shows the topology; the assignment of the master node and of the slave nodes is defined by software.

6 Physical layer protocol

6.1 Electrical characteristic parameters. The electrical characteristic parameters of a CAN node in the recessive state are given in Table 1 and those in the dominant state in Table 2. Each table lists the parameter name, its symbol, a minimum, a nominal and a maximum value, and the test condition. In the recessive state, with no load, the bus output voltage V CAN-H and the bus output voltage V CAN-L are each 2.0 V minimum, 2.5 V nominal and 3.0 V maximum; the bus differential output voltage V diff-out is -500 mV minimum, 0 mV nominal and 50 mV maximum, again with no load; the bus differential input voltage V diff-in is -1.0 V minimum and 0.5 V maximum, with no nominal value stated, and a footnote says it is the threshold for receiving a recessive bit.

6.1 In the dominant state, measured with a load of R L/2, the bus output voltage V CAN-H is 2.75 V minimum, 3.5 V nominal and 4.5 V maximum and the bus output voltage V CAN-L is 0.5 V minimum, 1.5 V nominal and 2.25 V maximum; the bus differential output voltage V diff-out is 1.5 V minimum, 2 V nominal and 3.0 V maximum; the bus differential input voltage V diff-in is 0.9 V minimum and 5.0 V maximum, with no nominal value stated, and a footnote says it is the threshold for receiving a dominant bit. A second footnote states that R L is the terminating resistor.

6.2 Bit timing requirements. The nominal bit time is the time taken to send one bit when no resynchronization occurs and is the reciprocal of the nominal bit rate; its structure is shown in Figure 3. The nominal bit time is divided into four segments that do not overlap: the synchronization segment (SYNC_SEG), used to synchronize the different nodes on the bus, within which the transition edge of a bit falls; the propagation segment (PROP_SEG), used to compensate the physical delay inside the network, that delay including the signal propagation time on the bus and the delay inside the CAN node; phase buffer segment 1 (PHASE_SEG1), used to compensate the phase error of a transition edge and able to be lengthened on resynchronization; and phase buffer segment 2 (PHASE_SEG2), used to compensate the phase error of a transition edge and able to be shortened on resynchronization. The sample point, the instant at which each bit value on the bus is read and interpreted, lies at the end of phase buffer segment 1.

6.2 The programming of the bit time depends on the following parameters. The time quantum t SCL is a fixed unit of time determined by the oscillator period and by a programmable prescaler whose value is an integer between 1 and 32. For the nominal length of the bit time with no resynchronization, the synchronization segment is one time quantum long, the propagation segment can be programmed from 1 to 8 time quanta, phase buffer segment 1 can be programmed from 1 to 8 time quanta, and phase buffer segment 2 takes the greater of phase buffer segment 1 and the information processing time, the information processing time starting at the sample point, being the time reserved for computing the next bit level, and being less than or equal to two time quanta. The lengths of the propagation segment and of phase buffer segments 1 and 2 are programmable and the total number of time quanta t SCL in one bit time can be set between 8 and 25.

6.2 Resynchronization is used to correct the position of the sample point, and its effect is to lengthen phase buffer segment 1 or to shorten phase buffer segment 2. SJW sets the upper limit of that lengthening or shortening; SJW is a programmable value taken between 1 and the minimum of PHASE_SEG1 and 4.

6.2 Oscillator frequency tolerance. The oscillator frequency f osc has to satisfy formula (1), and the relation between the maximum tolerance d f and the times of phase buffer segment 1, phase buffer segment 2, SJW and the bit time is given by formulas (2) and (3). The equations are printed as displayed formulas and are not reproduced here. In their legend, f osc is the oscillator frequency in megahertz (MHz); f nom is the nominal oscillator frequency in megahertz (MHz); d f is the maximum tolerance of f osc; t PHASE_SEG1 is the time of phase buffer segment 1 in microseconds (µs); t PHASE_SEG2 is the time of phase buffer segment 2 in microseconds (µs); min (t PHASE_SEG1, t PHASE_SEG2) is the shorter of the two phase buffer segment times in microseconds (µs); t bit is the bit time in microseconds (µs); and t SJW is the SJW time in microseconds (µs). The oscillator frequency tolerance used by the CAN bus controller has to satisfy formulas (2) and (3), and the tolerance used by a spacecraft CAN bus controller is generally not greater than 0.1 %.

6.3 Bit rate. A high-speed CAN bus supports bit rates in the range 125 kbps to 1 Mbps. The recommended choices are 500 kbps for a bus length not greater than 130 m and 1 Mbps for a bus length not greater than 40 m.

6.4 Bus cable. Twisted pair is used for the bus cable and its physical parameters are given in Table 3, which lists a minimum, a nominal and a maximum value for each parameter. The impedance is 95 minimum, 120 nominal and 140 maximum, expressed in ohms. The resistance per unit length has a nominal value of 70, expressed in milliohms per metre, with no minimum and no maximum stated. The specified line delay has a nominal value of 5, expressed in nanoseconds per metre, with no minimum and no maximum stated. A first footnote says that the differential voltage at the receiving node should take into account the effect of the conductor resistance between the transmitting node and itself; a second says that the bus delay should take into account the transceiver delay and the cable propagation delay, that is, PROP_SEG is greater than twice the bus delay.

6.5 Connection method. The CAN bus drivers CAN-L and CAN-H of each communication