MUSIC GROUP

AES50 – Applications in Live Concert Sound

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Presentation

- Origins and current status of AES50
- Relation to proprietary Klark Teknik SuperMAC and HyperMAC technologies
- Frame-Based vs. Packetised Networking
- Suitability for live concert sound
- Implementation in MUSIC Group products
- Interfacing to other networking protocols
- AES50 – Live TV Concert Events

The MUSIC Group

- ***The MUSIC Group*** is one of the world's largest holding companies for pro audio and music products brands.
- Corporate parent company for ***MIDAS®***, ***KLARK TEKNIK®***, ***BEHRINGER®*** and ***BUGERA®***
- Chairman and CEO is ***ULI BEHRINGER***
- ***The MUSIC Group*** provides a comprehensive product range covering multiple product categories to a wide spectrum of end-users including professionals, corporations and amateurs, as well as for public and commercial applications. Products include loudspeakers, amplifiers, mixers, powered mixers, computer-based recording and DJ products, microphones, headphones, wireless systems, musical instruments and professional lighting systems.

http://www.music-group.net/

AES50

AES50 is an Audio Engineering Society open standard defining the bidirectional transmission of multichannel digital audio over 100 Mbit/s CAT 5/5e cable

AES50-2005

AES standard for digital audio engineering –

High resolution multi-channel audio interconnection (HRMAI).

Contrary to popular belief, Midas and Klark Teknik do not own AES50!!

AES-R6

Guidelines Document:-

AES-R6-2005
AES project report -
Guidelines for AES standard for digital audio engineering -
High resolution multi-channel audio interconnection (HRMAI), AES50

Revisions to both AES50-2005 and AES-R6-2005 have been proposed by Midas and Klark Teknik to the AES Standards Committee SC-02-02 to include changes based on experience of real-world implementation.

AES50 and SuperMAC

AES50 is an Audio Engineering Society open standard

- Anyone is free to create their own implementation.

SuperMAC is a proprietary implementation of AES50.

- AES50 is based on SuperMAC, which was created by Sony Pro-Audio Lab, Oxford
- SuperMAC was licensed by Sony to Midas for the XL8 digital console project
- ***SuperMAC was purchased by Klark Teknik in 2007***
- Klark Teknik can identify SuperMAC as being ***AES50-Compliant***, however the AES does not operate a certification programme for conformity with its standards

HyperMAC

HyperMAC is a higher capacity Ethernet-based digital transmission system, also created by Sony Pro-Audio Lab.

- Uses Gigabit Ethernet for higher channel counts than SuperMAC offers
- Sony offered HyperMAC on a similar royalty-fee basis to SuperMAC
- Midas licensed HyperMAC for XL8 console project to replace multicore analogue snakes
- ***HyperMAC is proprietary technology owned by Klark Teknik, also purchased from Sony in 2007***

AES50 and HyperMAC Comparison

AES50 (SuperMAC)

- 100 Mbit/s over CAT5/CAT5e copper cable (100 metres)
- 24 bidirectional channels @ 96 kHz (48 bidirectional channels @ 48 kHz)
- Latency per link = 6 Samples (62.50 µs) @ 96 kHz (3 Samples (62.50 µs) @ 48 kHz)
- 5 Mbit/s Ethernet auxiliary data channel

HyperMAC

- 1 Gbit/s over CAT5e/CAT6 copper cable (100 metres) or 50/125 µm multimode optical fibre (500 metres)
- 192 bidirectional channels @ 96 kHz (384 bidirectional channels @ 48 kHz)
- Latency per link = 4 Samples (41.66 µs) @ 96 kHz (2 Samples (41.66 µs) @ 48 kHz)
- 200 Mbit/s Ethernet auxiliary data channel

Packet-based Ethernet Audio Systems

Many Ethernet audio networks use computer industry standards – typically the Internet Protocol (IP).

- Audio samples are collected into "***Packets***", with a header containing information about the source, destination etc.
- These Packets can then be delivered over standard Ethernet networks, and the Packets decoded at the receiver – ***and won't necessarily arrive in the order they are sent!!***
- This approach has the advantage that such systems are ***compatible with off-the-shelf IT equipment*** such as network switches and routers.
- However, to provide smooth audio playout, such systems typically have to ***buffer*** up an amount of data to ensure that the ***variability*** of the network can be compensated for.
- The effect of this buffering is to increase the ***latency*** of such systems, making them unsuitable for in-ear monitoring applications.

Frame-Based Audio Transmission

AES50 (and HyperMAC) take a very different approach to IP-based audio systems.

- They use the ***physical layer*** only of the Ethernet technology – the cables and transceivers at each end.
- There is no need to send and decode complex header information (required for Ethernet Packets) because the link is only designed to send audio data from ***Point to Point***, not generic computer data across the Internet.
- Audio samples are be streamed continuously using ***Ethernet Frames*** to achieve a far more efficient use of the available bandwidth that IP-based solutions can physically offer.

AES50 (and HyperMAC) are <u>not</u> compatible with off-the-shelf IT equipment and require dedicated routers e.g. Midas DL461, DL371.

- Such routers can however be designed for the rigours of concert touring (e.g. rear-mounted connections, use of Neutrik EtherCons)

AES50 Performance

- *100 Mbit/s over CAT5/CAT5e copper cable (100 metres)* — ***Defined Bandwidth***

- *24 bidirectional channels @ 96 kHz* — ***Defined Number of Channels***
- *48 bidirectional channels @ 48 kHz*

- *Latency per link = 6 Samples (62.50 µs) @ 96 kHz* — ***Defined Ultra-Low Latency***
  3 Samples (62.50 µs) @ 48 kHz

- *5 Mbit/s Ethernet auxiliary data channel* — ***Defined Auxiliary Data Bandwidth***

All of the Above – All of the Time!!

AES50 in Use

AES50 has been thoroughly proven on many high profile tours, live events and installations including:-

Led Zeppelin (O2 Arena), Metallica, AC/DC, Oasis, REM, The Verve, Aerosmith, Depeche Mode, OMD, Arctic Monkeys, Kings of Leon, Paul Weller, Manic Street Preachers, The Noisettes, Kasabian, Porcupine Tree, Marillion, Deacon Blue, Beady Eye, Rod Zombie, Jamiroquai, Slipknot, The Script, Foo Fighters, Biffy *Clyro, Pulp, Marco Borsato, Jason Derulo, Sir Cliff Richard, Phish, Jay-Z, Faithless, Beverley Knight, Teenage Cancer Trust, Harry Connick Jr., Florence and the Machine, Megadeth, Snow Patrol, Fall Out Boy, Avenged Sevenfold/Buckcherry, The Pogues, A-ha, Rihanna, Jan Smit, Simply Red, Gloria Estefan, Paolo Nutini, Glastonbury Festival, T in the Park, Metal Hammer Festival (Poland), Francofolies (France), Houston Rodeo, Rambert Dance Company, New York Metropolitan Opera in Central Park, White Noise (New Victory Theater, NY), Priscilla, Queen of the Desert (Palace Theater, NY), Placido Domingo (Bird's Nest Stadium, Beijing), Nobel Peace Prize Concert (Oslo), Mikhail Gorbachev's 80th Birthday Celebration, Eiffel Tower (Paris), Westover Church (Greensboro, NC), Christian Faith Center (Seattle), Shibuya-AX (Tokyo), JCB Hall (Tokyo), Hatch (Osaka), Malai Theatre (Moscow), Crocus City Hall (Moscow), Shenzhen Poly Cultural Center, Suzhou Science and Cultural Center, Guangzhou Opera House, Infosys Auditorium (Bangalore)…*

AES50 – Key Attributes for Live Sound

AES50 is ideally suited to Live Concert Sound applications, as it <u>simultaneously</u> provides:-

- *High Channel Count*
- *Ultra-low and Deterministic Latency*
- *Accurate Phase-Aligned Low-Jitter Clock Distribution*
- *Single cable Bidirectional Interconnection for Audio and Sample Clocks*
- *Minimal Configuration – Ease of Deployment and Use*
- *Comprehensive Error Detection and Correction*
- *Redundant Networking Capability*

Low and Deterministic Latency

Keeping transmission latency to an absolute minimum is critical with the increased adoption of in-ear monitoring.

- The delay that a vocalist experiences between singing a note and hearing it in their earpieces cannot be perceptibly greater than the time it takes for the sound to be physically transmitted from their mouth to their ears

- Even for latencies below which a time delay cannot be consciously identified, the effect can be disturbing and performances will be impaired, e.g. between ***3 – 5 ms***

Completely deterministic transmission latency and clock distribution means that precise phase alignment between many different channels can be guaranteed.

- When a large number of microphones are being used on stage in close proximity to each other, such as on a drum kit where a certain amount of spill is inevitable, a clear and coherent stereo image is presented in the Front Of House mix that the audience hears

In-Ear Monitoring Latency – Midas XL8 Console

In a Midas XL8 digital console system, the signal path will be typically configured:-

Microphone → Splitter System → Router → DSP → Router → Output Box → In-Ear Monitor

- This involves ***four AES50 links***, so including the additional samples required for converting the received data into an internal data format such as I^2S or similar:-

Splitter System → Router	6 + 2 samples	83.33 µs
Router → DSP	6 + 2 samples	83.33 µs
DSP → Router	6 + 2 Samples	83.33 µs
Router → Output Box	6 + 2 samples	83.33 µs
	Total	**333.33 µs**

- To minimise the additional system latencies Midas digital consoles use premium low latency analogue-to-digital and digital-to analogue converters that add a further ***141.67 µs*** combined latency. The internal processing latency from input to auxiliary output on an XL8 is ***106 samples***, or ***1.10 ms***

- The total system latency in a Midas XL8 digital console system from microphone to in-ear monitor is therefore ***less than 1.60 ms,*** well below latencies identified by vocalists as problematic (***3 – 5 ms***)

AES50 Error Detection and Correction

AES50 has two forms of error detection and correction:-

- A ***Cyclic Redundancy Check (CRC)*** checksum is calculated at the transmitting end of the link and sent with the corresponding Ethernet frames.

- A robust Hamming Code ***Forward Error Correction*** scheme that allows individual bit errors to be corrected at the receiving end of the link.

AES50 also "scrambles" the audio data in such a way that adjacent bits relate to different samples, which allows burst errors to be fully corrected.

- *This means that a poor quality link (due to a bad cable or external interference) can be detected by the receiver, while still passing perfect audio.*

AES50 Connections

AES50 uses the four pairs of Cat 5/5e cable as follows:-

1 - Audio data transmit +
2 - Audio data transmit –
3 - Audio data receive +
4 - Sync signal transmit +
5 - Sync signal transmit –
6 - Audio data receive –
7 - Sync signal receive +
8 - Sync signal receive –

- Separate copper pairs in the Cat 5/Cat 5e cable for audio data and clock connections allows reliable, phase-accurate, low-jitter clocks to be delivered to the end-points of the system.

- Clock synchronisation is very simple to configure, units equipped with AES50 interfaces are either ***Master*** (internally clocked) or ***Slave*** (externally clocked)

All that is necessary to create an operational audio network is to connect up the AES50 interfaces and select the Clock Source (Internal/External) for each unit

AES50 Network Topology

- Whilst AES50 is inherently a point-to-point connection, the used of specialised cross-point routers enables the creation of audio networks in a Star topology.

- This approach offers robust, low-latency and deterministic latency audio routing, with the benefits of a true packet-switched network for the control data.

- Star topology is centralised, not distributed, giving:-

  - *Better latency control,*
  - *Better reliability*
  - *Finer routing granularity*

Network Redundancy

AES50 easily supports the implementation of redundant networks.

- Reporting of Error and Link status information such as:-
  - *CRC error detection*
  - *Clock synchronization status,*
  - *Link status*

  makes it very easy to provide AES50 link health reporting to the user, and to implement redundant links with manual or automatic change-over.

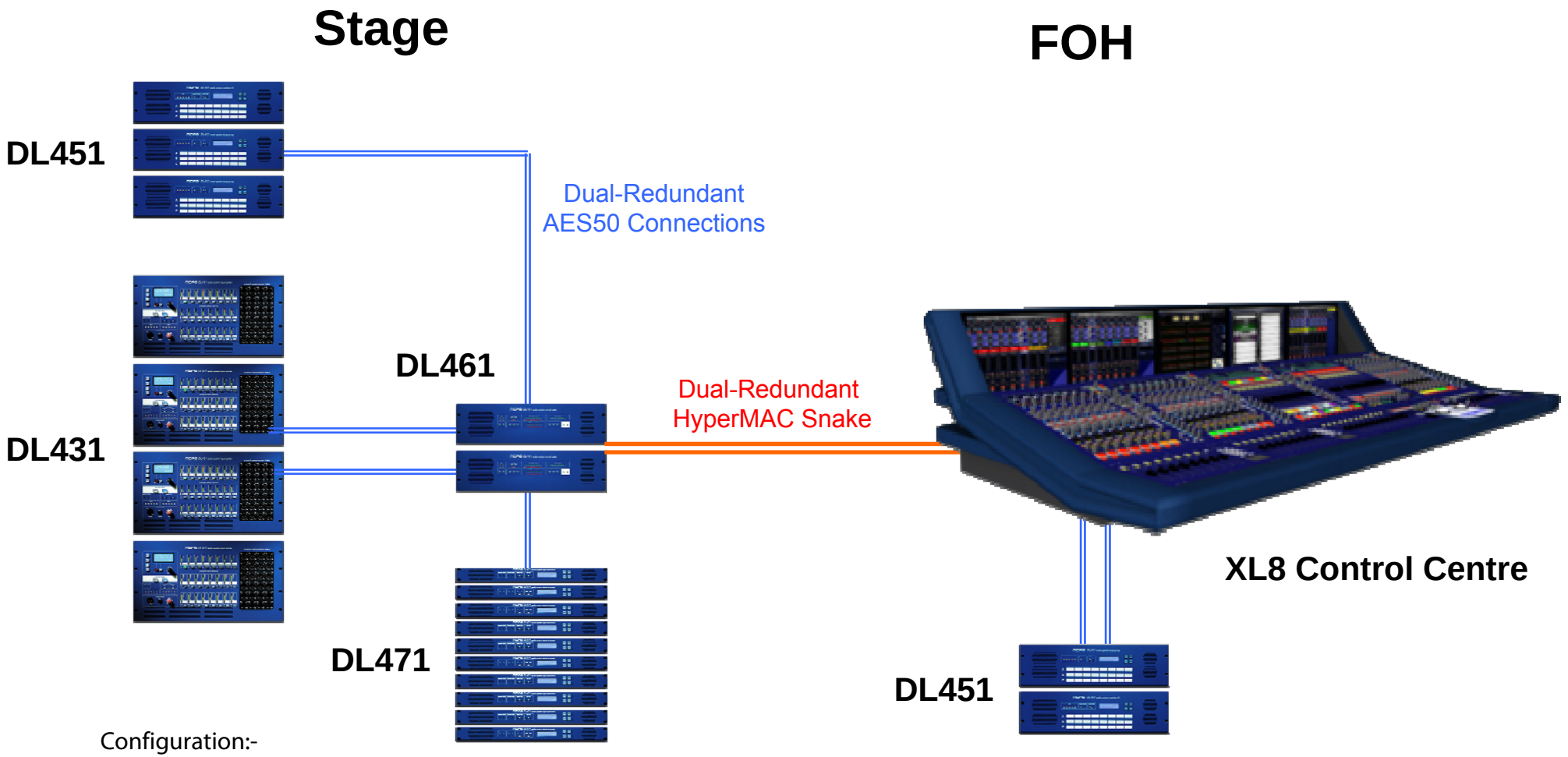
- **Dual Redundant and N+1 Redundant Networks are supported**

N+1 Redundancy - Example

N+1 redundant networking can be implemented as follows:

- Three 96 kHz AES50 connections can support a maximum of 72 Inputs and 72 Outputs, and a fourth AES50 connection provided for N+1 Redundancy.
- The three active AES50 connections are identified as A, B and C, independent of the physical AES50 ports 1-4.
- The AES50 Router knows that an AES50 peripheral unit is connected, and changeover to redundant spare is automatic, for example:-
  - *Router sees cable C fail (e.g. loss of sync)*
  - *Router un-maps existing C connection, maps C to redundant spare*
  - *Router sends Ethernet Control Data message to peripheral unit via A, B and C with new mapping*

MIDAS XL8 Live Performance System



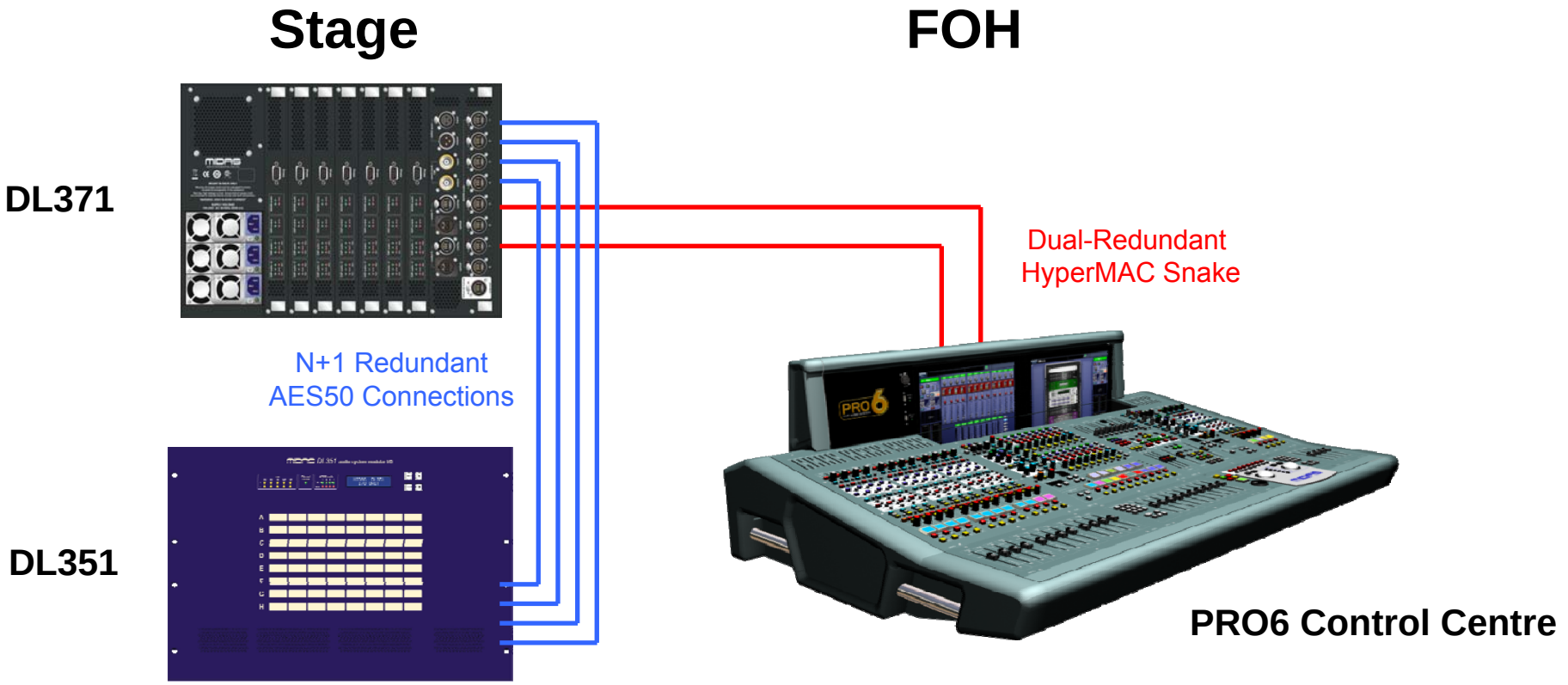
Configuration:-

- 1 x XL8 Control Centre
- 4 x DL431 Mic Splitters
- 5 x DL451 Modular I/O
- 2 x DL461 Routers (Dual Redundant)
- 10 x DL471 DSP Engine (N+1 Redundant)

Connections:-

Network:	432 In x 432 Out
Console:	112 In x 51 Out or 144 In x 19 Out

MIDAS PRO6 Live Audio System



Configuration:-

- 1 x PRO6 Control Centre
- 1 x DL371 DSP Engine
- 1 x DL351 Modular I/O

Connections:-

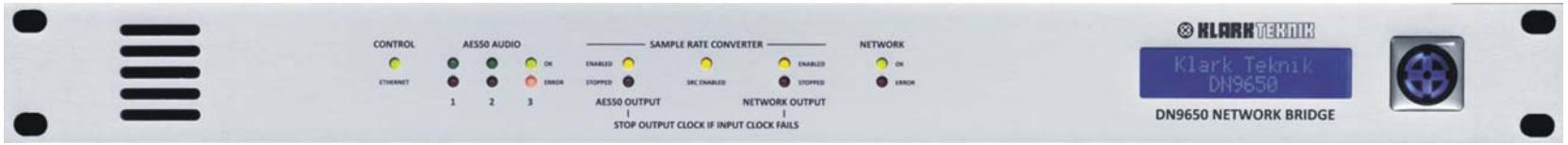
Network:	264 In x 264 Out
Console:	80 In x 19 Out or 64 In x 35 Out

BEHRINGER X32 Digital Console – *Coming Soon!!*

32-Channel, 16-Bus Total-Recall Digital Mixing Console for Live and Recording Applications

- 48-channel digital snake ready via AES50 ports featuring KLARK TEKNIK's SuperMAC networking capability for ultra-low jitter and latency

KLARK TEKNIK DN9650 Network Bridge



The DN9650 Network Bridge interfaces AES50 networks to Third Party formats:-

- *Audinate Dante*
- *Aviom A-Net*
- *Cirrus Logic CobraNet*
- *Digigram EtherSound*
- *MADI (AES10)*

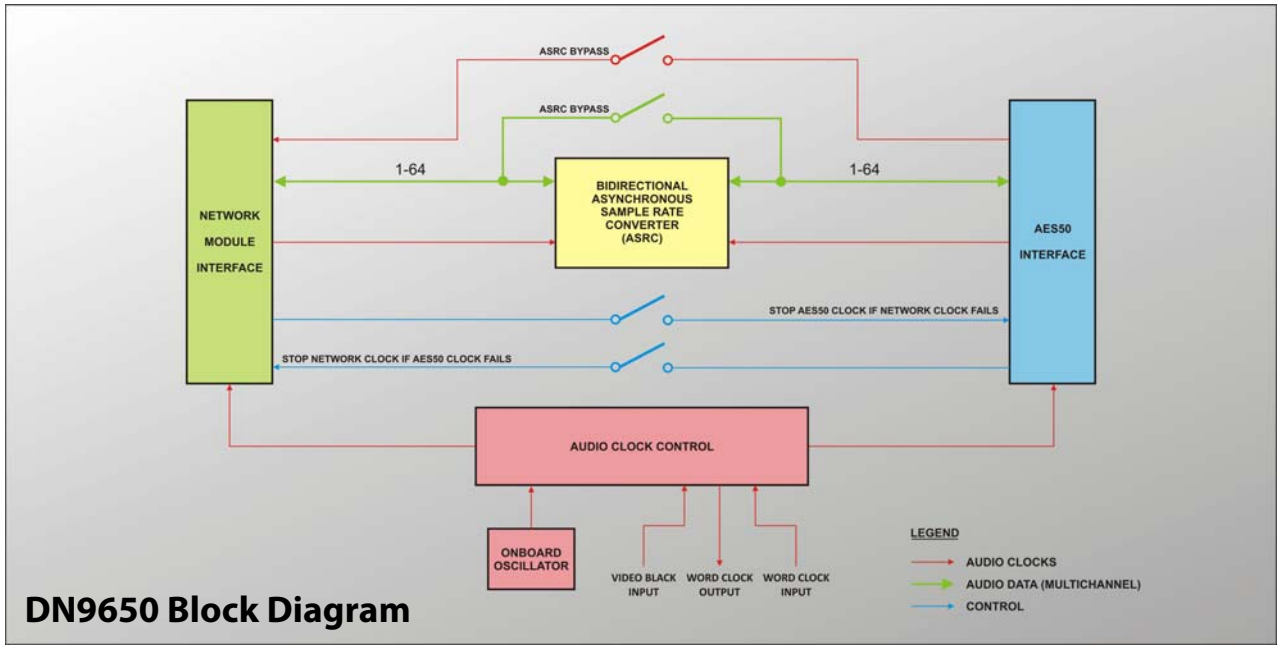
The DN9650 AES50 Bridge supports network modules designed and manufactured by Cirrus Logic, Inc., Lab X Technologies, LLC, and Audinate Pty Ltd.

DN9650 – Network Clock Domain Management

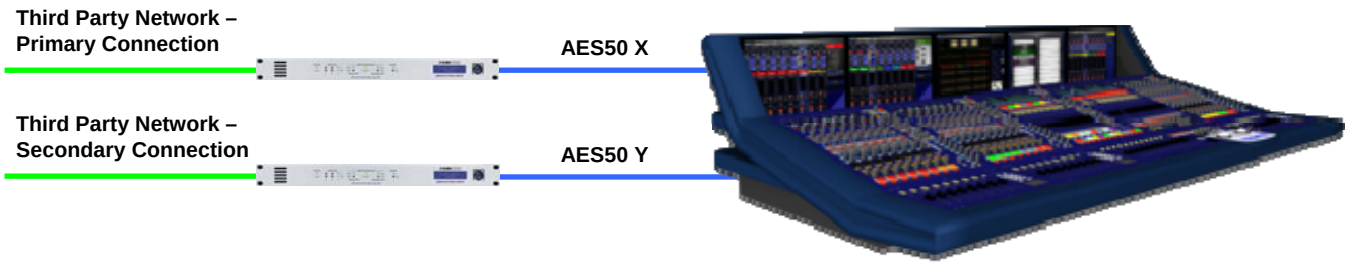
Users need to interface AES50 to Third Party networks and external clock sources:-

- Very high channel count Bidirectional Asynchronous Sample Rate Converter (ASRC) is required
  - ***72 Channels in each direction (3 x 24-Channel AES50 ports @ 96 kHz)***
  - ***The DN9650 clock synchronisation scheme is divided into two domains, with the AES50 domain and Third Party network domain separated by the ASRC***
  - ***Provides isolation between Clock Domains as well as conversion between sampling frequencies***
- Transmission method required for propagating network clock failures across ASRC required for redundant switchover:-
  - ***User-selectable Bidirectional "Stop Output Clock if Input Clock fails" function, to propagate network failures across ASRC for automatic or manual redundancy switchover***

DN9650 – Interfacing to Third Party Networks



DN9650 Block Diagram



AES50 – TV Broadcast Events

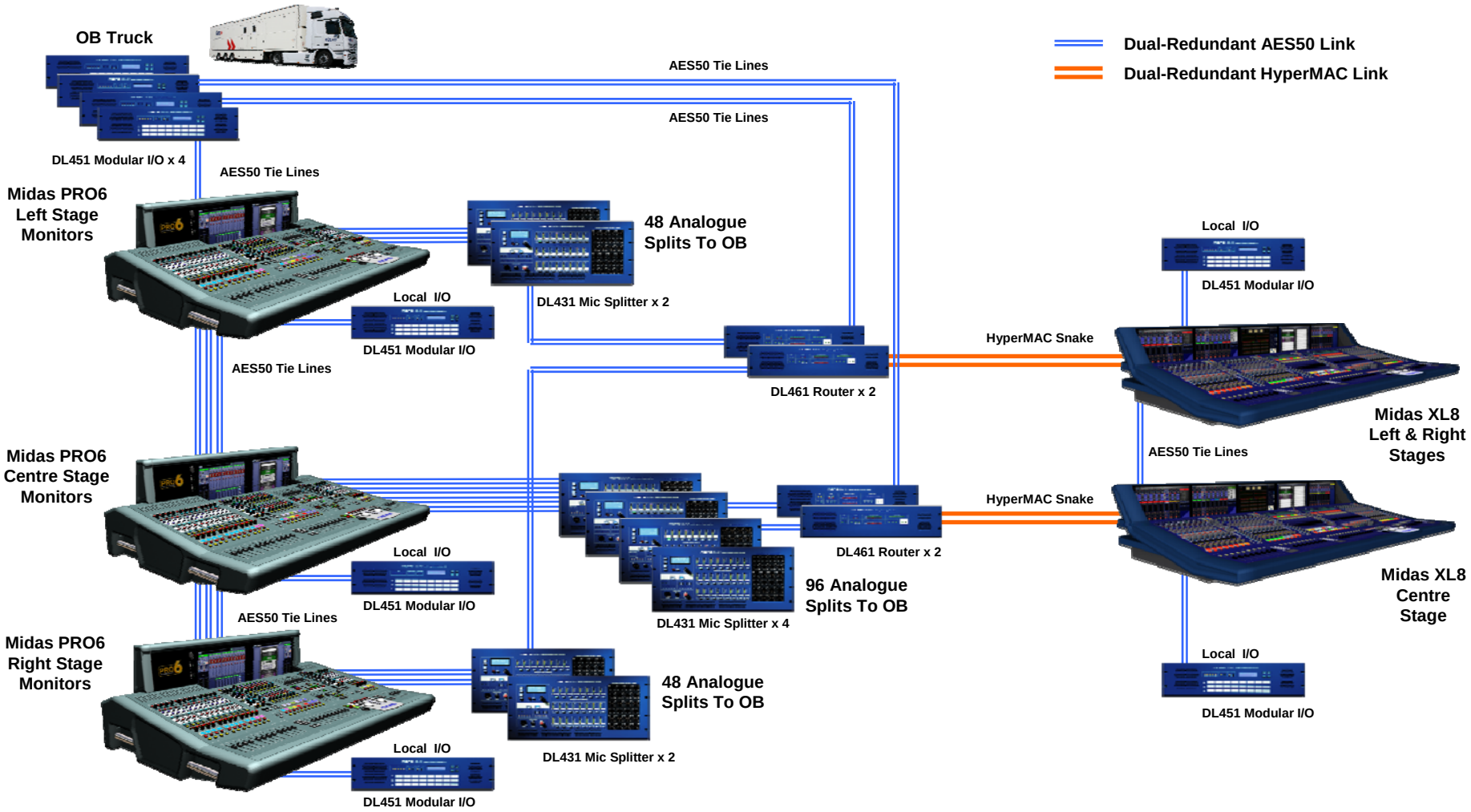
Large scale networks have been deployed for major TV broadcast events featuring multiple Midas XL8 and PRO6 consoles connected and synchronised via AES50 and HyperMAC.

Network reliability and resilience is critical at these events – there is no Take Two!!

Nobel Peace Prize Concert 2008, 2009, 2010	**(AVAB-CAC)**
Glastonbury Jazz World Stage 2009	**(APR Audio)**
The Brit Awards 2010	**(Britannia Row)**
The Classical Brit Awards 2010, 2011	**(Britannia Row)**
Mikhail Gorbachev 80th Birthday Celebration 2011	**(Britannia Row)**
The Eurovision Song Contest 2010	**(AVAB-CAC)**

Nobel Peace Prize Concert, Oslo

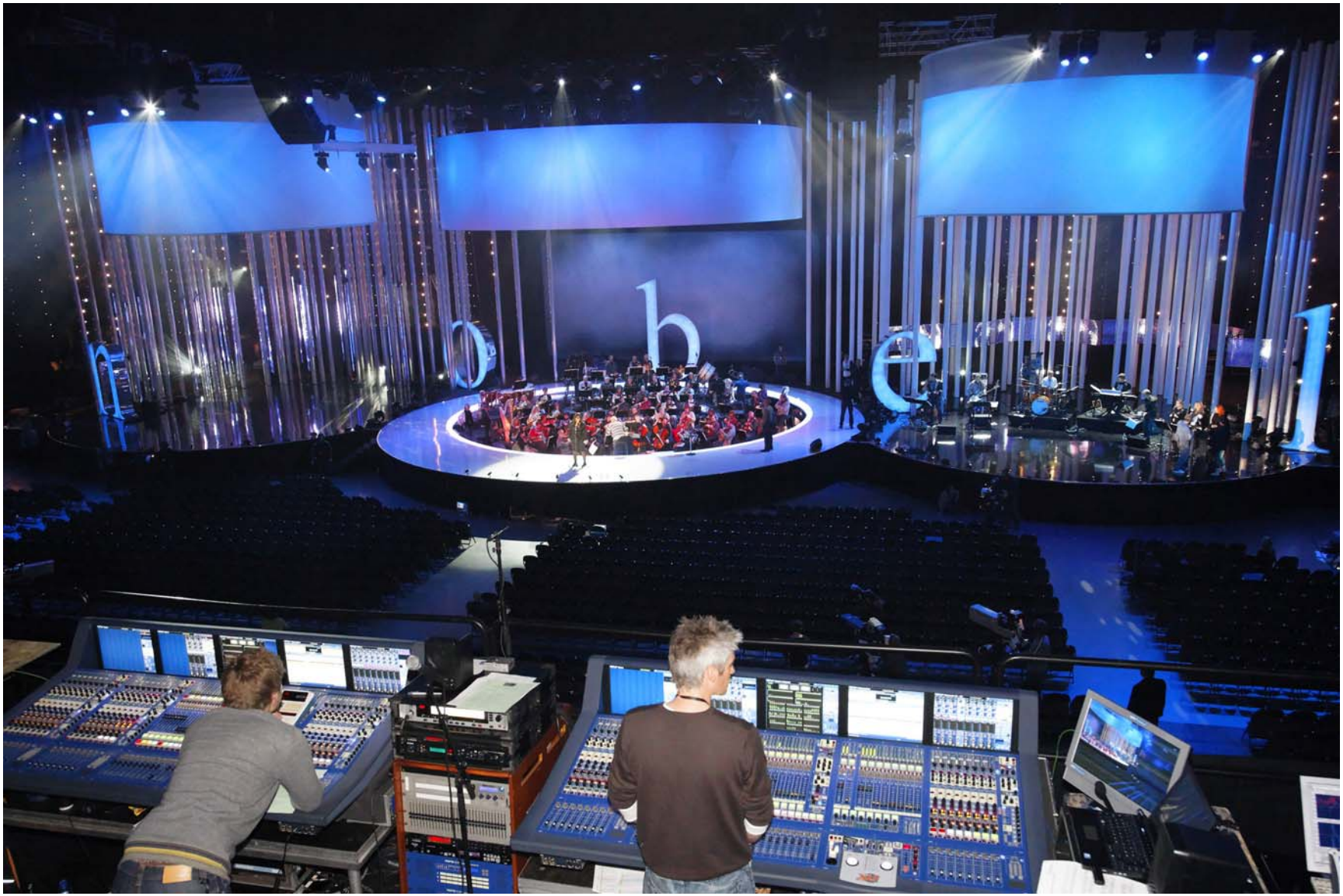
A single synchronised networked system with over 300 Inputs and 200 Outputs across three stages was built using dual-redundant AES50 and HyperMAC connections. All synchronisation achieved using AES50 and HyperMAC – No additional clock distribution required!



Note: DL371 and DL471 DSP Engines Omitted For Clarity

Nobel Peace Prize Concert 2008

Nobel Peace Prize Concert 2009



Nobel Peace Prize Concert 2010

www.supermac-hypermac.com

Dedicated Klark Teknik website for Proprietary SuperMAC and HyperMAC Technologies

- Technical information
- Developer and *Royalty-Free* Licensing Information
- Comprehensive FAQ section

- ***Also relevant for AES50***

- E-mail: **info@supermac-hypermac.com**

Thank You!

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