Diagnostic Communication of Vehicles

Electronic Transmission Control
GS-TC/ENC-Bp
Piroska, László

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Main Functionality of an Automotive Control Unit

- Main task: Fulfill its controlling functionality (e.g. control transmission unit)
- Measure and collect the needed data for its main tasks
- Check and filter the incoming / measured signals
- Detect and log errors
- In case of error – according to the type – surmount error, or restrict functionality
- Configuration interface
- Automatic adaptation to environment
- Protection against stealing / manipulation
- Fulfill international and local standards
- Programmable / Patchable
- Provide information to other control units
- Communicate with an external tester

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Goals of the Diagnostic Communication I.

- Main task: Fulfill its controlling functionality
- Measure and collect the needed data for its main task
  - Continuous observation of the control unit
  - Check reactions of the control unit
- Check and filter the incoming / measured signals
- Detect and log errors
  - Read error memory (source of the error, art and status)
  - Check reliability of incoming / measured signals

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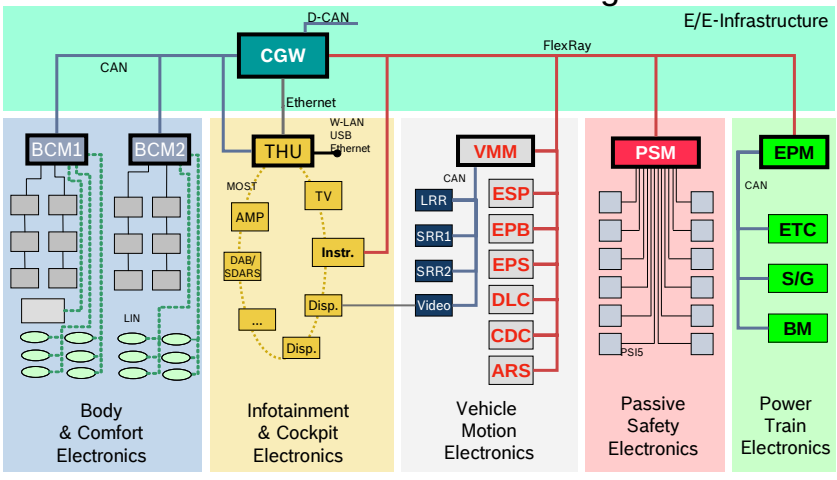
Goals of the Diagnostic Communication II.

- In case of error: surmount error or restrict own functionality according to the type of error
  - Read out error code
  - Provide information to find the source of the error
- After fixing error clear error memory
- Provide information to other control units
- Configuration interface
  - Read and write configurable parameters (adapting to the other control units or local law)
- Automatic adaptation to environment
  - Be able to clear learning values

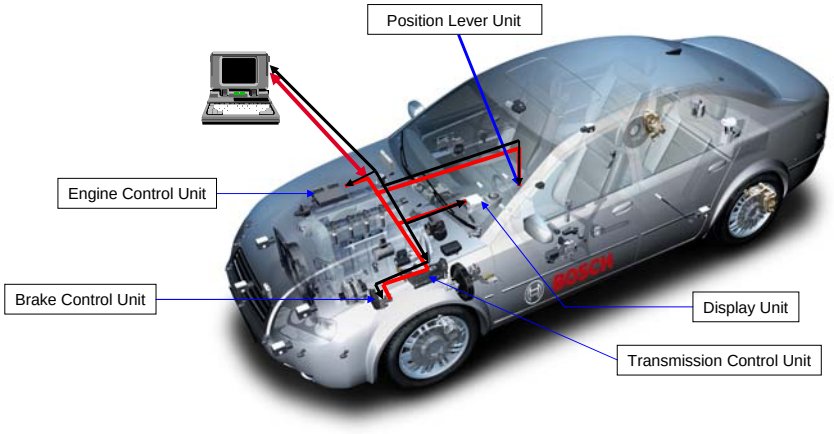
Goal of the Diagnostic Communication III.

- Protection against stealing / manipulation
  - Authentification of ignition key and other control units
  - Chip-tuning protection
- Programmable / Patchable
  - The main part of the control unit SW can be reprogrammed
- Should fulfill international and local standards
  - CARB (Californian Air Resource Board) /
  - OBD (OnBoard Diagnostic)
  - EOBD (European OnBoard Diagnostic)
  - KOBD (Korean OnBoard Diagnostic)
  - ISO 14229 / ISO 14230 / ISO 15031 / ISO 15765 / ISO 11898
  - …

Vehicle Network Architecture in a High End Car



Communication System in the Vehicle



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Applicability and relationship between international standards

Applicability	OSI 7 layer	Enhanced diagnostics services (non emission-related)	
	Application (layer 7)	ISO 14229 / ISO 15765-3	ISO 14229 / ISO 14230-3
Seven layer	Presentation (layer 6)	---	---
according to	Session (layer 5)	ISO 15765-3	ISO 14230-3
ISO/IEC 7498	Transport (layer 4)	ISO 15765-2	---
and	Network (layer 3)	ISO 15765-2	---
ISO/IEC 10731	Data link (layer 2)	ISO 11898	ISO 14230-2
	Physical (layer 1)	ISO 11898	ISO 14230-1
		CAN	K-Line

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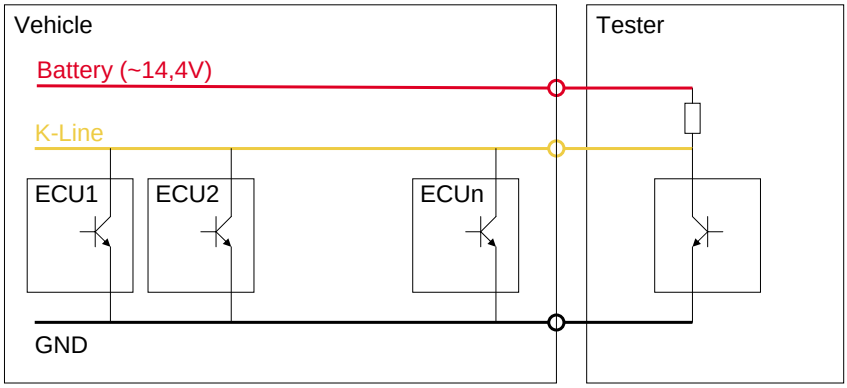
K-Line Layer 1



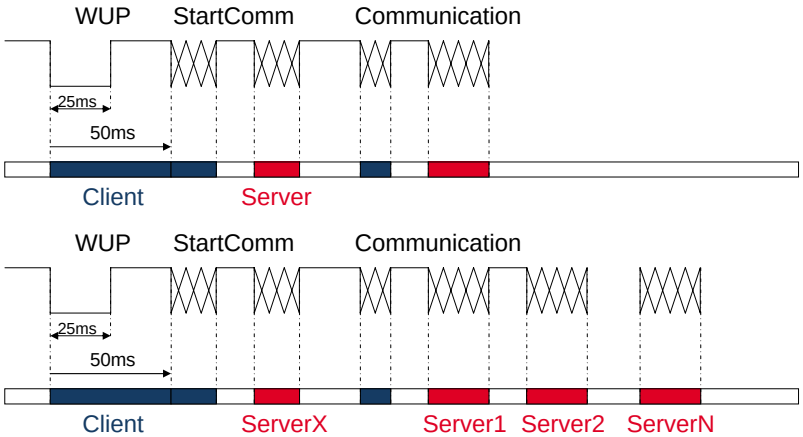
K-Line Layer 1

- Logical 0:
  - K-Line is under 20% of battery voltage at transmitter side
  - K-Line is under 30% of battery voltage at receiver side
- Logical 1:
  - K-Line is above 80% of battery voltage at transmitter side
  - K-Line is above 70% of battery voltage at receiver side

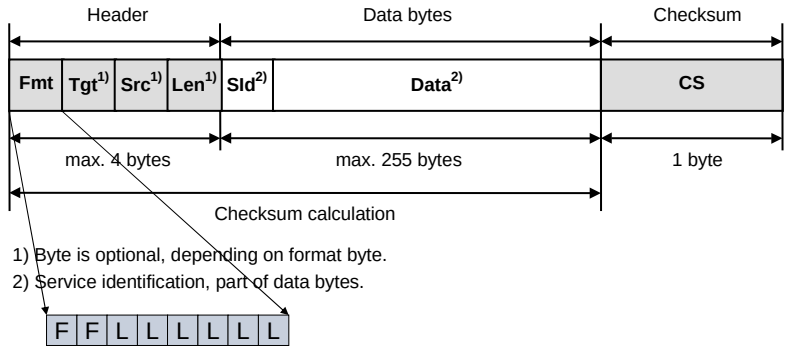
K-Line Layer 2: Overview

- No continuous communication: must be initialized by tester (WUP or 5BaudInit)
- No communication between the control units
- Each host has one or more fix addresses; multicasting is also possible
- Fixed Baud-rate at start of the communication (10.4 kBaud), it can be changed (until 250kBaud)
- Defined but configurable timeout values for communication session, request – response, response – next request separation time
- Initialization phase determines several format parameters of the further communication
- Arbitration: CSMA/CD

K-Line Layer 2: Initialization



K-Line Layer 2: Message Structure



1) Byte is optional, depending on format byte.
2) Service identification, part of data bytes.

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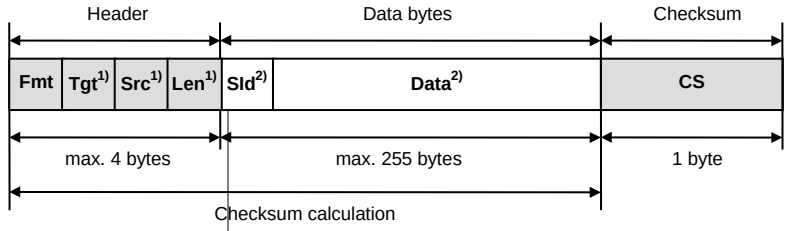
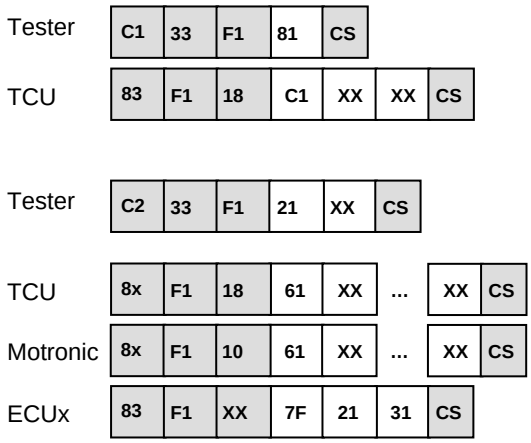
KWP2000 – K-Line, Layer 5-7: Service IDs



- 0x01 – 0x3E, 0x80 – 0xBF: Possible Service IDs
- SID + 0x40: positive response
- 0x7F: negative response

KWP2000 – K-Line, Layer 5-7: Service IDs: Example



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K-Line

- Reserved for diagnostic communication
- Longer data packets can be transmitted
- Configurable communication speed
- Arbitration must be implemented by SW (UART)
- Additional wire + HW Component (Layer1)
- Additional SW Driver for Layer 2

CAN

- Diagnostic & continuous communication between ECUs
- A CAN frame is max. 8 bytes: encapsulation of request required
- Fixed speed: because of the continuous bus configuration
- Bus arbitration, CAN-frame structure is handled by HW
- Wire + required HW component already exists
- SW Drivers already exist, only sw of diagnostic communication must be implemented

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CAN Layer 1 and Layer2

- Defined by ISO 11898

CAN Layer 3 and Layer4

	CAN ID	dlc	Data							
SF	0xXXX	2-8	N_PCI	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX
FF	0xXXX	8	N_PCI		0xXX	0xXX	0xXX	0xXX	0xXX	0xXX
FC	0xXXX	3-8	N_PCI			--	--	--	--	--
CF	0xXXX	2-8	N_PCI	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX	0xXX

0x0L : L=Length of Data (4 bit)

0x1L LL : L=Length of Data (12 bit)

0x3F BB SS
F: FlowControll Status
B: BS: max number of CF without FC
S: STmin follow-up time of CFs

0x2N : N=SequenceNumber

KWP2000 over CAN

	CAN ID	dlc	Data							
Tx	0x7DF	8	0x02	0x10	0x81	0xXX	0xXX	0xXX	0xXX	0xXX
Rx	0x7E9	8	0x02	0x50	0x81	0xXX	0xXX	0xXX	0xXX	0xXX
Tx	0x7DF	8	0x02	0x21	0x80	0xXX	0xXX	0xXX	0xXX	0xXX
Rx	0x7E9	8	0x10	0x0A	0x61	0x81	0x01	0x02	0x03	0x04
Tx	0x7E1	8	0x30	0x00	0x00	0xXX	0xXX	0xXX	0xXX	0xXX
Rx	0x7E9	8	0x21	0x05	0x06	0x07	0x08	0xXX	0xXX	0xXX

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ISO/IEC 10731	Data link (layer 2)	**ISO 11898**	**ISO 14230-2**
	Physical (layer 1)	**ISO 11898**	**ISO 14230-1**
		CAN	K-Line

Purpose of the Services

- **Diagnostic and Communication Management**
- Data Transmission
- Stored Data Transmission
- Input / Output Control
- Remote Activation of Routine
- Upload / Download
- CARB / OBD / EOBD / KOBD

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KWP2000

StartDiagnosticSession (0x10)

- Sets diagnostic session: this session determines the availability of other services
- Prepares jump to other SW parts of the ECU
- Over K-Line: change Baud-rate

StopDiagnosticSession (0x20)

UDS

DiagnosticSessionControl (0x10)

- Sets diagnostic session: this session determines the availability of other services
- Prepares jump to other SW parts of the ECU
- May change timing values (not configurable)
- Enables or sets back SecurityAccess
- Can reactivate deactivated CAN communication, deactivated error storing
- Resets responseOnEvent

KWP2000

ECUReset (0x11)

- After checking preconditions restarts the ECU software
- Reset type may be hard or key-on-off

TesterPresent (0x3E)

- Keeps communication alive: avoid communication timeout

UDS

ECUReset (0x11)

- After checking preconditions restarts the ECU software
- Reset type may be hard, key-on-off, soft, enable / disable rapidPowerDown

TesterPresent (0x3E)

- Keeps communication alive: avoid communication timeout

KWP2000

SecurityAccess (0x27)

- Authentication of the tester, restrict access
- May define different security levels
- Valid during the communication period

AccessTimingParameters (0x83)

- Timeout values and message separation time can be read / written

UDS

SecurityAccess (0x27)

- Authentication of the tester, restrict access
- May define different security levels
- Valid only at the activated diagnostic session or communication period

AccessTimingParameters (0x83)

- Timeout values and message separation time can be read / written

KWP2000

ReadECUIdentification (0x1A)

- The tester requests only a LocalID
- The ECU provides information about itself, e.g. SW and HW IDs, versions, other logistic data

UDS

CommunicationControl (0x28)

- Activate / Deactivate sending and receiving CAN Frames for/from other ECUs (vehicle internal communication)
- Increases bandwidth for flash programming; prevents CAN timeout errors
- Does not deactivate diagnostic CAN channel

SecuredDataTransmission (0x84)

- This service encapsulates another service
- Security SubLayer of the transmitter encodes the encapsulated service
- Security SubLayer of the receiver decodes the encapsulated service

UDS

ControlDTCSettings (0x85)

- Activate / Deactivate storing of errors into error memory
- Used at flash programming and development

ResponseOnEvent (0x86)

- Configures the ECU to send a response without a request in case of a defined event
- Permanent and temporally configuration

LinkControl (0x87)

- Configures communication speed, if the medium is configurable

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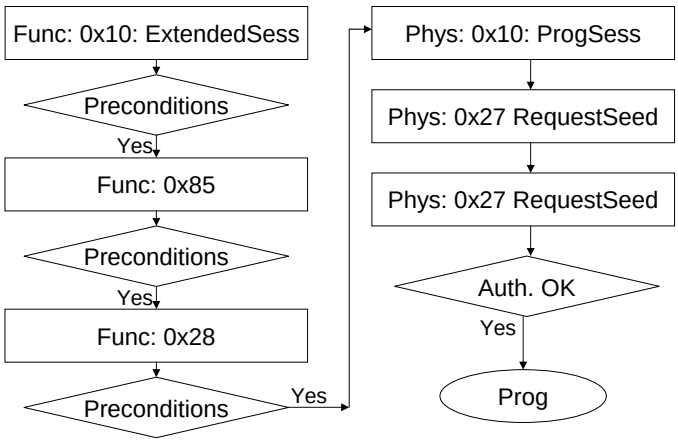
Example: Starting of Flash Programming



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KWP2000 and UDS

ReadMemoryByAddress (0x23)

- The tester requests a memory address and number of bytes
- The ECU – if authentification level allows – reads out the block
- The format of the request is different at KWP2000 and UDS

WriteMemoryByAddress(0x3D)

- The tester sends a memory address, and number of bytes and a data string (according to the number of bytes)
- The ECU writes the data string into its memory
- The format of the request is different at KWP2000 and UDS

KWP2000

ReadDataByLocalIdentification (0x21)

- The tester requests one or more LocalIDs (1 byte long ID)
- A localID identifies a part of memory (not necessarily in one block)
- The ECU – if authentification level allows – reads out the block
- These IDs identifies mainly pre-defined memory parts, but dynamic definition is also allowed
- A localID must not be unique within a vehicle
- LocalID can be read out periodically

WriteDataByLocalIdentification (0x3B)

- The tester sends a localID (1 byte long ID) and a data string
- The ECU writes the data string into its memory

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KWP2000

SetDataRate (0x26)

- If any data is requested periodically, the repetition of the response can be fast, medium or slow
- This message defines, what does “fast”, “medium” and “slow” means

KWP2000

ReadDataByCommonID (0x22)

- Similar to readDataByLocalID (0x21)
- CommonID is 2 bytes long, but unique or means the same for more ECUs

WriteDataByCommonID (0x2E)

- Similar to writeDataByLocalID (0x3B)
- CommonID is 2 bytes long, but unique or means the same for more ECUs

UDS

ReadDataByID (0x22)

ReadScaleingDataID (0x2D)

- Descendant of KWP2000 0x1A, 0x21 and 0x22
- The same as KWP2000 0x22, but periodical read not supported

WriteDataByID (0x2E)

- The same as KWP2000 0x2E

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KWP2000

DynamicallyDefineLocalID (0x2D)

- The tester requests one or more memory addresses and length, AND/OR LocalIDs, AND/OR CommonIDs
- The ECU orders the requested memory parts to a dynamic LocalID
- By requesting that dynamic ID internal data can be read out with low CPU overload
- dynamicallyDefinedLocalID can be erased

UDS

DynamicallyDefineDataID (0x2D)

- The tester requests one or more memory addresses and length, AND/OR dataIDs
- The ECU orders the requested memory parts to a dynamic DataID
- By requesting that dynamic ID internal data can be read out with low CPU overload
- dynamicallyDefinedLocalID can be erased

UDS

ReadDataByPeriodicID (0x2D)

- Similar to ReadDataByID
- The response is periodical

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Purpose of the Services

- Diagnostic and Communication Management
- Data Transmission
- **Stored Data Transmission**
- Input / Output Control
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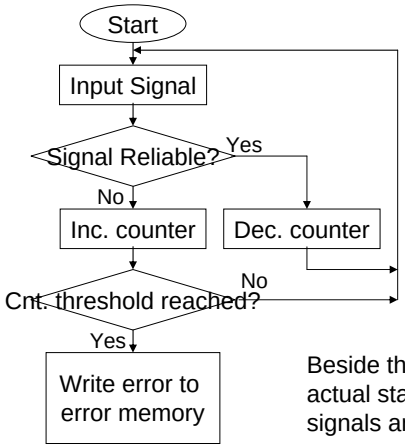
Onboard Diagnostic



Signal is analog or digital

Fulfills filter criteria; open/short-circuited, timeout

Beside the error code the type of the error, the actual status; and actual value of some related signals are also stored

KWP2000

ReadDiagnosticTroubleCode (0x13)

ReadDiagnosticTroubleCodeBy Status (0x18)

ReadStatusOfDiagnosticCode (0x17)

ReadFreezeFrameData (0x12)

- Error memory queries, by different filtering criteria

UDS

ReadDTCInformation (0x19)

- Error memory queries, by different filtering criteria
- The filtering criteria is sent by the sub-function of the service

KWP2000 and UDS

ClearDiagnosticInformation (0x14)

- Clears one, a group of, or all the stored errors from error memory

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Purpose of the Services

- Diagnostic and Communication Management
- Data Transmission
- Stored Data Transmission
- **Input / Output Control**
- Remote Activation of Routine
- Upload / Download
- CARB / OBD / EOBD / KOBD

KWP2000

InputOutputControlByLocalID (0x30)

InputOutputControlByCommonID (0x2F)

- Can directly control the actuator signals
- Access to actuators is application-specific

UDS

InputOutputControlByIdentifier (0x2F)

- Can directly control the actuator signals
- Access to actuators is application-specific

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Purpose of the Services

- Diagnostic and Communication Management
- Data Transmission
- Stored Data Transmission
- Input / Output Control
- **Remote Activation of Routine**
- Upload / Download
- CARB / OBD / EOBD / KOBD

KWP2000

StartRoutineByLocalID (0x31)

StartRoutineByAddress (0x38)

StopRoutineByLocalID (0x32)

StopRoutineByAddress (0x39)

RequestRoutineResultByLocalID (0x33)

RequestRoutineResultByAddress (0x3A)

- Controls routines, as erasing memory, calculate checksum, testing routines, etc

UDS

RoutineControl (0x31)

- Controls routines, as erasing memory, calculate checksum, testing routines, etc
- Control option is at the sub-function

Purpose of the Services

- Diagnostic and Communication Management
- Data Transmission
- Stored Data Transmission
- Input / Output Control
- Remote Activation of Routine
- **Upload / Download**
- CARB / OBD / EOBD / KOBD

KWP2000 and UDS

RequestDownload (0x34)

- The tester specifies an address and a length (not one byte), but no data
- Specifies compressing methods
- The ECU starts a downloading session

RequestUpload (0x35)

- The same as RequestDownload, but initializes uploading session

TransferData (0x36)

- Transfers the data bytes, with a help of sequence number, until the required amount of data is reached

RequestTransferExit (0x37)

- Terminates downloading / uploading

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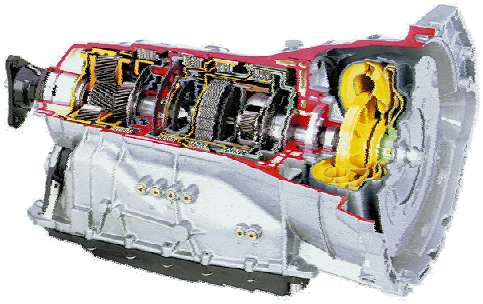
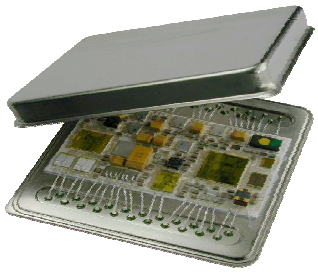
Questions?





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