Advances towards a compact in-vehicle Ethernet-, Camera-, Radar- & LIDAR-measurement for high-bandwidth driver assistance systems
Growing Sensor Arrays, more Diversity and Increasing Data Rates

Sensors and Recorded Data for L3 - L5

- **L3**: Camera: 200 MByte/s, Radar: 100 MByte/s, Lidar: 50 MByte/s
- **L4**: Camera: 500 MByte/s, Radar: 200 MByte/s, Lidar: 100 MByte/s, Fusion ECU: 50 MByte/s
- **L5**: Camera: 1000 MByte/s, Radar: 500 MByte/s, Lidar: 200 MByte/s, Fusion ECU: 100 MByte/s

Autonomous driving level:
- L3
- L4
- L5

Number of sensors:
- L3: 5
- L4: 10
- L5: 15

Data in MByte/s:
- L3: 0 to 200
- L4: 0 to 500
- L5: 0 to 1000
ADAS Logging

Storage Cost - and what it implies for logging

- 1 PB in Cloud ~ 4억 7천만원/yr*
- Validation of fully automated vehicles
  - 406 억 required**
  - 5% real driving data, rest simulation
  - Even at only lowest bandwidth level (~325MByte/s) that’s ~9TB/8h shift or ~136PB of total storage

→ 550억 / yr

→ Data compression, early on = value

- Lossy compression - e.g. H.264 for video
  > Not suitable for signal based data
  > Not ideal for raw video from automotive cams
    - resimulation / DNN learning typ. needs full info
- Lossless compression – e.g. JPEG lossless (typically)
  > Up to 40% reduction in size possible


** Klaus Büttner/BMW, BMWBlog Oct’17
Strong reason for ADAS – new EU legal regulations for 2022/24

Driver drowsiness and distraction (camera/radar)

Intelligent speed assistance (camera, GPS)

Lane-keeping assistance (camera)

Advanced emergency braking (camera + radar)

European Commission - Press release

Road safety: Commission welcomes agreement on new EU rules to help save lives

Brussels, 26 March 2019

The EU institutions have reached a provisional political agreement on the revised General Safety Regulation. As of 2022 new safety technologies will become mandatory in European vehicles to protect passengers, pedestrians and cyclists.

New technologies on the market can help reduce the number of fatalities and injuries on our roads, 90% of which are due to human error. In May 2018, the Commission proposed to make certain vehicle
Mechanical & environmental considerations

- Confined trunk volume ~500-600l
- Temperature management can be difficult, esp. hot climate/summer testing
- Cabling - shall be robust

→ Make system easy to setup & compact – esp. for high-channel count setups
→ Use Ethernet where possible as reliable intra-measurement system connection
ADAS Logging

Many & diverse Sensors and Devices must be measured in one System

- Radar/LIDAR (RAW Data, XCP, proprietary Eth)
- Reference LIDARs (IBEO, Teledyne, Quanergy, ...)
- Context Cameras
- Vehicle Cameras (MobilEye-based, RAW Data ...)
- XCP-based Systems
- Analog sensors (pressure, accelerometer ...)
- GPS / IMU (GeneSys ADMA, OxtS ...)
- Vehicle Networks
- Other proprietary sensors
Scaling up to multichannel systems - today
ADAS Logging – Software

3 in 1 Use Case: Visualization & Calibration / Logging / Data Analysis

- **Engineer Mode (day shift):**

- **“Just Collect miles” Mode (night shift/weekend):**

Same high-end logging system in the trunk

CANape Configuration Visualization

CANape log

CANape/ vSignalyzer Offline Data Analysis

Mobile UI Visualization

LAN or WLAN
VX1000 system for high-speed measurement

Single source raw & debug data measurement

Multiple sources raw & debug data measurement

Size reduction? Easier setup & cabling?
VX1161 – Multi channel module for compact logger setups

- Compact, highly flexible and scalable system
- Multi ECU support
- Up to 20 Gbit/s measurement data rate
- Data transfer to Host PC via 2 x 10 Gbit/s Ethernet
- Cascading of several Base Modules
- Reduced wiring efforts
- Time synchronization
  - IEEE1588 PTP
  - Vector Hardware Sync
- 4 ETH ports to connect addtl. measurement devices
- Powerful SoC for Add-on features
- Reduced wiring efforts
VX1161 – Specs & Interface Options

8 slots for VX1161.xx cards
Size 342 x 256 x 95 mm
Temp -40°C to +60°C

6 CAN FD
1 FlexRay

10 Gbit/s Ethernet uplink
10 Gbit/s Ethernet cascading or uplink bandwidth extension
4x1 Gbits/s ETH/100MBit/BroadR-Reach for XPOD or VX1000 Base modules

POD Interface Cards for raw & XCP data
DAQ data 10...>100MByte/s

For various debug target interfaces (ex. JTAG, DAP, DAP2, Aurora, Nexus CI.3, RTP_DMM........)

New device class ➔ Video interfaces
Video logging – Common System Setups

A1) Video via built-in measurement adapter (by ECU maker)

B) Video TAP in grabber (centralized video ECU)

A2) Built-in video-TAP in ECU

C) Raw-data-over-ECU-trace
Video Logging - Current solution for MobilEye-based Camera ECUs

- Logging of image raw data (LVDS) & CPU debug information (Eth)
- Image compression on PC → resources!
- Low level timesync in grabber HW
- Access to (subset of) debug information for health monitoring
- Several multi-tier1 OEM projects worldwide
**Video Logging – Grabber HW for Multi-Channel System**

**VX1161.51 Video Card**

- Slot-in-card for multi slot measurement rack
- First release ~end of Q3/2019 (video use case) with
  - FPD-Link III SerDes card
  - Support for up to 4 ch “endpoint” mode - record video stream from TIER1 camera measurement adapter
Video Logging – Tapping Cameras for centralized Controllers

**Further Video cards in dev**
- Dual-HW-TAP Channel card for GMSL(2) → Measurement of up to 4 GMSL2 cameras using 2 slot-in-cards per base rack
- Initially supported **software** feature: “Endpoint mode” → “plain” recording of GMSL/GMSL2 cameras i.e. logging system configures imager
- Release ~beginning Q2/2020
Dramatic increase in vehicle network data rates

100BASE-T1/1000BASE-T1 Network

Sum of data rates:

\[
\begin{align*}
\text{2022 Mbit/s} & + \text{565 Mbit/s} \\
\text{2587 Mbit/s}
\end{align*}
\]

Logging specific Requirements:

- Monitor high Eth data rates in-vehicle
- **Must have**: Data Preselection in HW
- Logging: Avoid “duplicates” → Option to record information once at source only
Interfaces for Logging of Next Gen Network

- Today: VN5640 12+4 Channel
  - 6 x / 3 x TAP 100BaseT1
  - 6 x / 3 x TAP 100/1000BaseT1
  - 4 x 1000BaseTx

- Robustness: Harting iX industrial connectors

- 12 + 4 x Debug Interfaces
- Lidar, LowEnd Fusion-ECU & Radar

Outlook: VN5240 = 12 * 100/1000BaseT1
PC connection 10 Gb/Eth + 10 Gb/eth cascading port

Brick-LE Example Setup with 24 x Auto-Eth
→ CANape + Brick + Eth Interfaces = in-vehicle Eth logging solution
Features for in-vehicle logging - Passive Bypass

No power to meas. device = car down?
Features for in-vehicle logging - Passive Bypass

- Onboard high frequency relays → closed TAP connection between two ECUs while the VN5240 powered down

- Initial state of the relays after device-power up configurable (open/closed)
Features for in-vehicle logging - Passive Bypass

- Onboard high frequency relays → closed TAP connection between two ECUs while the VN5240 powered down

- Initial state of the relays after device-power up configurable (open/closed)

- Opening passive TAP on power-up, depending on configured use-case and initial power-up configuration

→ Active TAP & measurement practically instantaneous
Automotive Ethernet

Features for in-vehicle logging - Monitor Filter

- Only subset of Ethernet frames typ. relevant
- Avoid duplicates on multi-hop connections for Logging use case

- Hardware based frame filter mechanisms
- Support of various protocol-parts/layers
  - MAC-address (source/destination)
  - Ethertype
  - Double tagged VLAN IDs
  - IPv4-address (source/destination)
  - IPv6-address (source/destination)
  - TCP/UDP port
Monitor Filter Example: Transmission from ECU #A to ECU #E

Events to Application

T1 = RX_Event: Source Address A (Channel 1)
T2 = RX_Event: Source Address A (Channel 3)
T3 = RX_Event: Source Address A (Channel 6)
T4 = RX_Event: Source Address A (Channel 8)
Monitor Filter Example: Filter Definition per Port & Filter Behaviour

**Rules:**

- **F1**: MAC-Addr = A
- **F2**: MAC-Addr = B
- **F3**: MAC-Addr = B
- **F4**: MAC-Addr = C
- **F5**: MAC-Addr = C
- **F6**: MAC-Addr = C
- **F7**: MAC-Addr = D
- **F8**: MAC-Addr = D
- **F9**: MAC-Addr = E
- **F10**: MAC-Addr = F

Filter @ Port 16:

```java
if(MAC-Addr == A) {
    filterMarker = 1
}
if(currentFrame.filterMarker != 1) {
    dropFrame();
}
```
Supported Device
Example – Camera + LIDAR + Pointed Cloud
Example

Example – Camera + GPS
Summary

- Ease of use for „collecting miles“ scenario - CANape log

- Size reduction - Compact multi-channel sensor logging interface

- Video logging as part of multichannel system – also compressing data in HW

- Ethernet – ideal as measurement network
  → More robust cabling, compact HW setups by cascading
  → Precise timesync via PTP

- Ethernet = vehicle network backbone → Filtering in HW required
  → Saves disk space & CPU resource

Thank you for your interest – Questions?
For more information about Vector and our products please visit

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