COMED ATM Payload Demonstrator

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COMED ATM Payload Demonstrator

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# Table of Contents

1. Application Scenarios and Reference Payload Architecture

3. COMED ATM Payload Demonstrator - Rationale and Objectives

4. DVB-S Demodulator

5. ATM Switch

6. DVB-S Modulator

7. Demonstrator Configuration and Tests Performed

8. Conclusion
GEO - Broadband Satellite Systems

Services:
- Forward Links:
  - Digital Video Broadcast
  - Remote Video Broadcast
  - Internet Services
- Return Links:
  - Video on Demand
  - Web Browsing
  - High Data Rate

On-Board Functions:
- Demodulation
  - High Data Rate Links: DVB-S
  - Low Data Rate Links: DVB-RCS
- Switching
  - ATM / MPEG-Mux
- Modulation
  - DVB-S

Communication Satellite

Small User Terminals

Spotbeams

TV Broadcast Providers

Corporate Networks

Internet Service Providers
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MEO - Communication Satellite Systems

Services: Symmetrical Links between Fixed Ground Stations or Vehicles, e.g. Leased Lines at 155 Mbps (STM-1)

Switching Scheme: ATM, Quasi-Static Connections

Transmission Waveform: DVB-S

Intersatellite Links: Optical

Throughput: 1 - 5 Gbps

Example: MEDIS
Reference Architecture of On-Board Processing Payload

- **DVB-S Demodulators (155 Mbps)**
  - Synchron. Demod.
  - Decoder

- **DVB-S Demodulators (1 - 50 Mbps)**
  - FDMUX
  - Synchron. Demod.
  - Decoder

- **DVB-RCS Multi-Carrier Demodulator**
  - FDMUX
  - Synchron. Demod.

- **ATM / MPEG2 Packet Switch**
  - ATM Cell Switch or MPEG2-TS Multiplexer
  - Input Process
  - Output Process

- **DVB-S Modulators (50 Mbps)**
  - Framing Encoding
  - Modulation

- **Gateway Forward Links**
  - DVB-S m x 50 Mbps

- **User Return Links**
  - High Data Rate Return Links
  - DVB-S n x (1 ... 50 Mbps)

- **Gateway Return Links**
  - DVB-S m x 50 Mbps

- **Low Data Rate Return Links**
  - DVB-RCS l x 144 ... 2048 kbps

- **DVB-S Demodulators (1 - 50 Mbps)**
  - ATM Switch

- **On-Board Data Handling**
COMED ATM Payload Demonstrator - Rationale and Objectives

- Attractive Applications of On-Board Processing Payloads in the Field of Broadband GEO Systems and MEO Systems
- Support of German Satellite Industry Necessary to Compete
- Tesat-Spacecom and German DLR Initiated the COMED Program with the Following Objectives:
  - Development of the Basic Technology for On-Board Demodulators and Switches
  - On-Ground Demonstration of Technology and Capability at Tesat
  - In-Orbit Verification Envisaged
### Characteristics Of DVB-S Demodulator

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Standard</td>
<td>DVB-S</td>
<td>-</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>QPSK</td>
<td>-</td>
</tr>
<tr>
<td>Decoding</td>
<td>Reed-Solomon + Viterbi</td>
<td>-</td>
</tr>
<tr>
<td>Synchronisation</td>
<td>Carrier Frequency and Phase</td>
<td>-</td>
</tr>
<tr>
<td>Synchronisation</td>
<td>Clock Frequency and Phase</td>
<td>-</td>
</tr>
<tr>
<td>Input IF Frequency</td>
<td>0 ... 475</td>
<td>MHz</td>
</tr>
<tr>
<td>Number of Carriers</td>
<td>1 ... 5</td>
<td>-</td>
</tr>
<tr>
<td>Carrier Bandwidth</td>
<td>1 ... 50</td>
<td>MHz</td>
</tr>
<tr>
<td>Total Input Bandwidth</td>
<td>Max. 200</td>
<td>MHz</td>
</tr>
<tr>
<td>User Data Rates per Carrier</td>
<td>1 ... 100</td>
<td>Mbps</td>
</tr>
<tr>
<td>Overall Data Rate</td>
<td>Max. 200</td>
<td>Mbps</td>
</tr>
<tr>
<td>Eb/N0 @ BER = 10^{-10}</td>
<td>7.5</td>
<td>dB</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>15 (155 Mbps Version)</td>
<td>W</td>
</tr>
<tr>
<td>Mass</td>
<td>3 (155 Mbps Version)</td>
<td>kg</td>
</tr>
<tr>
<td>Status</td>
<td>DVB-S Demodulator ASIC under Development, EM in Q4/2002</td>
<td>-</td>
</tr>
</tbody>
</table>
Architecture of On-Board DVB-S Demodulator (155 Mbps)

- **IF = 475MHz**
- **Total BW = 150 MHz**
- **IF-Input signal**
- **TMTC**: 8bit Data, 8bit Addr
- **JTAG**: 8bit Data, 8bit Addr
- **Supply Voltages**
- **Digital Signal Processing**
  - **8bit Data**
  - **8bit Addr**
- **Configuration and Telemetry**
- **User Data Interface**
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Broadband Analog-to-Digital Interface

Functions: A/D-Conversion, Deserializer 1:2:4:8
Sampling Scheme: Bandpass-Sampling
A/D-Wordlength: 8 bit
Effective Wordlength: 7 bit
Input Frequency: up to 1.5 GHz
Sampling Rate: up to 1 Gsps
Power Consumption: 10 W
Technology: Space Qual. A/D-Converter
Status: Breadboard Verified
**On-Board ATM Switch - Design Trade-Offs**

**Requirements**
- Switching Scheme Independent of Transmission Protocol
- Support Various Transmission Protocols: ATM, MPEG-Mux, IP, MPLS
- Scalability (Throughput 1.2 Gbps ... 10 Gbps)
- Support Quasi Static Connections

**Technical Solution**
- Use Internal Label Switching (Insertion of 10 Byte Header)
- Separate Application Specific Functions and Generic Functions
  - Physical Layer Interface Unit (to Interface to Mod./Demod.)
  - Port Controller (to Adapt to Switching Scheme)
  - Generic Switch Element (to Perform Switching)
- High Speed Data Interfaces to Interconnect Functional Blocks
- Configuration of Links (VCI/VPI) through Controller Interface
Architecture of ATM-Switch Demonstrator (1.2 Gbps)
FPGA Developments

ATM Switch Element
- 8 x8 Switch Matrix, 1.2 Gbps Throughput, Internal Packet Format
- Supports Various Packet Formats (MPLS, ATM, IP, MPEG2)
- Status: Verified in Target System

ATM Switch Port Controller
- Adaption of ATM Cells to Internal Packet Format
- Status: Verified in Target System

Utopia to SpaceWire Interface
- Adaption of SpaceWire Interface to Utopia Interfaces
- Status: Verified in Target System

Physical Layer Interface Unit
- Interface to Demodulator/Modulator
- Status: Verified in Target System

- All FPGAs Realised with Xilinx Virtex II
- Design Is Compatible to Space Qualified ASICs
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ATM-Switch - Hardware

User Data Interfaces

SpaceWire
8 x 155 Mbps

Configuration & Monitoring

PCI Bus Interface

Univeral ATM Switch Board (FPGA Based)

Compact PCI Unit

Univeral ATM Switch Board

Univeral ATM Switch Board
Architecture of On-Board ATM-Switch (5 Gbps)
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OBP-Controller Software

Embedded Software:
- Control and Configuration of Switch and Demod
- TM/TC Interface
- Power PC, Vx-Works, C

Satellite Ground Terminals:
- IP-Applications
- Linux PC

Control Station:
- Configuration of OBP (Link Management)
- Graphical User Interface
- Windows NT, Java
## COMED ATM Payload Demonstrator

### Characteristics of On-Board ATM-Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching Architecture</td>
<td>Shared Memory, Label Switching</td>
<td>-</td>
</tr>
<tr>
<td>Supported Transmission Protocols/Formats</td>
<td>IP, ATM, MPLS, MPEG2</td>
<td>-</td>
</tr>
<tr>
<td>Switch Matrices</td>
<td>8 x 8, 16 x 16, 32 x 32</td>
<td>-</td>
</tr>
<tr>
<td>Data Interfaces (SpaceWire)</td>
<td>155</td>
<td>Mbps</td>
</tr>
<tr>
<td>Throughput of Single Switch Element</td>
<td>1.2</td>
<td>Gbps</td>
</tr>
<tr>
<td>Max. Throughput (4 Level Cascade)</td>
<td>10</td>
<td>Gbps</td>
</tr>
<tr>
<td>Status</td>
<td>FPGA Based Demonstrator Successfully Tested,</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Concept and Parts Transferable to Space Qualified Hardware</td>
<td></td>
</tr>
</tbody>
</table>
### Characteristics of On-Board DVB-S Modulator

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Freq. Range</td>
<td>17.7 ... 20.2</td>
<td>GHz</td>
</tr>
<tr>
<td>Modulation Scheme</td>
<td>QPSK</td>
<td>-</td>
</tr>
<tr>
<td>Formatting and Coding</td>
<td>According to DVB-S Std.</td>
<td>-</td>
</tr>
<tr>
<td>Transmission Data Rate</td>
<td>Up to 70</td>
<td>Mbps</td>
</tr>
<tr>
<td>Carrier Suppression</td>
<td>&gt; 30</td>
<td>dB</td>
</tr>
<tr>
<td>Single Sideband Suppression</td>
<td>&gt; 30</td>
<td>dB</td>
</tr>
<tr>
<td>RF Output Power</td>
<td>-20 ... 0 in Steps of 0.5 dB</td>
<td>dBm</td>
</tr>
<tr>
<td>Amplitude Accuracy</td>
<td>0.2</td>
<td>dB</td>
</tr>
<tr>
<td>Phase Accuracy</td>
<td>3</td>
<td>Deg.</td>
</tr>
<tr>
<td>Size</td>
<td>142 x 86 x 15</td>
<td>mm³</td>
</tr>
<tr>
<td>Mass</td>
<td>250</td>
<td>g</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>4</td>
<td>W</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-20 ... + 60</td>
<td>°C</td>
</tr>
<tr>
<td>Status</td>
<td>EQM Successfully Tested</td>
<td>-</td>
</tr>
</tbody>
</table>
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Block Diagram of On-Board DVB-S Modulator

Microwave Section

Analogue I/Q Modulator

Baseband Section

LO_in

QPSK_out

+6V

-6V

+5V

-5.2V

+3.1V

+3V

SDB

+3V

+6V

SOSF

DATA

Clock1

Clock2

Formatter

D A

D A

CONTROL SECTION
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On-Board DVB-S Modulator - EQM
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Overview of COMED OBP Payload Demonstrator

Test Modulator
DVB-S Modulator

RF-Link

OBP Payload Demonstrator
DVB-S Demodulator
On Board Switch

Data Links (Ether/IP)

Data Link (Ether/IP)
Application Terminal (PC)
Sat. Ground Terminal Simulator

Data Link (Ether/IP)
Application Terminal (PC)
Sat. Ground Terminal Simulator

Data Link (Ether/IP)
Application Terminal (PC)
Sat. Ground Terminal Simulator

Test Monitoring & Control Station (PC)

ATM Cell Generator and Analyser

HP ATM Test Equipment

Demonstrator Local Area Network (DLAN)
Test Data Link (UTOPIA)

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Satellite Ground Terminals 1... 3

ATM-Switch
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Configuration of Connections

<table>
<thead>
<tr>
<th>Nr</th>
<th>SOT Sr.</th>
<th>Appl. Sr.</th>
<th>VPI Sr.</th>
<th>VCI Sr.</th>
<th>SOT Dest.1</th>
<th>Appl. Dest.1</th>
<th>VPI Dest.1</th>
<th>VCI Dest.1</th>
<th>SOT Dest.2</th>
<th>Appl. Dest.2</th>
<th>VPI Dest.2</th>
<th>VCI Dest.2</th>
<th>Traffic</th>
<th>Bitrate[kbps]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SGT1</td>
<td>HP-CGA</td>
<td>10</td>
<td>16</td>
<td>SOT3</td>
<td>HP-CGA</td>
<td>20</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CBR</td>
</tr>
<tr>
<td>2</td>
<td>SGT1</td>
<td>HP-CGA</td>
<td>6</td>
<td>18</td>
<td>SGT2</td>
<td>SAR</td>
<td>29</td>
<td>393</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CBR</td>
</tr>
</tbody>
</table>

- Connections:
- Release Connection
- Modify Connection
- New Connection
- OK
- Data Ack/Send
- Cancel
### Configuration of ATM Switch Port Controller

![Configuration SGT 1 Port 2](image)

#### Priorities:

<table>
<thead>
<tr>
<th>Slot</th>
<th>Queue 1 (CBR)</th>
<th>Queue 2 (nrt-VBR)</th>
<th>Queue 3 (UBR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot 1</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 2</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 3</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 4</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 5</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Slot 6</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 7</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 8</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 9</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Slot 10</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 11</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Slot 12</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Slot 13</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 14</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Slot 15</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Slot 16</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

#### Buttons:
- Change Priority
- All Slots Same Priority
- OK
- Cancel
- Send
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COMED OBP Payload Demonstrator

- Analysis of Switching Characteristics under Various Application and Load Conditions
  - Throughput
  - Cell Loss Rate
  - Back Pressure Mechanism

- Characterisation of End-to End Data Transmission
  - Bit Error Rate
  - Quality of Service (Jitter) etc.

- Demonstration of Unicast and Broadcast Applications

- Demonstration of IP-Applications (IP-Radio, MP3 Streaming)

- Demonstration of Complete DVB-S / ATM Based Communication System with Real Hardware Suited to be Transferred to Space Qualified Technology
Conclusion

- On-Board Equipment under Development at Tesat-Spacecom
  - DVB-S Demodulator
  - ATM-Switch
  - DVB-S Modulator

- Attractive Technical Solutions Available
  - Flexibility in Data Rates, Carrier Frequency, Transmission Protocols
  - Excellent Performance
  - Concepts Providing Minimum Mass and Power

- Functions Verified through COMED ATM Payload Demonstrator

- Transfer to Space Qualified Hardware Feasible

➡ Prepared to Deliver Flight Hardware