Devices and Buses for Device-Networks – Lesson-3: Serial Communication Buses

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I^2C Bus

- Number of device circuits in a number of processes in a plant
- One IC used for measuring temperatures and pressures
- These ICs are mutually network through a common synchronous serial bus. I^2C is popular bus for these circuit.

1. Serial Communication Inter- Integrated Circuit Bus (I^2C) Bus

Three standards:

- 100 kbps Industrial I^2C,
- 100 kbps SM I^2C,
- 400 kbps I^2C

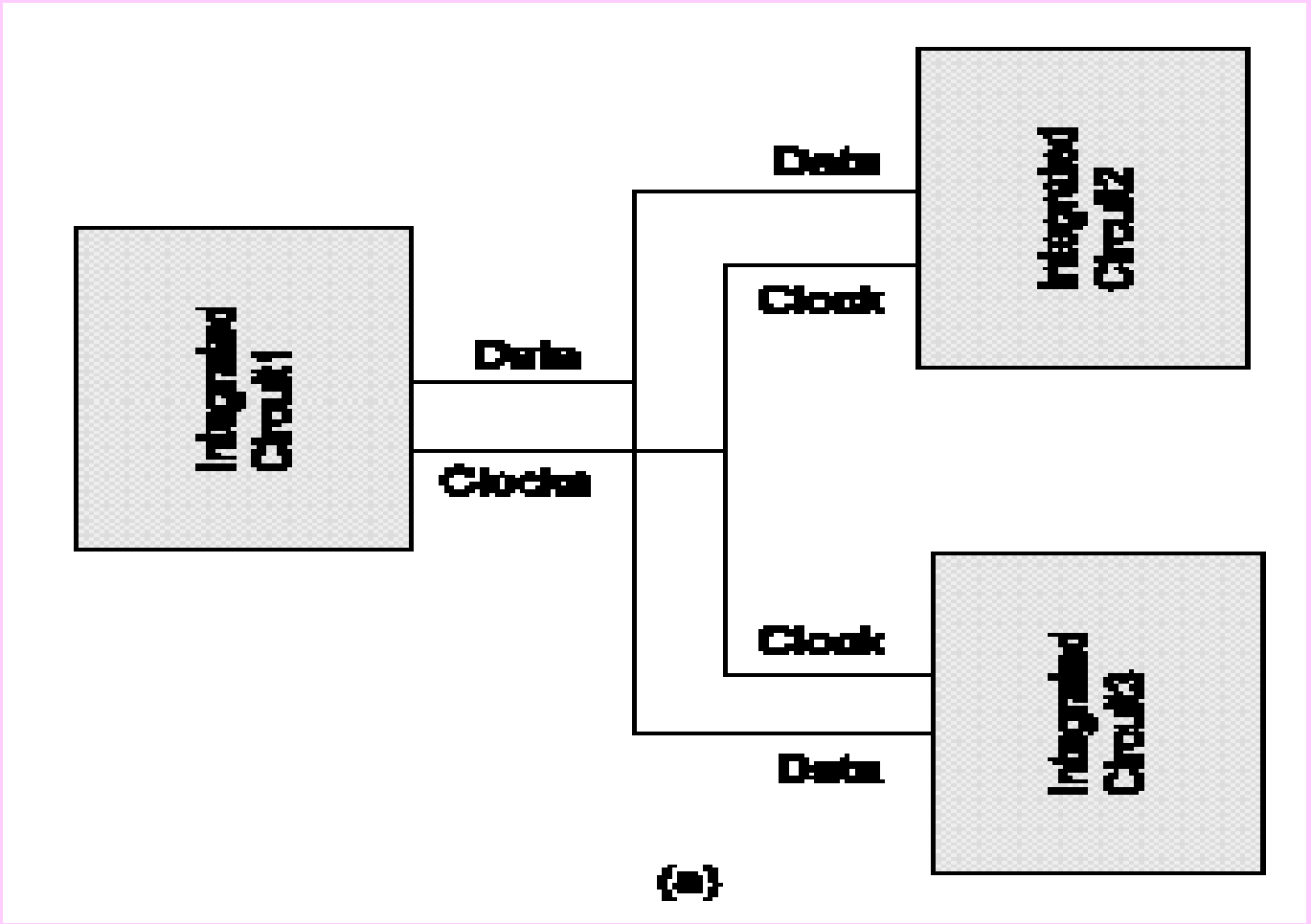
I^2C Bus

- I^2C originally developed at Philips Semiconductors.
- I^2C Bus has two lines which carry signals
  - One line for clock
  - Another for bidirectional data
- Each device has an address through which data transfer takes place. The master can address 127 other slaves at an instance.

I^2C Bus

- It has a processing element functioning as a bus controller or a microcontroller with I^2C Bus interface circuit
- Each slave can also optionally have an I^2C bus controller and processing element. A number of masters can also connect to the bus.

Inter ICs Signals



- However, at any instance, there can be only one master, which is one that initiates a data transfer on SDA(serial data) line and which transmits the SCL (serial clock)pulses.
- The disadvantages of this bus is the time taken by algorithm in master hardware that analyses the bits through I^2C in case the slave hardware doesn't provide for the hardware that supports it.

I^2C Data Transfer rate

- Synchronous Serial Communication 400 kbps up to 2 m and 100 kbps for longer distances

I^2C protocol defines the frame bits

1) First from a sending device (called master)- a start bit like an UART start bit

2) The receiving device (called slave) address communicated by

Second field of 7 bits called address field. It defines the slave address, which is being sent the data frame (of many bytes) by the master.

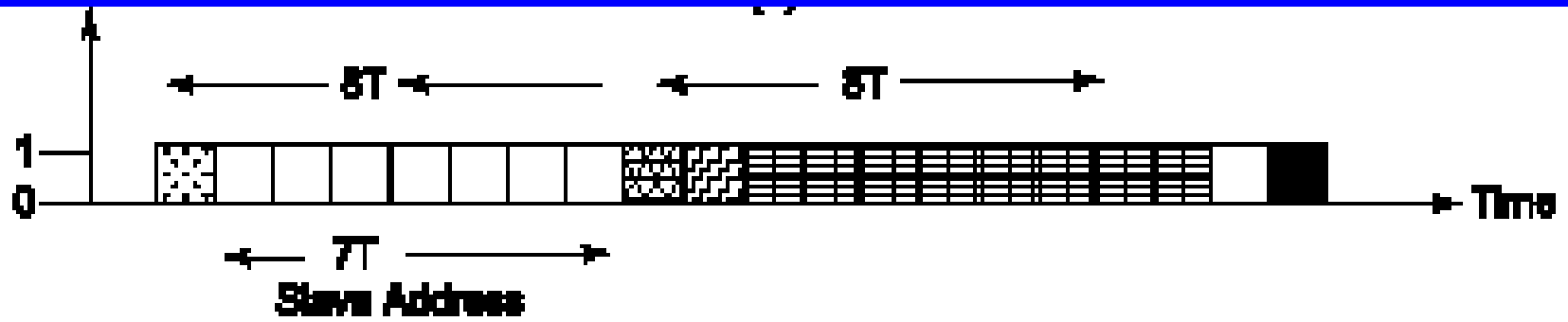
- The transmitting device address not defined because only one master sends to the destined slave
- The frame-length not defined because like an UART only 8 bits of information (like temperature data) transmit at an instance in the frame on the bus data. Receiving device already know the frame-size in advance.

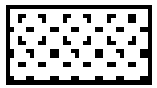
3) Frame-content specifications are by the 3rd and 4th

3rd field - 1 control bit : defines whether a read or write cycle is in progress.

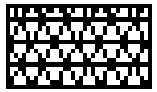
4th field - 1 control bit: defines whether the present data is an acknowledgment (from the slave)

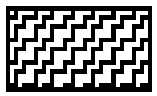
Format of the Bits

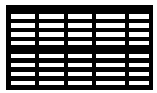



Start Bit


Start Address Bit


Read/Write Indicating Bit


Acknowledgement Bit


Data Bits


NACK Bit


Stop Bit

4) Frame Data is at the 5th field of 8 bits

It is for IC device data byte.

5) Sixth field of 1-bit : It is a NACK (negative acknowledgement). If active then acknowledgment after the transfer is not needed from the slave, else acknowledgement is expected from the slave.

- Not succeeded by the frame trailing bits. Receiving device does not check the errors, if any in reception and detect end of the frame.

6) Last 7th field of 1-bit is a stop bit like an UART stop bit

2. Serial Communication Distributed Control Area Network (CAN) Bus

- Distributed Control Area

Network Application example - a network of embedded systems in an automobile

CAN Bus

- Number of devices and controllers are located and are distributed in a car
- An automobile uses number of distributed embedded controllers, including those for the brakes, engine, electric power, lamps, inside temperature control, air-conditioning, gate, front dash board display, meter display panel etc.
- Embedded controllers must network through a bus.
- CAN bus is a standard bus in distributed network.
- It is mainly used in automotive electronics.
- Also used in medical electronics and industrial plant controllers.

CAN Bus

- CAN bus network has a serial line, which is bi-directional. It has multimaster and multicast features.
- A CAN device sends and receives bits at a rate of 1Mbps.

Three standards:

- 33 kbps CAN,
- 110 kbps Fault Tolerant CAN,
- 1 Mbps High Speed CAN

Each field in a CAN frame

- First field of 12 bits
  - Contains packet's 11-bit destination address and RTR bit (remote transmission request)
  - Destination address specified by 11-bit
  - RTR is defined on the basis of whether the data byte being sent is a data for the device or a request to the device
  - If RTR = 1, packet is for the device at destination address
  - If RTR = 0, (dominate state) packet is a request for the data from the device

Each field in a CAN frame

- Second field of 6 bits
  - Control field

Third field of 0 to 64 bits

length depend on the data length code in the control field

Fourth field of 16 bits

it is CRC (cyclic redundancy check) field 15 bits CRC pin and 1-bit destination bit

the receiver node uses it to detect errors, if any, during the transmission

Each field in a CAN frame

Fifth field of 2 bits

First bit is ACK slot. The sender sends it as 1 and the receiver, which would send back 0 in this slot when it detects error in reception. The sender after sensing 0 in the ACK slot, retransmits the data frame.

The second bit is the 'ACK delimiter' bit. It signals the end of ACK field. If the transmitting node does not receive any acknowledgement of data frame within a specified time slot, it should retransmit.

Sixth field of 7 bits: This is the end of the frame specification and has seven 0s.

CAN protocol defines the frame bits [Refer Table 3. 3]

1) There is a CAN controller between the CAN bus-line and host nodes. CAN controller has BIU (Bus Interface Unit) consisting of the buffer and driver
2) Method for arbitration is CSMA/AMP (Carrier Sense Multiple Access with Arbitration on Message Priority basis)

Each Distributed Node Uses:

- Twisted Pair Connection up to 40 m –for bi-directional data Line, which pulls to Logic 1 through a resistor between the line and + 4.5V to +12V
- Line Idle state is Logic 1

Each Distributed Node:

- Uses a buffer gate between an input pin and the CAN line
- Detects Input Presence at the CAN line pulled down to dominant (active) state logic 0 (ground ~ 0V) by a sender to the CAN line

Each Distributed Node:

- Uses a current driver between the output pin and CAN line and pulls line down to dominant (active) state logic 0 (ground ~ 0V) when sending to the CAN line

- Data frame starts with logic 1 and ends with seven logic 0s after first detecting that dominant state is not present at the CAN line

3. Universal Serial Bus (USB) Bus

Three standards:

- 1.5 Mbps Low speed 3 m channel and 12 Mbps High speed 25m channel) USB1.1,
- 480 Mbps High speed 25 m USB 2.0

Example of Devices using USB Bus

- Pen drive
- Memory Stick
- Printer
- Scanner
- Mobile playing station attachment to computer through a cradle

Important Features:

- A USB device can be attached, configured and used, reset, reconfigured and used, share the bandwidth with other devices, detached (while others are in operation) and reattached and has *plug and play* device feature.

- Hot attachment, which means computer system need not restart when the device is plugged-in

- USB devices are at the:
  - Hubs, which gives the additional attachment points to the USB device
  - Functional nodes, which gives the applications for examples digital camera USB port, scanner USB port, ISDN connection

Summary

We learnt the I^2C, CAN and USB buses:

- (i) I^2C is a serial bus for interconnecting ICs. It has start and stop bits as in an UART. It has seven fields for start
- 7-bits address, defining a read or write, defining byte as acknowledging byte, data byte, NACK and end.

We learnt

- (ii) CAN is a serial bus for interconnecting a central control network. Exemplary use is in automobiles. It has fields for bus arbitration bits, control bits for address and data length, data bits, CRC check bits, acknowledgement bits and ending bits

We learnt

- (iii) USB protocol has features—a USB device can be configured and used, reset, reconfigured and used, share the bandwidth with other devices, detached (while others are in operation) and reattached. USB devices are plug and pay devices with hot attachment features.

We learnt

- (iv) There are many new emerging serial communication and bus protocols, which give the very high speed Gbps + devices

End of Lesson 3 of Chapter 3