ADVANCES IN DAB TRANSMISSION SYSTEMS
CONNECTING WHAT’S NEXT
RICH REDMOND
• Transmitter Options for DAB networks
• Advancements in energy efficiency
• Considerations using liquid or air cooled
• Configuration for redundant operations
  • Transmitter redundancy and link redundancy
• Reinventing transmitter sites
  • Multi - Channel Transmitter systems
  • Multi Carrier transmitter
STRUCTURE OF A DAB NETWORK IN PRACTICE

- **Studio 1**: Audio Signal, PAD, SI
- **Studio N**: Audio Signal, PAD, SI
- **Data Provider**: NPAD, Content, MOT

**Public or Private IP Cloud**

**SERVICE PROVIDERS**
- Audio Encoder
- Audio Encoder
- Audio Encoder

**ENSEMBLE PROVIDER**
- Ensemble Multiplexer
- Data Inserter

**EDI over IP Network**
- Multicast or Unicast

**TX NETWORK PROVIDER**
- COFDM Main Transmitter
- Transmitter

**DAB FRAME**
- Files
- Data Inserter
- Ensemble Multiplexer
- SFN Adaptation
GATESAIR RADIO PRODUCT FAMILY

**Low Power**
- VAXT 80/150
  - Ultra Compact

**Air Cooled**
- VAX 300/450
- VAX 550/750

**VLX Liquid Cooled**
- VAX 1.2kW - 13.6kW
- VLX 1.5kW - 45.6kW
KEY FEATURES

- High-efficiency Doherty PA’s
  - VHF BIII is a single broadband design 170-240MHz
- ETI and EDI inputs
  - Additional input board options
  - 2 – EDI plus 2-ETI
  - 4 – ETI inputs
- Adaptive pre-correction circuits with MER ≥ 33dB
- Configurable as: Transmitter, On-channel SFN Gap-Filler, or Transposer
- Modular design, PA and Power Supply plug-in and can be replaced in a few minutes.
DAB ULTRA-COMPACT VHF MODELS / POWER LEVELS

1RU Models
- 80 W
- 150 W

2RU Models
- 300 W
- 450 W

3RU Models
- 550 W
- 750 W
FRONT AND REAR OF 1RU ULTRA-COMPACT

Input Slot #1

Input Slot #2

Touch screen LCD

Control Ethernet Port

USB Port

GPS Receiver (opt.)

Power Supply

RF Power Amplifier

10 MHz In/Out

GPS In

AC Power

Cooling Fans (4)

RF Monitoring

RF Out

Feedback for Pre-correction

Input Slot #1

Input Slot #2

Touch screen LCD

Control Ethernet Port

USB Port

GPS Receiver (opt.)

Power Supply

RF Power Amplifier

10 MHz In/Out

GPS In

AC Power

Cooling Fans (4)

RF Monitoring

RF Out

Feedback for Pre-correction
INPUT CARDS

FRONT PANEL

Input Slot #1

Input Slot #2

Note that one or two input cards can be used, for flexibility

RF In
(For Transposers, Gap Fillers)

2 x EDI + 2 x ETI
Or
4 – ETI
(For Transmitters)

Touch screen LCD

USB Port

Control Ethernet Port
UNDER THE HOOD - WHERE ARE THE CABLES?

“No Cable” Design!

RF Power Amplifier
Modulator Board
Input Card
Power Supply
GPS Receiver Board
Interface Board
Controller Board
• Same 1RU exciter/driver and same input option cards as Ultra-Compact
• Available with single-drive or dual-drive (option)
• Multiple PA systems include a 36RU rack (single PA systems - rack optional)
• GPS/GLONASS option
SYSTEM CONTROLLER

RF AMPLIFIERS

COMBINER LOADS

BACK PANEL VIEW

INTERCONNECT
Maxiva DAB Liquid-Cooled VLX-OP Series

**KEY FEATURES**

- High Efficiency (Broadband PA’s)
- Low consumption Pump and Heat Exchanger (pump + heat exchanger + external fans = 535W)
- Dual Redundant Pumps standard
- Coolant reserve tank (8 liters) for automatic liquid refilling, reduces on-site maintenance
- Liquid Cooled Control Unit: level (liquid + refilling), pressure, temperature, pump status, etc.
- Very small external heat exchanger with 24V power, 2 fans or 4 fans
- Heat Exchanger automatic reverse fan rotation feature to remove debris (user settable timing)
Maxiva Liquid-Cooled VLX-OP VHF Series

Single Rack Systems

- **15.2 kW** 8 PA’s
- **11.4 kWz** 6 PA’s
- **9.5 kW** 5 PA’s
- **7.6 kW** 4 PA’s
- **5.7 kW** 3 PA’s
- **3.8 kW** 2 PA’s
VLX-OP LIQUID-COOLING SYSTEM

Automatic Liquid Refilling System (8 litres capacity)

Dual Liquid Pumps

Refilling System

Lower Portion of Liquid-Cooled Tx Rack
VLX-OP HEAT EXCHANGERS

- Fans 24V DC
- Speed-controlled
- Programmable auto-reversing to clear debris

61 cm W x 80 cm H x 26 cm D
(24” W x 31.5” H x 10.2” D)

72 cm W x 96 cm H x 27 cm D
(28.3” W x 37.8” H x 10.6” D)
• Efficiency of a transmitter:
  • Definition: (RF Power Out / AC Power In) x 100%
European Electricity Pricing - Cents/kW-Hr (2019 Data)
• Transmitter System Efficiency

• Some Items may have fixed losses:
  • Control System
  • Exciters

• Some Items may have varying losses:
  • PA Module (varies with modulation, saturation)
  • Drivers (varies with modulation, saturation)
  • Cooling System (speed-controlled pumps and fans)
  • Power Supplies (can vary depending on load)

• Why are low power transmitters less efficient than high power?
  • As power is reduced, fixed losses become a larger part of the equation
• Power Amplifiers
  • Most older designs used Class AB PA’s
    • PA Efficiency in range 23% to 33% (Overall Tx efficiency in range of 16% to 27%)
  • Most new designs uses High-Efficiency (Doherty) PA’s
    • PA Efficiency over 50% VHF and UHF (Overall Tx efficiency often > 40%)

• Power Supplies
  • 12 years ago 86% was “state-of-the-art” efficiency
  • Today – power supplies can be up to 96% efficient

• Cooling System
  • Older less efficient transmitters used large high volume and pressure blowers
  • Large pumps and heat exchangers in liquid-cooled transmitters
  • New systems use variable speed fans and pumps and have less heat to remove
Clearly, the design of the power supply has a significant impact on total efficiency.

Example of a high-efficiency power supply:
- Efficiency 96% at 50% FL
- Power factor typ. 0.995
- Input voltage range typ. 185 – 300 VAC

<table>
<thead>
<tr>
<th>Item</th>
<th>Old Technology PS 86% Effy.</th>
<th>Recent Power Supply 90% Effy</th>
<th>New High Eff. PS 96% Effy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Power Output (W)</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Power Amplifier Efficiency</td>
<td>51%</td>
<td>51%</td>
<td>51%</td>
</tr>
<tr>
<td>Combining losses (dB)</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>RF power before losses (W)</td>
<td>10,715</td>
<td>10,715</td>
<td>10,715</td>
</tr>
<tr>
<td>DC Power to PA’s (W)</td>
<td>21,010</td>
<td>21,010</td>
<td>21,010</td>
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<tr>
<td>Power Supply Efficiency</td>
<td>86%</td>
<td>90%</td>
<td>96%</td>
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<tr>
<td>AC Power to Power Supplies (W)</td>
<td>24,430</td>
<td>23,345</td>
<td>21,886</td>
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<td>Power Supply Loss (W)</td>
<td>3420</td>
<td>2334</td>
<td>875</td>
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<tr>
<td>Drivers</td>
<td>600</td>
<td>600</td>
<td>600</td>
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<tr>
<td>Exciters</td>
<td>150</td>
<td>150</td>
<td>150</td>
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<tr>
<td>Control</td>
<td>120</td>
<td>120</td>
<td>120</td>
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<tr>
<td>Cooling</td>
<td>600</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>Total AC Input (kW)</td>
<td>29,321</td>
<td>27,149</td>
<td>24,231</td>
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<tr>
<td>Overall Tx Efficiency</td>
<td>34%</td>
<td>37%</td>
<td>41%</td>
</tr>
</tbody>
</table>
TCO VERSUS TRANSMITTER EFFICIENCY

TCO

• It’s the total cost to own and operate the transmitter system over time
• Includes initial equipment cost and delivery
• Includes the installation / commissioning costs
• Routine and unscheduled maintenance costs
• Repair/replacement and other operational costs

EFFICIENCY

• Transmitter efficiency = Power Out / Power In (tx only)
• System level efficiency may also include:
  - AC transformers and voltage regulators
  - Heat load to the room (HVAC power costs)
  - RF system losses (often significant)
  - RF feeder losses (often significant)
  - Even antenna gain and pattern?
Each element of the Transmitter lifecycle has a cost

Over the lifetime of the Transmitter, the total cost may far exceed the purchase price by several times

Questions:

• Is it really worth buying a new transmitter?
• Will I see a return on investment?
• When will it pay back for itself?

Let’s use the TCO Calculator and find out...
**AIR TO LIQUID-COoled 9.6kW TX TCO AND BREAKEVEN**

### User Entry Cells:
- `Existing Transmitter`
- `New Transmitter`

### Result Cells:
- `Diamond DHD45P2`
- `ULXTE-16`
- `9.6`
- `9.6`
- `kW`

### Existing Transmitter Costs:
- Planning Costs: $0 USD
- New Transmitter Cost: $0 USD
- Delivery / Shipping Costs: $0 USD
- Installation / Commissioning Costs: $0 USD
- Training Costs: $0 USD
- Average Annual Maintenance Costs: $11,000 USD
- Transmitter Efficiency: 19.9%
- Electricity Cost ($ per kW/hr): $0.15 USD
- Operational Hrs/day: 24
- Operational days/year: 365.25
- Major Repair / Upgrade at Year 5**: $45,000 USD
- Disposal Costs at EOL: $10,000 USD
- HVAC Efficiency Rating*: 14

### New Transmitter Costs:
- Planning Costs: $0 USD
- New Transmitter Cost: $1,200 USD
- Delivery / Shipping Costs: $5,500 USD
- Installation / Commissioning Costs: $29,000 USD
- Training Costs: $2,500 USD
- Average Annual Maintenance Costs: $4,500 USD
- Transmitter Efficiency: 42.2%
- Electricity Cost ($ per kW/hr): $0.15 USD
- Operational Hrs/day: 24
- Operational days/year: 365.25
- Major Repair / Upgrade at Year 5**: $10,000 USD
- Disposal Costs at EOL: $10,000 USD
- HVAC Efficiency Rating*: 14

### TCO & Breakeven Analysis

#### 9.6kW Tx

**Cooling Method (select Air or Liquid):**
- Air
- Liquid

**Planning Costs:**
- Existing: $0 USD
- New: $1,200 USD

**Transmitter Efficiency:**
- Existing: 19.9%
- New: 42.2%

**Operational Hrs/day:**
- Existing: 24
- New: 24

**Operational days/year:**
- Existing: 365.25
- New: 365.25

**Major Repair / Upgrade at Year 5**:
- Existing: $45,000 USD
- New: $10,000 USD

**Disposal Costs at EOL:**
- Existing: $10,000 USD
- New: $10,000 USD

**HVAC Efficiency Rating:**
- Existing: 14
- New: 14

**Calculated Summary Results**

<table>
<thead>
<tr>
<th>Item</th>
<th>Existing Transmitter</th>
<th>New Transmitter</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx Average Power Output</td>
<td>9.6 kW</td>
<td>9.6 kW</td>
<td>kW</td>
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<tr>
<td>Cooling Method (select Air or Liquid)</td>
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<td>Liquid</td>
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<tr>
<td>Planning Costs</td>
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<td>$1,200 USD</td>
<td>USD</td>
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<tr>
<td>New Transmitter Cost</td>
<td>$0 USD</td>
<td>$265,000 USD</td>
<td>USD</td>
</tr>
<tr>
<td>Delivery / Shipping Costs</td>
<td>$0 USD</td>
<td>$5,500 USD</td>
<td>USD</td>
</tr>
<tr>
<td>Installation / Commissioning Costs</td>
<td>$0 USD</td>
<td>$29,000 USD</td>
<td>USD</td>
</tr>
<tr>
<td>Training Costs</td>
<td>$0 USD</td>
<td>$2,500 USD</td>
<td>USD</td>
</tr>
<tr>
<td>Average Annual Maintenance Costs</td>
<td>$11,000 USD</td>
<td>$4,500 USD</td>
<td>USD</td>
</tr>
<tr>
<td>Transmitter Efficiency</td>
<td>19.9%</td>
<td>42.2%</td>
<td>%</td>
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<tr>
<td>Electricity Cost ($ per kW/hr)</td>
<td>$0.15 USD</td>
<td>$0.15 USD</td>
<td>USD</td>
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<tr>
<td>Operational Hrs/day</td>
<td>24</td>
<td>24</td>
<td>Hrs.</td>
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<tr>
<td>Operational days/year</td>
<td>365.25</td>
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<td>Days</td>
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<tr>
<td>Major Repair / Upgrade at Year 5**</td>
<td>$45,000 USD</td>
<td>$10,000 USD</td>
<td>USD</td>
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<tr>
<td>Disposal Costs at EOL</td>
<td>$10,000 USD</td>
<td>$10,000 USD</td>
<td>USD</td>
</tr>
<tr>
<td>HVAC Efficiency Rating*</td>
<td>14</td>
<td>14</td>
<td>SEER</td>
</tr>
</tbody>
</table>

#### Estimated Breakeven Period

**5 Years, 2 Months**

**Y / M**

**Reduction in Heat Load to Room:** 126,465 Btu/hr

**Annual Reduction in Carbon Emissions:** 149.8 Tons CO2

**Tx Power cost savings per year:** $33,520 USD

**HVAC Power Cost Savings per Year:** $11,878 USD

**Total Power Cost Savings per year:** $45,398 USD

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*SEER (Seasonal Energy Efficiency Ratio) usually between 10 and 22 (typical 14)

**For Tube Transmitters, include replacement Tube Costs**
CONFIGURATIONS FOR REDUNDANT OPERATIONS

• 1+1 – Main – Alt
• N+1 – multi transmitter back up
• Dual Drive
• Evaluate your tolerance for risk vs the cost to provide insurance
• Share back up in a multi transmitter site can be affordable
4000 SERIES FRONT PANEL

Front Panel Status on 4000 series

- RF/TS Signal Flow
- TX Status LEDs
- RF Signal Flow
- TX On Air
- LOCAL/AUTO/Load Control
- Manual/Remote Control
- Maximum # of swithovers
- RF In System
- RF In Presence TX
• Illustration of +1 redundancy
• TX 3 is off-line, Transport stream (RED) is rerouted for TX3 to +1 spare
• RF coax switch relay (BLUE) positions to put +1 TX to air
• Provides “Hitless” protection using Intraplex® Dynamic Stream Splicing technology for EDI streams
• IPConnect intercepts the streams from the Headend and reliably tunnels it to one or more exciters
• IPConnect works with unicast, multi-unicast and multicast topologies
• Also monitors and provides automatic failover between Main and Backup Headend at the Studio side
- Allows up to 3 DAB+ Carriers to be generated or re-transmitted through a single amplifier
- Advanced pre-correction and linear broadband amplification
- Unique solution ONLY available from GatesAir
- More economic than standard solutions
- More compact
- Less expensive to operate, lower power consumption
MULTICARRIER DAB+ 240W TOTAL POWER

- Touch screen LCD
- Control Ethernet Port
- USB Port
- ETI In #1
- ETI In #2
- ETI In #3
- Compact 1U rack 19 "chassis.
- Output power up to 240W rms total
- Common RF amplification.
- Wide Band VHF BIII Doherty Amplifier technology with high efficiency.
- Supported Modulations: DAB / DAB+ / T-DMB.
- Multi-carrier modulation (3 channels), for adjacent and non-adjacent frequencies.
- Adaptive pre-correction circuits.
- Built-in high-stability GPS / GLONASS receiver (Optional).
- Hot swappable amplifier and power supply.
- Input interface: 3 ETI inputs.
- SNMP, Web interface and Touch Screen display.
- USB service interface for up-grade / download.
- Ideal for low power multi ensamble sites – shared redundancy
- 7+1 6+2 redundancy
- Integrated Satellite receiver card
• New options for DAB transmission networks allow for network design flexibility
• Advancements in energy efficiency help reduce long term operating costs
• Energy consumption and costs can be impacted by using liquid or air-cooled transmitters
• Multiple options can allow for cost effective redundancy for transmitters and links
• Unique system configurations and modulation capabilities can simplify network deployment
ADVANCES IN DAB TRANSMISSION SYSTEMS
CONNECTING WHAT’S NEXT
RICH REDMOND