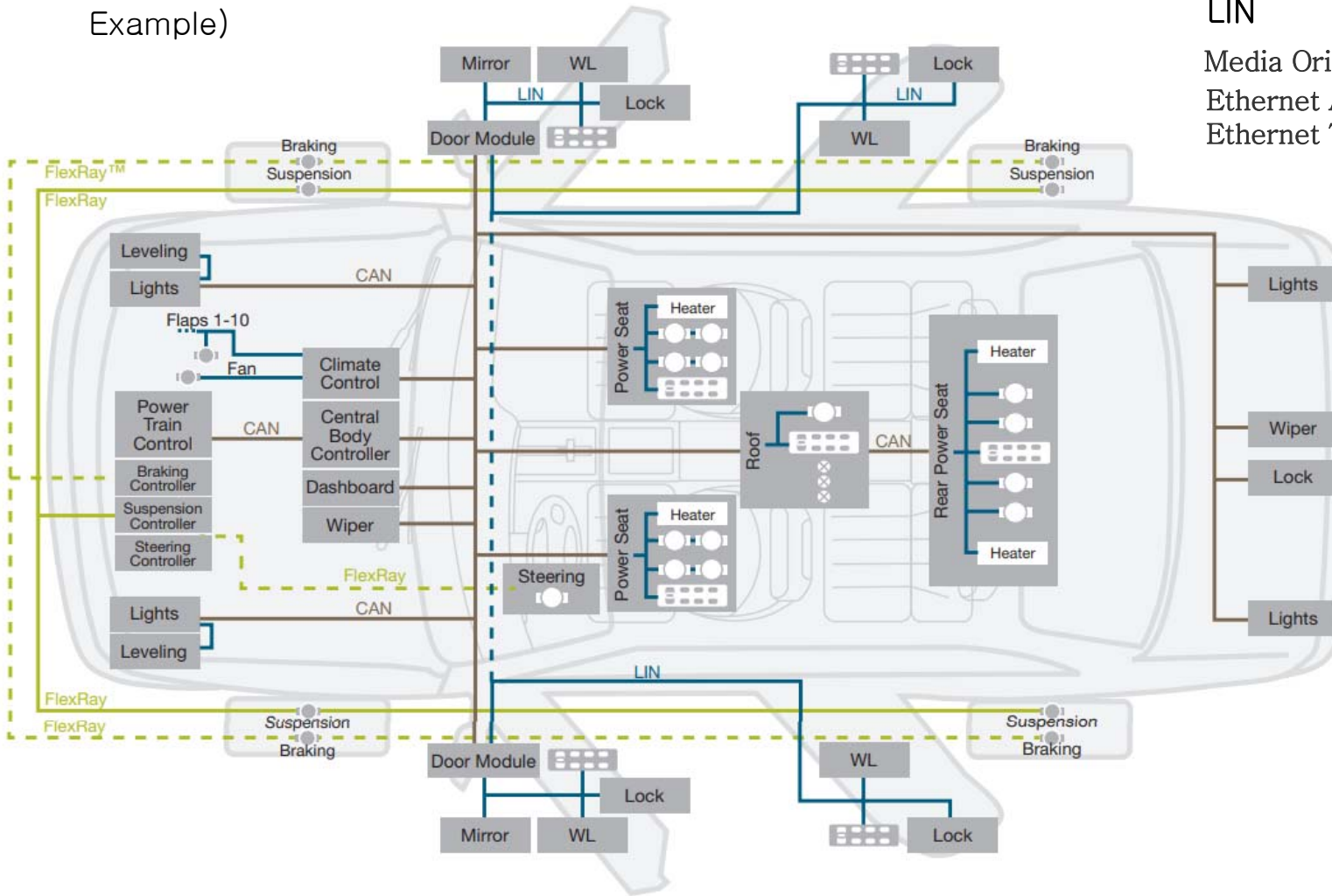


# In-Vehicle Network

Example)



CAN

LIN

Media Oriented Systems Transport (MOST)

Ethernet AVB (Audio Video Bridging)

Ethernet TSN (Time-Sensitive Networking)

<https://www.nxp.com/docs/en/brochure/BRINVEHICLENET.pdf>

# RS-232C

ASCII 전송      1:1 방식

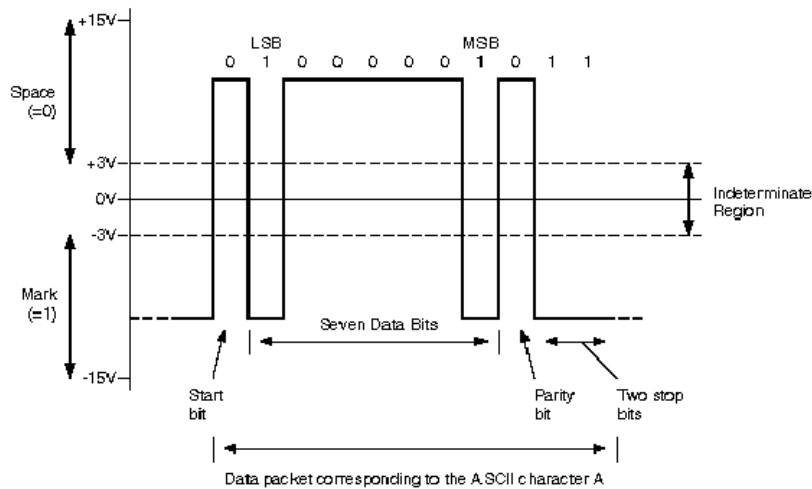
data와 parity를 포함하여 1의 개수가 짝수가 되게 하는 것; even parity  
 data와 parity를 포함하여 1의 개수가 홀수가 되게 하는 것; odd parity

Baud rate: 1초 동안에 보내는 bit 수

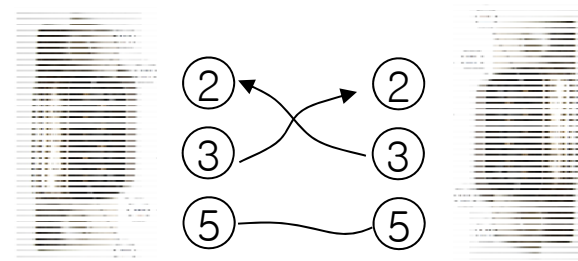
Data의 bit 개수  
 Parity bit 종류  
 Stop bit 개수

## RS232 logic and voltage levels

Data circuits	Voltage
0 (space)	+3 to +15 V
1 (mark)	-15 to -3 V



DB-25 Pin No.	DE-9 Pin No.	Abbreviation	Full Name
Pin 2	Pin 3	TD	Transmit Data
Pin 3	Pin 2	RD	Receive Data
Pin 4	Pin 7	RTS	Request To Send
Pin 5	Pin 8	CTS	Clear To Send
Pin 6	Pin 6	DSR	Data Set Ready
Pin 7	Pin 5	SG	Signal Ground
Pin 8	Pin 1	CD	Carrier Detect
Pin 20	Pin 4	DTR	Data Terminal Ready
Pin 22	Pin 9	RI	Ring Indicator



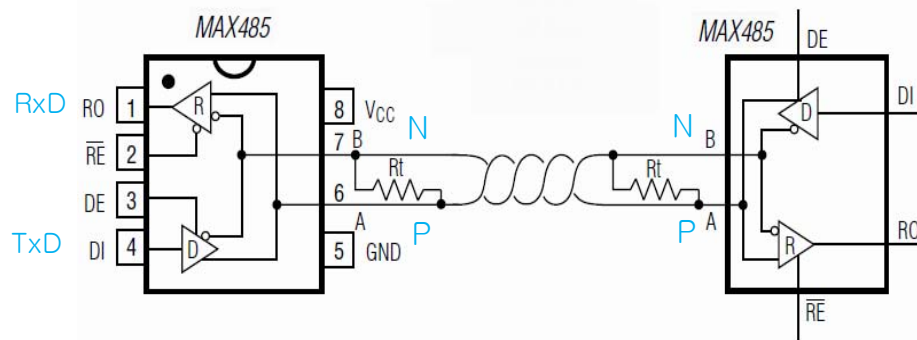
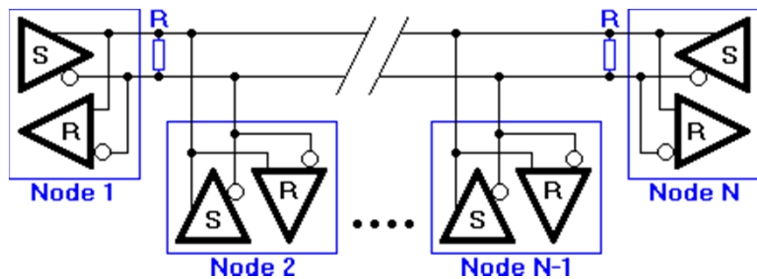
Start bit-data bit-parity bit-stop bit

# RS-485

## Multi-master 방식

- 2개의 선을 이용
- 2개 선의 전압 차이를 이용하여 1 과 0을 표현
- 장치마다 국번 (station number)를 부여

## RS485 network topology

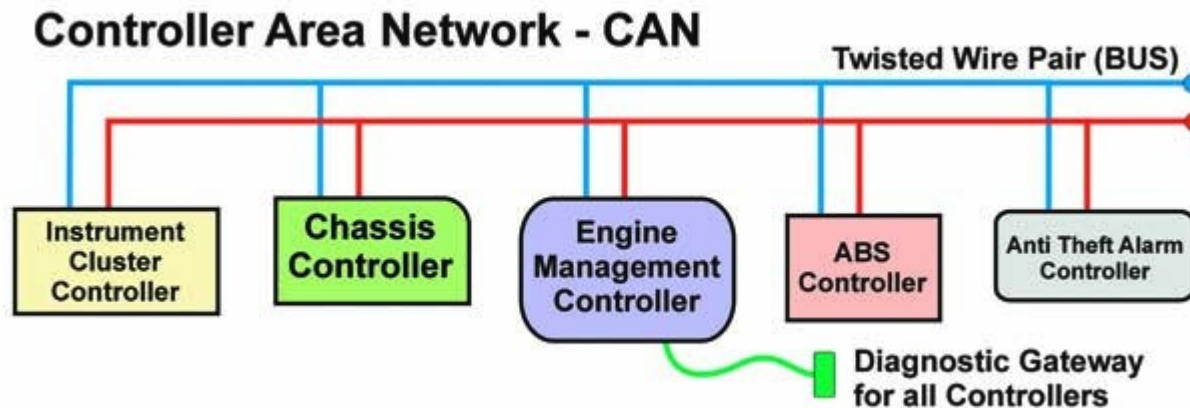


## RS-232C vs. RS485

	RS232	RS485
Differential	no	yes
Max number of drivers	1	32
Max number of receivers	1	32
Modes of operation	half duplex full duplex	half duplex
Network topology	point-to-point	multipoint
Max distance (acc. standard)	15 m	1200 m
Max speed at 12 m	20 kbs	35 Mbs
Max speed at 1200 m	(1 kbs)	100 kbs
Max slew rate	30 V/ $\mu$ s	n/a
Receiver input resistance	3..7 k $\Omega$	$\geq$ 12 k $\Omega$
Driver load impedance	3..7 k $\Omega$	54 $\Omega$
Receiver input sensitivity	$\pm$ 3 V	$\pm$ 200 mV
Receiver input range	$\pm$ 15 V	-7..12 V
Max driver output voltage	$\pm$ 25 V	-7..12 V
Min driver output voltage (with load)	$\pm$ 5 V	$\pm$ 1.5 V

## Controller Area Network (CAN)

- Developed by Robert Bosch GmbH for automotive applications in the early 1980s
  - publicly released in 1986. The Bosch CAN specification became an ISO standard (ISO 11898) in 1993 (CAN 2.0A), and extended in 1995 to permit longer device identifiers (CAN 2.0B).
  - CAN interconnects a network of modules (or nodes) using two wire, twisted pair cable.
- 
- ISO 11898 : 1Mbps 이상의 고속 통신 가능
  - ISO 11519 : 125Kbps 까지의 통신 가능



<https://www.quartoknows.com/blog/quartodrives/controller-area-network-can>

## Controller Area Network (CAN)

- 다중 통신망 (Multi Master Network). CSMA/CD+AMP

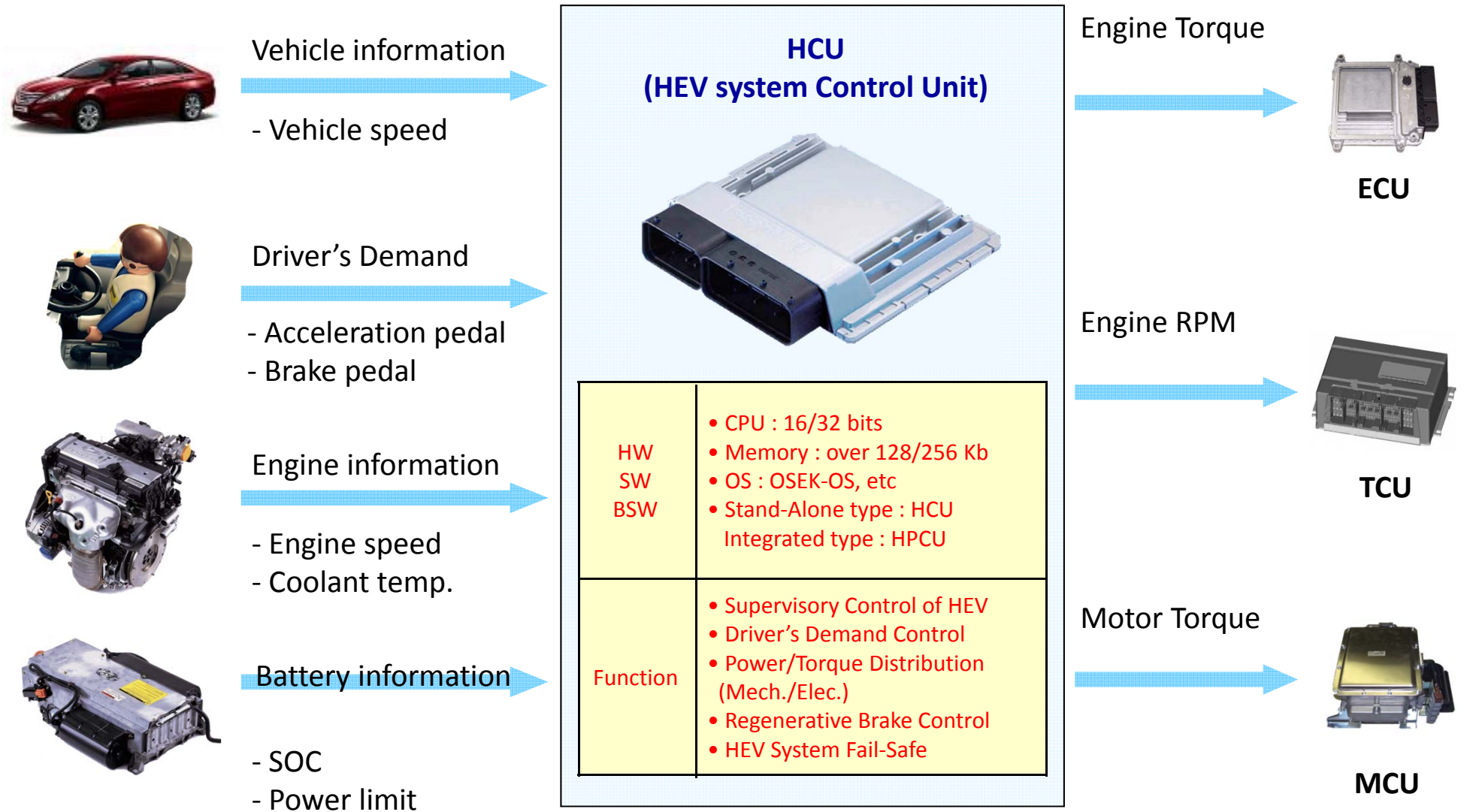
(Carrier Sense Multiple Access / Collision Detection with Arbitration on Message Priority) 방식.

- 먼저 CAN Node 에 메시지를 보내기 전에 CAN 버스 라인이 사용 중 인지를 파악.
- 메시지 간 충돌 검출을 수행.
- 어떠한 Node (시스템)로부터 보내어진 데이터 메시지는 송신측이나 수신측의 주소를 포함하지 않음.
- 데이터 메시지 항목에 유일한 식별자 (ID-11bit 또는 29bit)를 갖고 있음.
- 네트워크상에 연결된 모든 노드 (CAN Controller 시스템)는 네트워크상에 있는 메시지를 수신한 후 자신에게 필요한 메시지인지를 식별자를 통하여 평가한 후 자신이 필요로 하는 식별자의 메시지인 경우만 취하고 그렇지 않은 경우의 메시지는 무시.
- 식별자의 숫자를 비교하여 먼저 취할 메시지의 우선순위를 정함.  
식별자의 숫자가 낮은 경우가 우선순위가 가장 높다. (식별자가 1 인 경우가 10 인 경우보다 우선순위가 높음)  
우선순위가 높은 메시지가 CAN 버스의 사용 권한을 보장 받으며 이때 낮은 순위의 메시지는 자동적으로 다음 버스 사이클에 재전송,  
이때 까지도 높은 우선순위를 가진 메시지가 완료되지 않은 상태이면 전송을 완료할 때까지 대기함.

CAN has four frame types:

- **Data frame**: a frame containing node data for transmission
- **Remote frame**: a frame requesting the transmission of a specific identifier
- **Error frame**: a frame transmitted by any node detecting an error
- **Overload frame**: a frame to inject a delay between data and/or remote frame

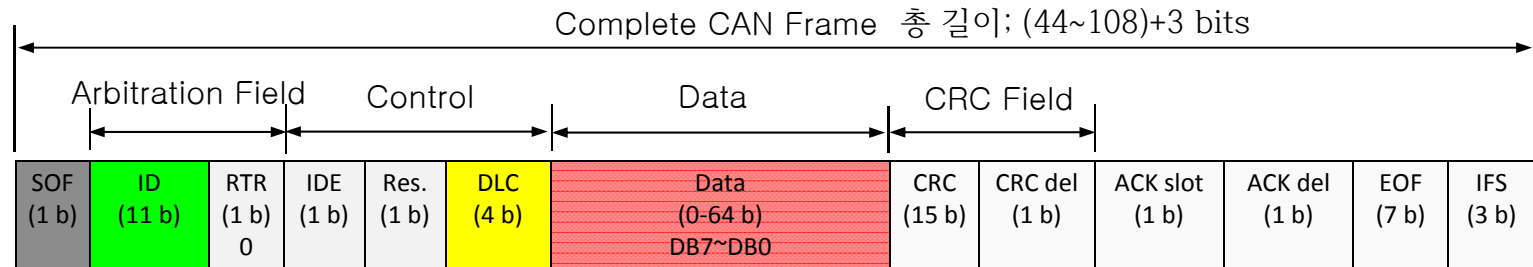
• Controls based on CAN Network



# Controller Area Network (CAN)

## CAN Base Frame (CAN Data Frame)

Ver. 2.0A

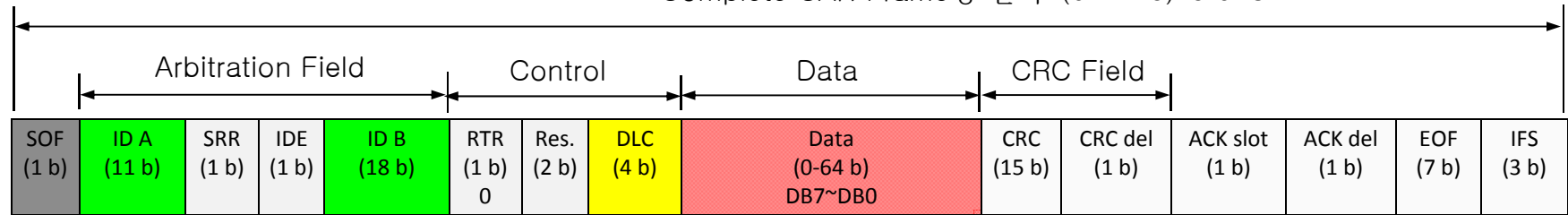


Field name	Length (bits)	Purpose
Start-of-frame	1	Denotes the start of frame transmission
Identifier	11	A (unique) identifier for the data which also represents the message priority
Remote transmission request (RTR)	1	Dominant (0) (see Remote Frame below)
Identifier extension bit (IDE)	1	Declaring if 11 bit message ID or 29 bit message ID is used. Dominant (0) indicate 11 bit message ID while Recessive (1) indicate 29 bit message.
Reserved bit (r0)	1	Reserved bit (it must be set to dominant (0), but accepted as either dominant or recessive)
Data length code (DLC)	4	Number of bytes of data (0-8 bytes)
Data field	0-64 (0-8 bytes)	Data to be transmitted (length in bytes dictated by DLC field)
CRC	15	Cyclic redundancy check
CRC delimiter	1	Must be recessive (1)
ACK slot	1	Transmitter sends recessive (1) and any receiver can assert a dominant (0)
ACK delimiter	1	Must be recessive (1)
End-of-frame (EOF)	7	Must be recessive (1)

# Controller Area Network (CAN)

CAN Base Frame (CAN Data Frame)  
Ver. 2.0B

(8~16) byte+ 3bit  
Complete CAN Frame 총 길이; (64~128)+3 bits



Field name	Length (bits)	Purpose
Start-of-frame	1	Denotes the start of frame transmission
Identifier A	11	A (unique) identifier for the data which also represents the message priority
Substitute Remote Request (SRR)	1	Must be recessive (1) (optional)
Identifier extension bit (IDE)	1	Must be recessive (1) (optional)
Identifier B	18	Second part of the (unique) identifier for the data which also represents the message priority
Remote transmission request (RTR)	1	Dominant (0) (see Remote Frame below)
Reserved bit (r1, r0)	2	Reserved bit (it must be set to dominant (0), but accepted as either dominant or recessive)
Data length code (DLC)	4	Number of bytes of data (0~8 bytes)
Data field	0~64 (0-8 bytes)	Data to be transmitted (length in bytes dictated by DLC field)
CRC	15	Cyclic redundancy check
CRC delimiter	1	Must be recessive (1)
ACK slot	1	Transmitter sends recessive (1) and any receiver can assert a dominant (0)
ACK delimiter	1	Must be recessive (1)
End-of-frame (EOF)	7	Must be recessive (1)

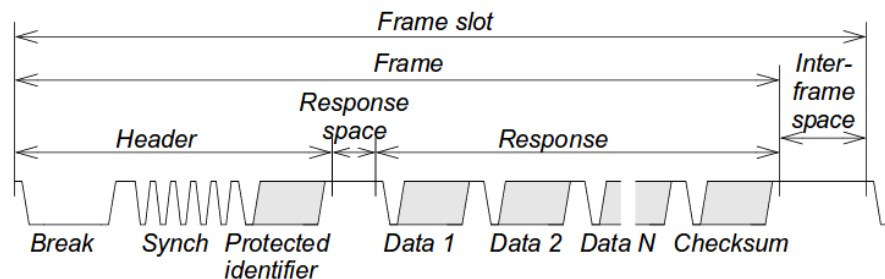
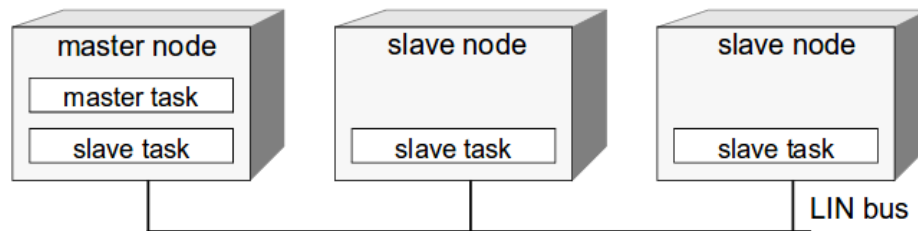


## Local Interconnect Network (LIN)

LIN PROTOCOL — ONE WIRE PROTOCOL FOR AUTOMOTIVE APPLICATIONS

LIN stands for Local Interconnect Network. According to the official LIN manual, the main properties of the LIN bus are:

- single master with multiple slaves concept.
- low cost silicon implementation based on common UART/SCI interface hardware, an equivalent in software, or as pure state machine.
- self synchronization without a quartz or ceramics resonator in the slave nodes.
- deterministic signal transmission with signal propagation time computable in advance low cost single-wire implementation.
- speed up to 20 kbit/s.
- signal based application interaction.



Synch: 0x55

LIN Specification Package  
Revision 2.0

September 23, 2003; Page 1

LIN Consortium, 2003.

anthony.moschella@ni.com

## CAN과 LIN 비교

	<b>LIN</b>	<b>CAN</b>
Automotive Use	Sub-networks	Networks
Medium Access Control	Single Master	Multiple Master
Bus Speed	2.4 – 19.6 KBaud (limited by EMI and clock synchronization considerations)	62.5 – 500KBaud
Typical Number of Nodes	2 – 10	4 – 20
Physical Layer	Single wire at battery voltage plus ground	Twisted Pair at 5V
Master Clock Generation	Crystal	Crystal
Slave Clock Generation	RC	Crystal or Resonator
Relative Cost	1/2	1