Controller Area Network (CAN)
What is Controller Area Network (CAN)?

- Controller Area Network (CAN), as its name implies, is the network established among microcontrollers.
- It is a two-wire high-speed network system which was firstly established to overcome the problems (wire harness, communication) faced in automobiles.
- CAN can be theoretically linked up to 2032 devices (assuming one node with one identifier) on a single network.
- However due to the practical limitation of the hardware (transceiver), it can link up to 110 nodes (with 82C250, Philips) on a single network.
- CAN offers high-speed communication up to 1 Mbits/sec, thus allowing real-time control.
- the Error Confinement and the error detection features make it more reliable in noise critical environments.
Who developed CAN?

- CAN was first developed by Robert Bosch GmbH, Germany in 1986 when they were requested to develop a communication system between three ECU's (electronic control units) in a vehicle by Mercedes.

- They found that UART is no longer suitable in this situation because it is used in point-to-point communication. The need for a multi-master communication system became imperative.

- The first CAN silicon was then fabricated in 1987 by Intel.

- In 1993, CAN became the ISO 11898 standard "Road Vehicles - Interchange of Digital Information - Controller Area Network (CAN) for high-speed Communication".
How does CAN work?

- CAN transmits signals on the CAN bus which consists of a CAN-High and CAN-Low.
- These 2 buses are carrying signals opposite to each other (to overcome noise interruption that simultaneously interfere on the bus)
- The voltage level corresponds to recessive (logical "1") is 2.5 Volts and dominant (logical "0") are 3.5 Volts for CAN-High and 1.5 Volts for CAN-Low respectively
- The voltage level on the CAN bus is recessive when the bus is idle.
- CAN uses bit arbitration technique in which the priority of accessing the bus is determined by the 11-bit identifier.
- Due to the architecture that "dominant" bit will always override "recessive" bit, the node with lower identifier will have higher accessing priority. This is part of the contribution from CSMA/CD-NDBA.
What are the features of CAN?

CAN's features include:

- Low cost.
- Extremely robust
- High speed (up to 1 MBits/sec)
- Reliable. Error handling and Error Confinement
- Automatic retransmitting of the faulty data
- Automatic disconnect of nodes which are suspected to be physically faulty
- Functional Addressing, i.e. no source/destination address, the data are "broadcasted" on the network.
CAN features

- Bus-access by message priority
  - CSMA/CR
    Carrier Sense Multiple Access / Collision Resolution
- Bus access conflicts resolved by arbitration
  - Bit-wise
  - Non-destructive
  - Allows for guaranteed latency time
- Message identifier
  - CAN has no node addresses
    Every node receive every message and decides itself whether to use it or not
CAN features

• Extensive ERROR checking
  – Five different checks
  – Every connected node participate

• Data consistency secured
  – A message is accepted by all nodes or none

• Different Bus Management Methods can be applied for CAN systems, e.g.,
  – Bit-wise arbitration
  – Master/Slave
  – Daisy Chain
  – TDMA
CAN features

• A Higher Layer Protocol is always required
  – CAN is only a low level specification
• The capability of CAN is restricted by the Higher Layer Protocol chosen
  – Market segment
  – Real-time requirements
  – Product Administration requirements
  – etc
What is CSMA/CD-NDBA?

- CSMA/CD-NDBA stands for Carrier Sense Multiple Access with Collision Detect.
- Majority of the low cost communication systems use baseband transmission techniques. The problem arises when many nodes are trying to transmit at one time, which results in a collision.
- With CSMA/CD the accessing of the bus is done by sensing (listening) the carrier on the bus (carrier sense), and transmit only when the bus is idle.
- When a collision is detected, all nodes which initiate the transmission will pull back to "listen" again until random time passed before the retransmission.
- To overcome this problem, NDBA technique is included. NDBA stands for Non-Destructive Bit Arbitration.
- NDBA guarantees the bit sent on the bus would not be destroyed when there is a collision. In CAN point of view, dominant bit (logical "0") will override recessive bit (logical "1"), the resultant bit on the bus will appear to be dominant, thus it would not be destroyed and can continue sending the remaining bits.
Physical layer

- CAN is differential - for noise cancellation
- Signal polarity will depend on whether you monitor CAN_H or CAN_L
- Up to 1Mbit/s (125kHZ here)
- CAN bus requires terminating.
Bit-wise Arbitration

Dominant

Recessive

Arbitration Lost

Module 1

Module 2

Bus Line
Bit-wise arbitration

The green node starts transmission of a recessive bit on the idle bus.
Bit-wise arbitration

The wave from the green node has not yet reached the red node. To this the bus is still free and the red node starts transmitting a dominant bit.
Bit-wise arbitration

Now the green node can see that there is a dominant bit on the bus and that it has lost arbitration. Thus a transmitter has to wait until the wave has reached the most distant node and back (plus internal delays) before judging the bus-line level.
Bit Stuffing

Five consecutive bits of same polarity render a stuff bit.
THANK YOU