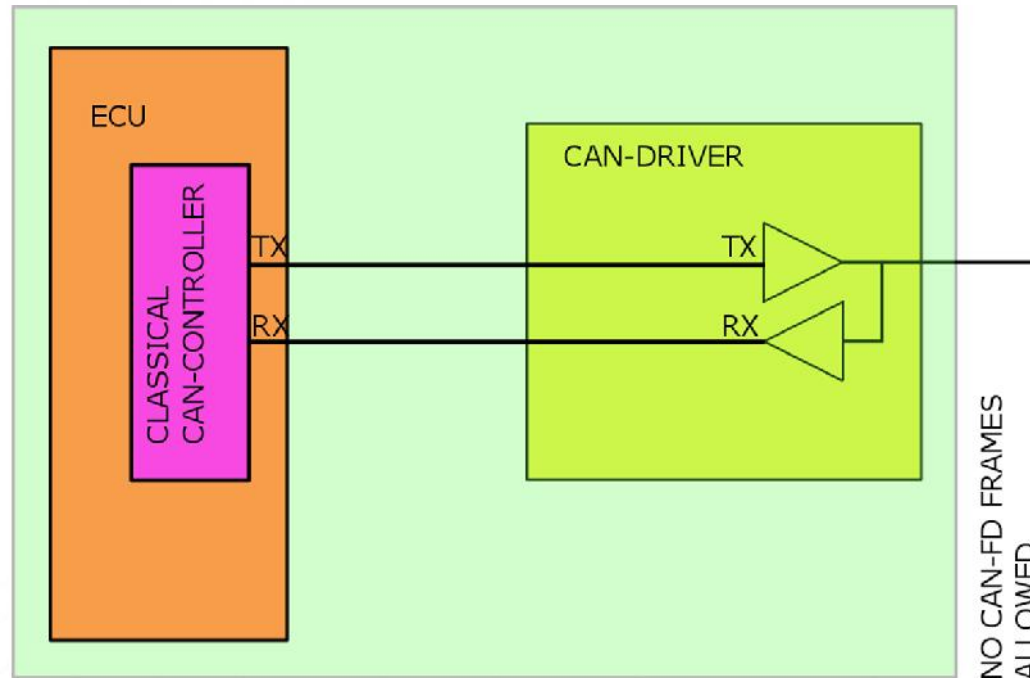




*CAN-FD FILTER FOR CLASSICAL CAN DEVICES
AND PHYSICAL LAYER DIAGNOSTICS
STUTT GART 30 JUNE 2015*

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THE CLASSICAL-CAN PROBLEM: RECEIVED CAN-FD FRAMES WILL CAUSE ERROR-FRAMES

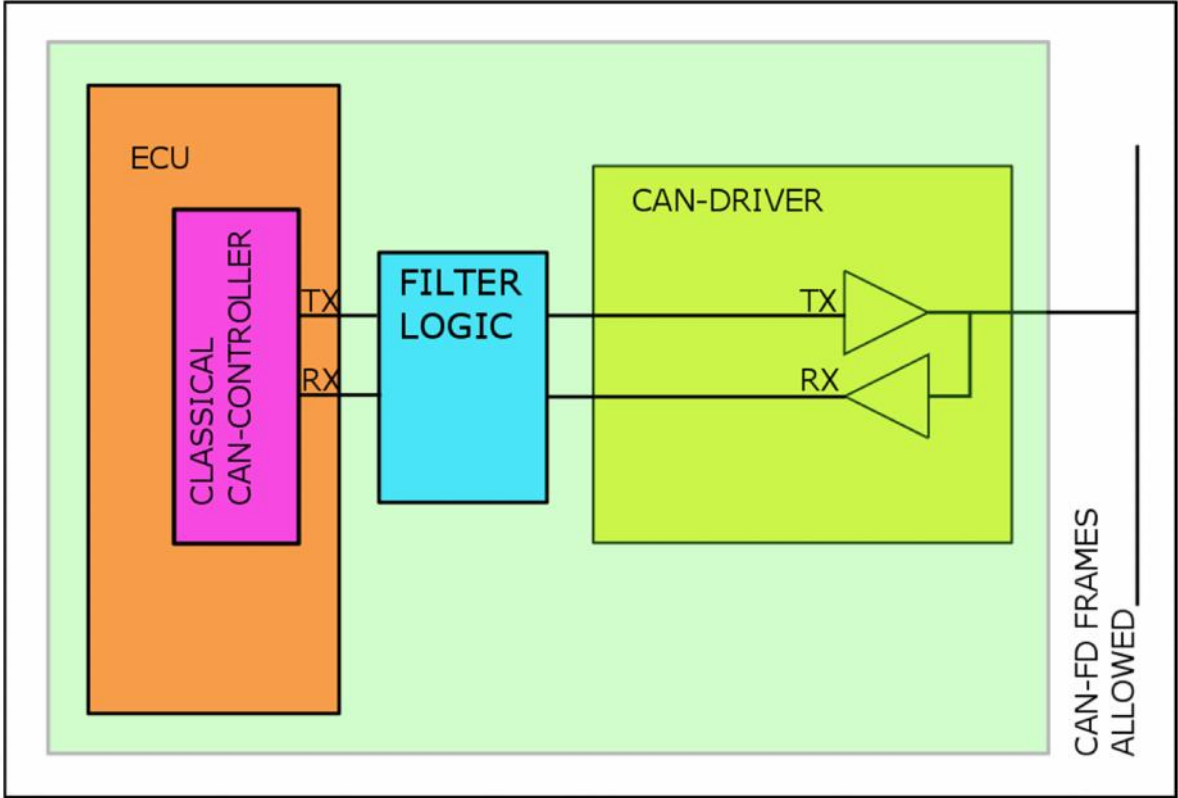


MANY THANKS TO THIS GREAT MAN
UWE KIENCKE
THE FATHER OF THE CAN-PROTOCOL.

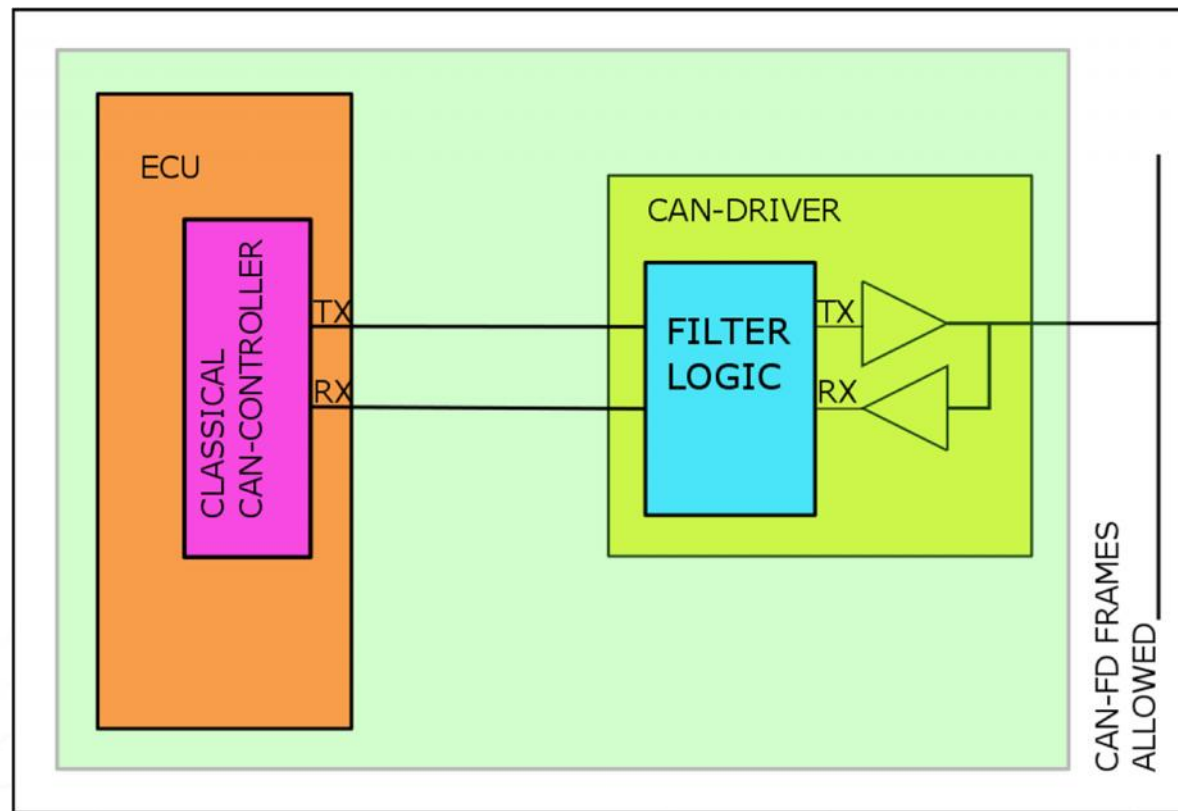


He gave us the CAN-protocol 1983,
including means to make a **filter**
preventing CAN-FD frames
reaching the Classical CAN-
controller and still comply to **all**
CAN-protocol rules.

THE LOGICAL FILTER WILL PREVENT CAN-FD FRAMES FROM REACHING THE CLASSICAL CAN-CONTROLLER



WITH FILTER INTEGRATED IN CAN-DRIVER, CAN ANY ECU BE CONNECTED TO A CAN-FD BUS BY REPLACING THE CAN-DRIVER CIRCUIT



ADVANTAGES

- Only the CAN-driver need to be replaced in existing ECU.
- No changes in the ECU software or hardware are necessary.
- All existing MCU with Classical-CAN can be used in a ECU for a CAN-FD system.
- Realtime performance given by the CAN-protocol will stay the same.
- Self contained intepeded of MCU hardware or software

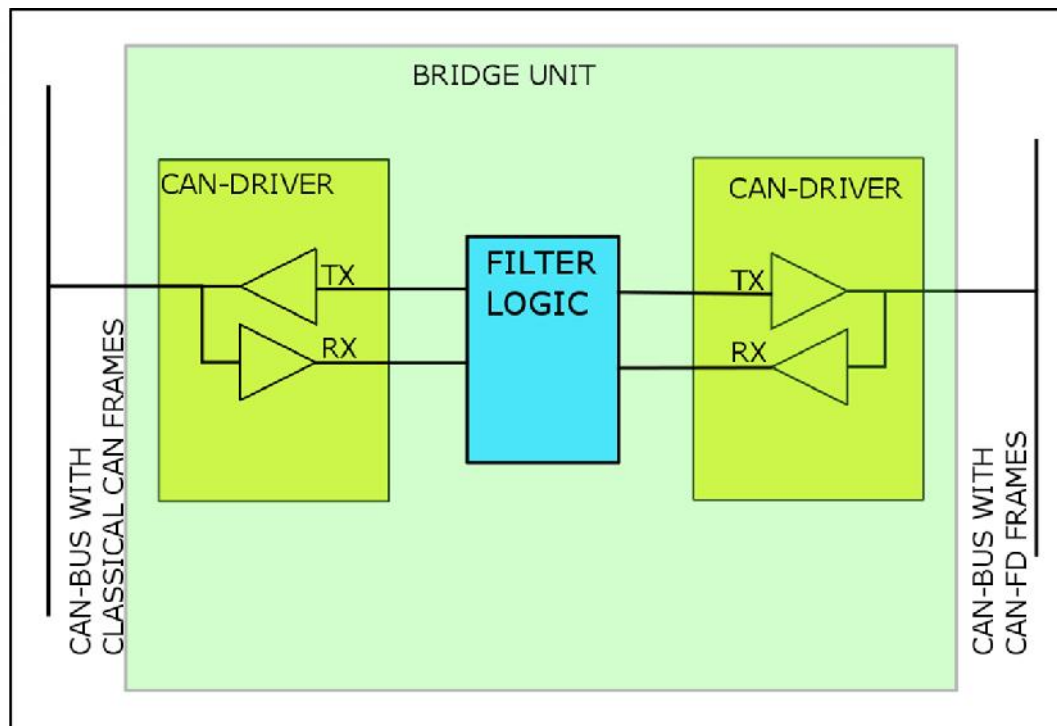
ADVANTAGES WITH FILTER COMPARED TO ISOLATION WITH PARTIAL NETWORKING

- No need to switch between different modes.
- Classical-CAN nodes can be programmed at the same time as CAN-FD nodes are programmed.

DISADVANTAGES

- The filter logic is larger than partial networking logic. To add the partial networking in the filter will demand very little extra logic.
- The bit-rate must be preprogrammed and fixed to keep the ECU SW and HW unchanged.

THE FILTER CAN BE USED IN A BRIDGE BETWEEN A CLASSICAL CAN BUS AND A CAN-FD BUS.



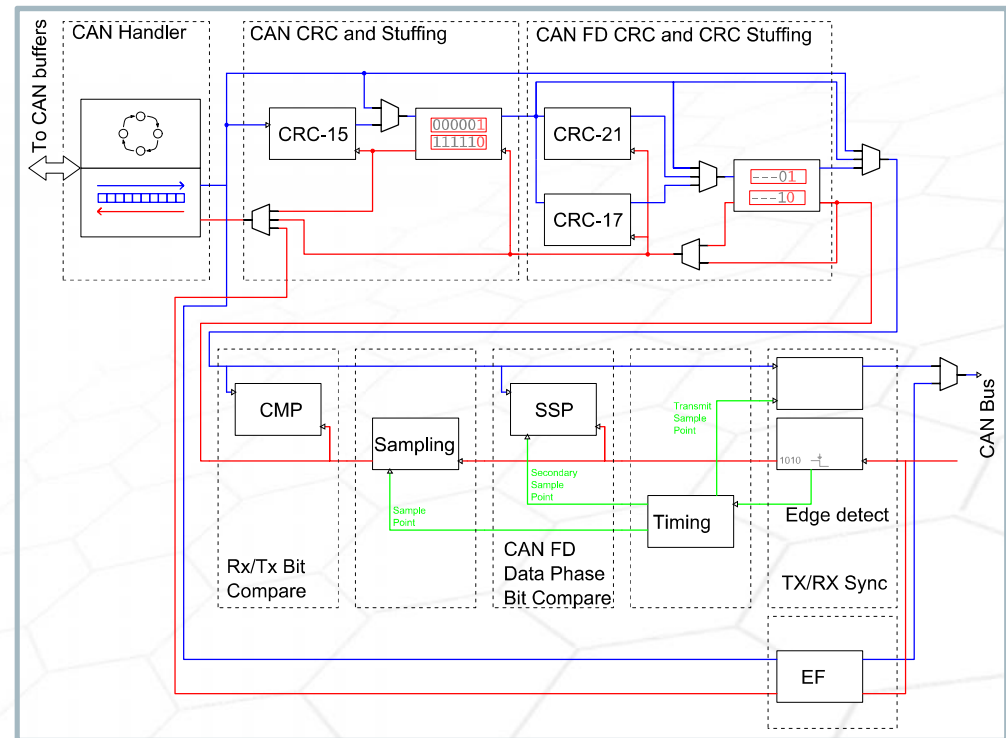
- **Arbitration is done concurrently on both CAN-busses.**
- The delays in the two added CAN-drivers will reduce the possible cable length on the two CAN-busses.
- The filter delay is only a few nano-seconds.

THE TOPICS COVERED IN THIS PRESENTATION ARE:

- Checking the bit-rate capability of your existing CAN-bus layout.
- Checking the margins in your running CAN-FD system.
- Checking the delays in the CAN-bus system.
- Why is high speed communication a problem?

KVASER HAS DEVELOPED A CAN-FD CONTROLLER

- First presented and tested with Bosch's CAN-FD controller at the CAN-FD Tech Day in Detroit on October 22 2012.
- Development over the last 2 years has concentrated on building diagnostic functions into the logic.
- Extra functions have been added to the CAN-controller to improve performance and robustness.
- High-speed sampling of the CAN-bus (1Giga sample per second) has been included.



AVAILABLE DIAGNOSTIC FUNCTIONS

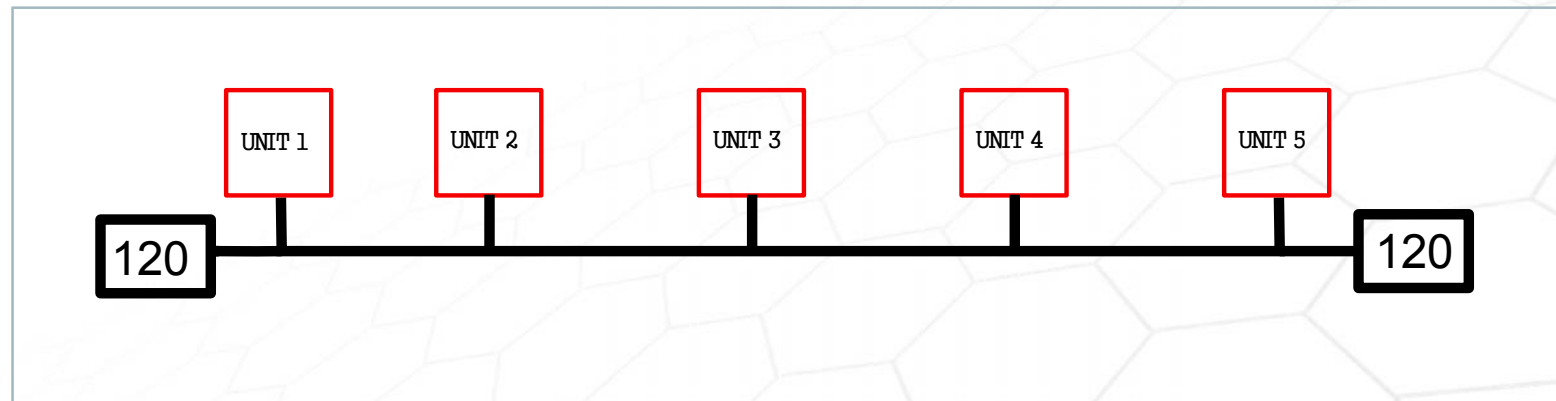
- Detecting if there is noise in the CAN-frame.
- Detecting noise in-between CAN-frames.
- Measuring the clock tolerance of the CAN-frame.
- Measuring the length of the TimeQuanta in different CAN frames.
- Measuring the distance in time to units connected to the CAN-bus.
- Measuring the location of the sampling point in different CAN frames.
- Measuring the SJW used in different CAN frames.
- Mapping CAN-ID to different CAN-units on the CAN-bus.
- Detecting if arbitration has occurred in the received CAN-frame.
- Checking the location of all edges in the received CAN-frame.
- Detecting when bit-rate is too high to produce a correct CAN-frame.



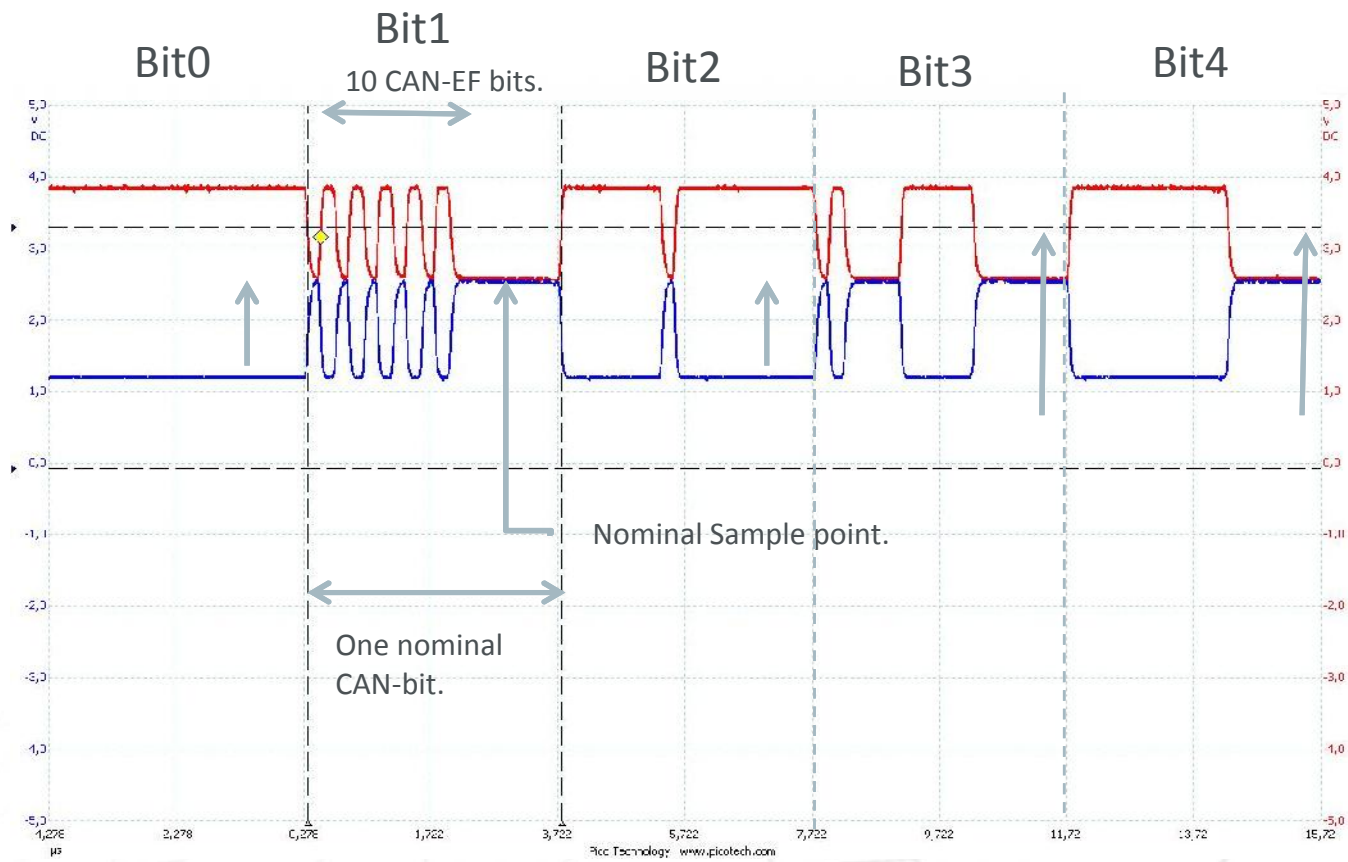
CHECKING THE BIT-RATE CAPABILITY OF
YOUR EXISTING CAN-BUS LAYOUT.

HOW TO TEST FOR FUTURE CAN-FD?

- Few CAN-FD controllers are currently available for test.
- To achieve an accurate measurement it is necessary to have active units in every location.
- It is worthwhile checking the performance of the bus layout that you use today in order to understand how CAN FD will impact your system design and what bus layout modification might be needed.

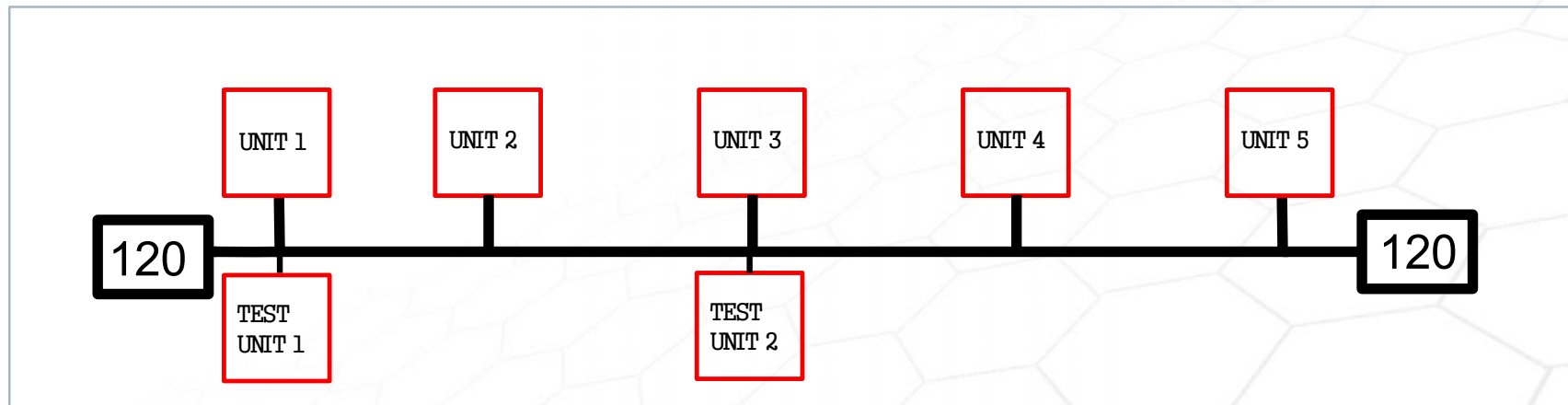


CLASSIC CAN WILL IGNORE NOISE IN THE PROPAGATION SEGMENT.



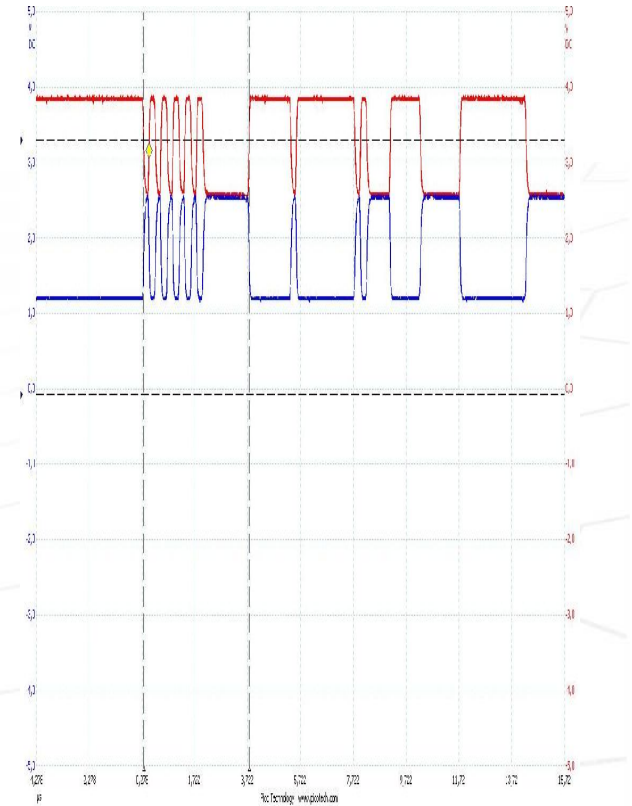
TEST SETUP

- Two test units at two different locations.
- To get full test coverage it is necessary to check every future unit location where CAN-FD frames will be used.
- The test-frames will arbitrate as normal Classic CAN-frames.



TEST FUNCTIONS

- The test CAN-frames will be considered as Classic CAN-frames for all Classic CAN nodes.
- The test can be done in a classic, working CAN system. Just a few extra test-frames are required, with unique CAN-ID.
- The bit length is programmable to any value.
- The test will provide detailed information of every bit.
- The data pattern is programmable by software.
- Also the test pattern has CRC-protection.
- It is just some extra information in a Classic CAN-frame.



CHECKING THE MARGINS IN YOUR CAN-FD SYSTEM.

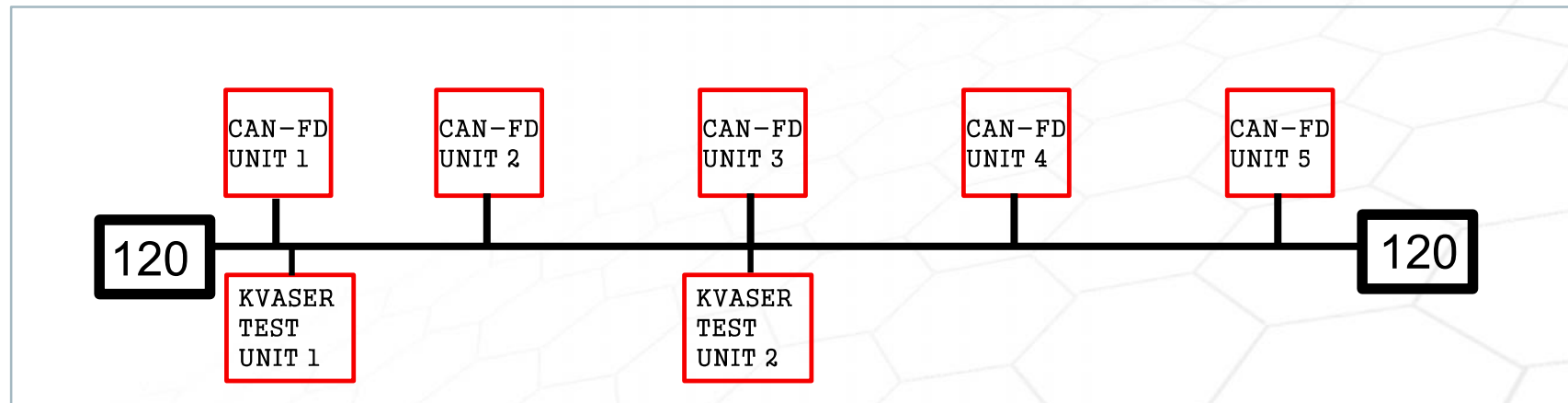
- Checking possible bit-setting in your CAN-bus network layout.
- Checking that your CAN-FD units have the correct setting for the TQ and sample point.

WHY IS THIS NEEDED?

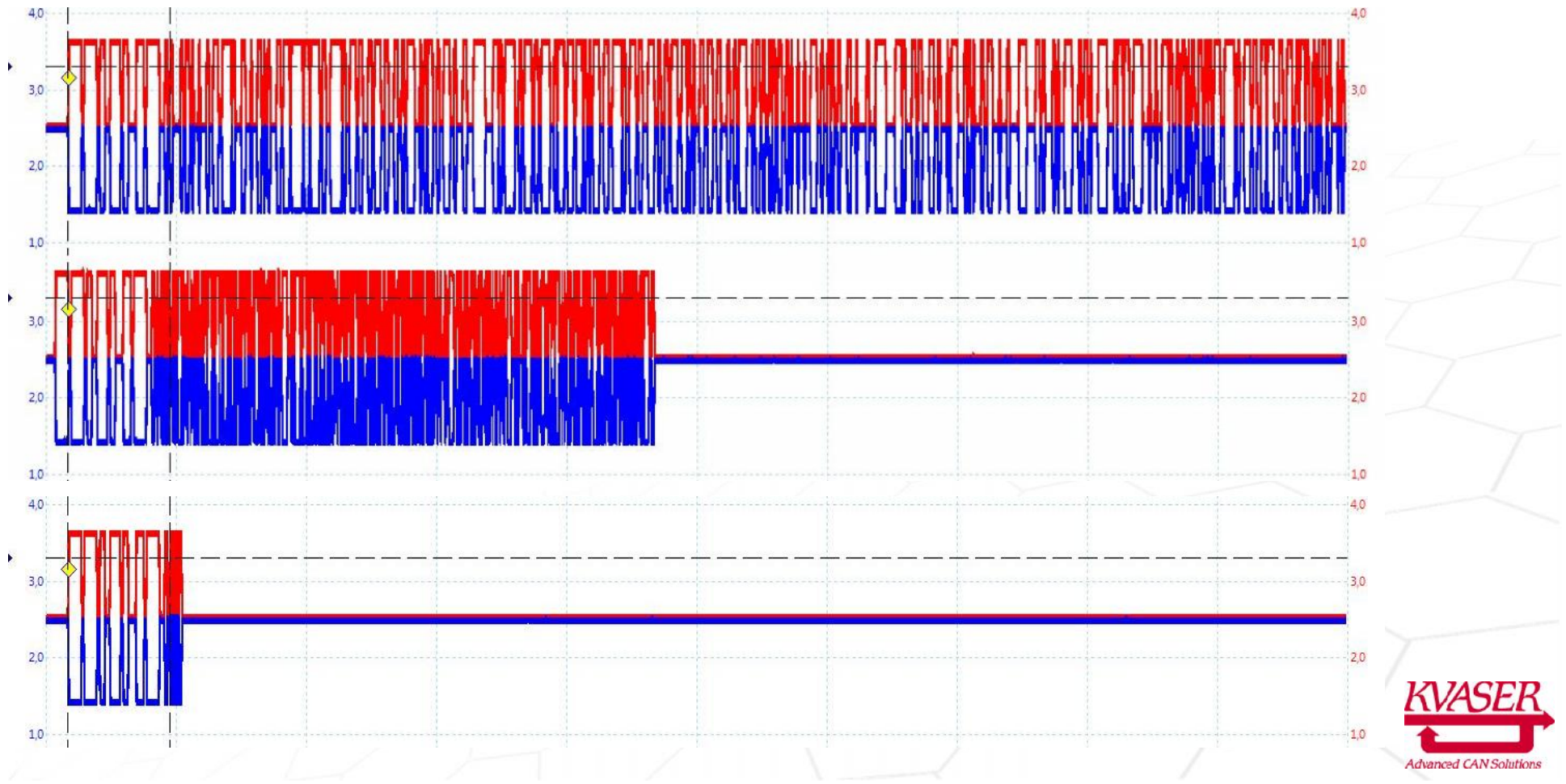
- Higher bit-rate will increase the demands on the physical layer.
 - How to secure the performance of the physical layer
- The new constraints set by CAN-FD.
 - How to secure the setting of the nominal bits.
 - CAN-FD demand common *Time Quanta* and location of *sampling point*.

TEST SETUP

- Two test units at two different locations.
- Special BRS test mode, with Kvaser bit-rate switch.
- All standard CAN-FD units must be silent.



CAN-FD DYNAMIC BIT-RATE TEST



SPECIAL BRS MODE IS USED FOR CAN-FD TEST AND DIAGNOSTIC

- **Special Kvaser BRS mode, during the bit-rate switch in the CAN-FD-Frame.**
 - To handle any ratio between arbitration- and data- bit-rate.
 - The ratio can be from 1:1 to 1:1000, with clock cycle increments.
 - To be independent of the configuration of the arbitration bits.
 - To be independent of the oscillator tolerance in the test unit.

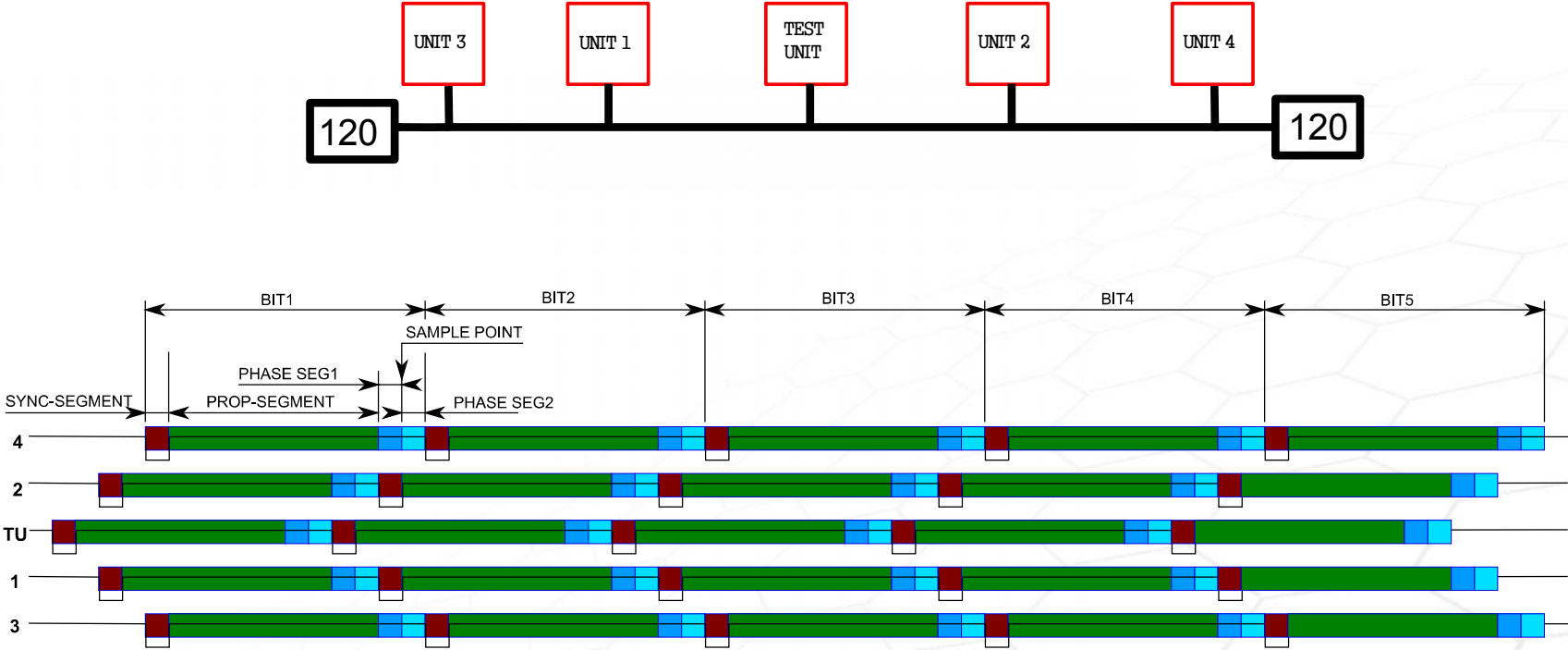
CAN-FD SAMPLE POINT CHECK

- The special BRS mode can be used to check the sample point location in standard CAN-FD frames.
- The logic will receive any CAN-FD frame, with any setting of:
 - sample point, oscillator tolerance or time quanta.
- The received BRS bit will be analyzed and reversed engineered.
- The measured setting of the received BRS-bit can be compared with the expected BRS setting.

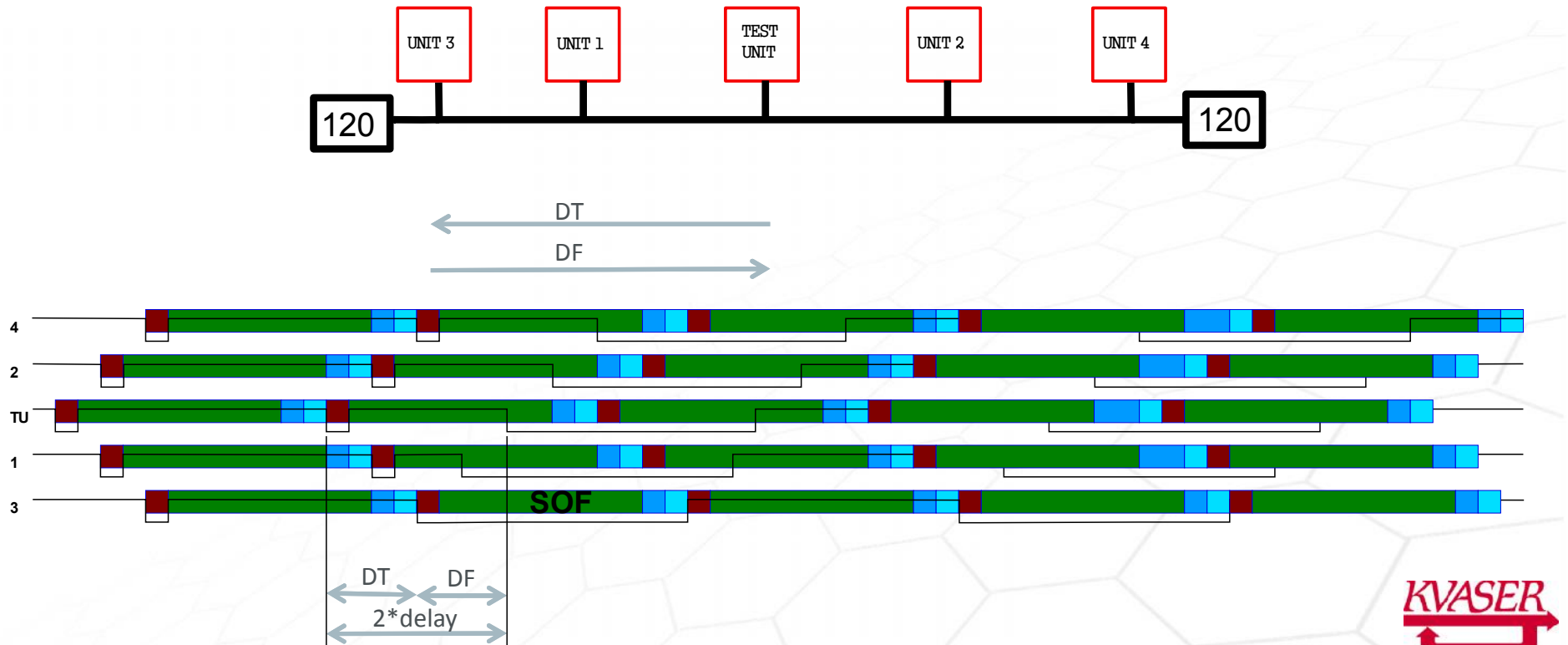
CHECKING THE DELAYS IN THE CAN-BUS

- Checking the communication delay.
- Measuring the length of the Time Quanta in the received CAN-frame.

IDLE SYNC FUNCTION IN KVASER CAN LOGIC



MEASUREMENT OF DELAY TIME TO OTHER UNITS AND TIME QUANTA USED IN MODULE



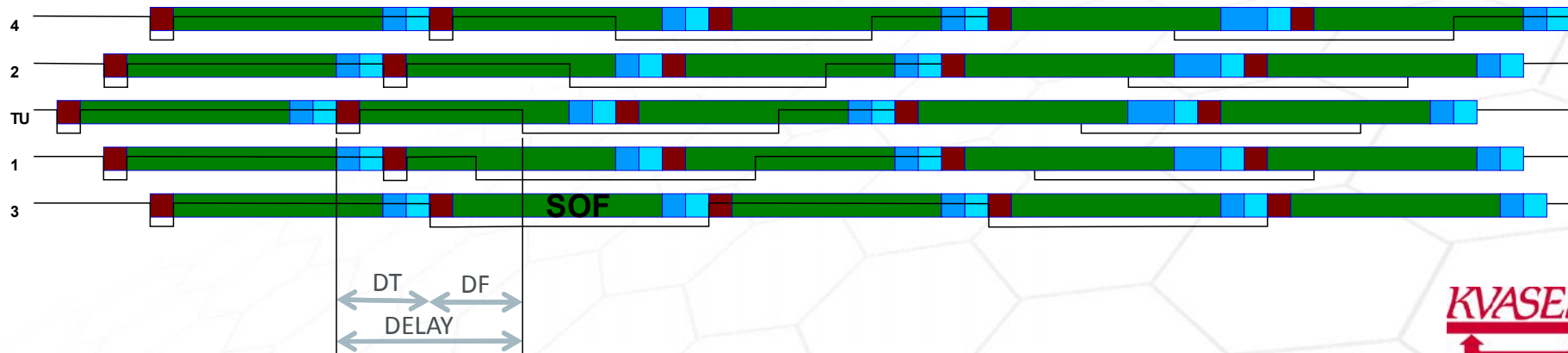
CALCULATION OF DELAY AND TIME

Measuring delay for several messages with the same CAN-ID (from same unit).

1. $DELAY = DT + DF + TQu3/2 \pm TQu3/2$
2. $Avg(DELAY) = DT + DF + TQu3/2$
3. $Max(DELAY) - Min(DELAY) = TQu3$
4. $DT = DF$.

The equation to the left will give us:

- $TQu3$ the TQ setting in unit 3.
- Distance, DT , in nanoseconds to unit.



OTHER SIGNATURES TO SEPARATE LOCATION OF UNITS

1. By moving around the tester to different locations.
2. By matching the measurement against a data base.
3. By different Time Quanta (not a good idea if you use CAN-FD).
4. By varying oscillator precision (must be separated by more than +/- 20 ppm for short messages).

TWO USE CASES FOR MEASUREMENT

- **Reverse engineering of the system.**
 - Which CAN-ID is used?
 - How many units are there?
 - What is the distance to different units?
 - What is the bit-configuration in different units?
- **Conformance test of documented system.**
 - Are all CAN-ID active?
 - Are all units present?
 - Are all units located at correct distance?
 - Is bit-configuration correct in all units?



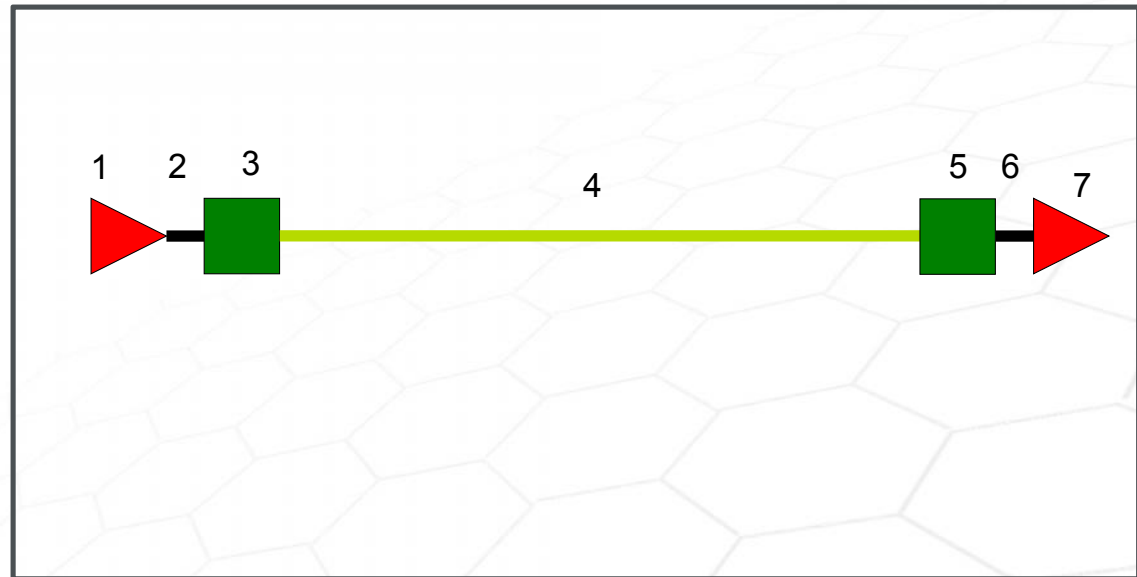
WHY IS HIGH SPEED COMMUNICATION
DIFFICULT?

HIGH SPEED COMMUNICATION IS ACHIEVABLE, WITHOUT PROBLEMS:

1. EtherNet, 10, 100, 1000 Mbit/s
2. USB, 12, 480, 5000 Mbit/s
3. SATA, 1500-6000 Mbit/s
4. HDMI, < 16000 Mbit/s
5. Firewire, 400-3200 Mbit/s
6. FlexRay, 10 Mbit/s

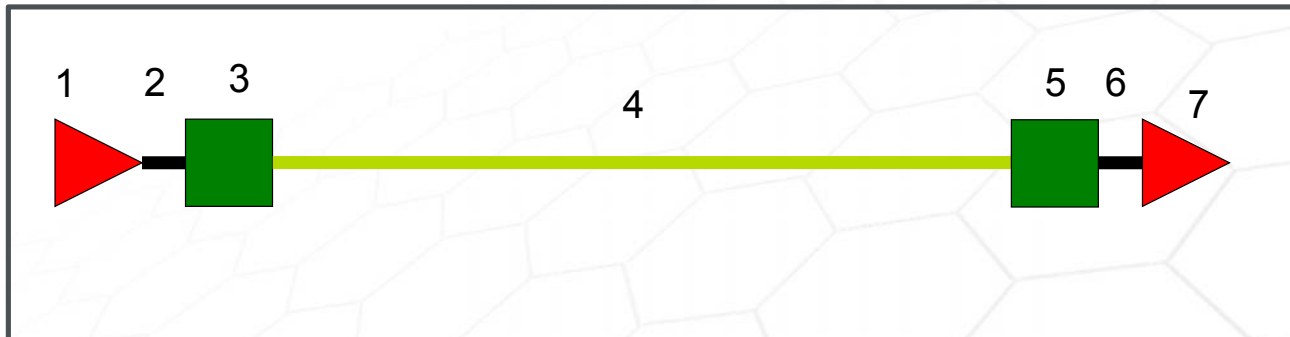
HIGH SPEED COMMUNICATION LINK

1. Transmitter
2. PCB routing
3. Connector
4. Cable
5. Connector
6. PCB routing
7. Receiver



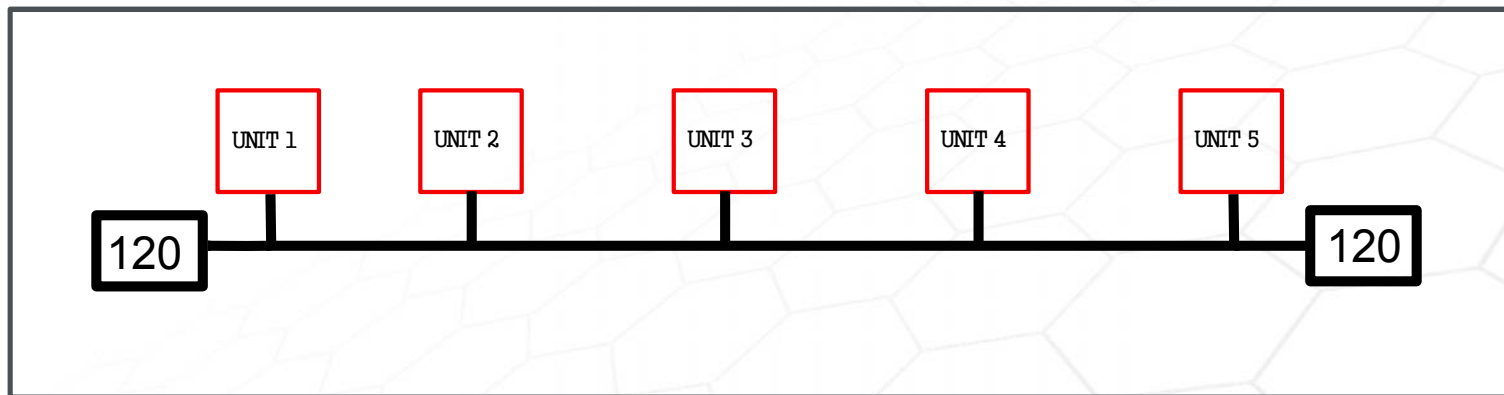
HIGH SPEED COMMUNICATION FEATURES

- Point to point connection.
- Impedance matching from transmitter to receiver.
- Special cable designs.
- Special connector designs.



A PERFECT CAN SYSTEM

- Short stub from unit to CAN-bus wires.
- Continuous impedance from one end to the other end.
- Matching termination on both ends.
- Will work without any problem up to 10 Mbit/s.



THE PROBLEM IS THE RISE AND FALL TIME

- If the rise and fall length is longer than the length of the wire.
 - will all impedance variations be hidden.
 - It will work as a DC-signal.

HOW RISE AND FALL TIME DEPENDS ON BIT-RATE

	speed reduction	67 percent		
	speed of light	3,00E+08 meter/second		
	Propagation	4,98E-09 nanoseconds/meter		
	fall/rise ratio	5 percent		
	Bit-rate	rise/fall time	rise/fall length	
	bit/s	second	meter	
	1000000000	5,00E-11	1,01E-02	
100 Mbit/s	100000000	5,00E-10	0,10	
	10000000	5,00E-09	1,01	
1 Mbit/s	1000000	5,00E-08	10	
	100000	5,00E-07	101	
	10000	5,00E-06	1005	
Power line	300	1,67E-04	33500	

- It is the slew-rate that sets a requirement for impedance matching in your bus-layout!
- Good impedance matching will also give you better EMC-performance.



*THANK YOU!
QUESTIONS?*

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