

TMX-2010 Transport Multiplexer

ATSC Application Note

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1 Introduction

With local network broadcast affiliates rushing to meet the FCC mandated on-air date for transitioning to digital ATSC broadcasting, determining an entry-level but fully compliant encoding and multiplexing solution that is extensible to future more sophisticated ATSC broadcast applications has become a common goal in the industry. For example, a new ATSC broadcaster may begin with a digitally compressed MPEG version of their traditional programming along with the FCC compliant amount of program and system information protocol (PSIP), but later grow to add more programs (multicasting) including high definition and data services.

Motorola BCS has designed a modular system to best meet a phased approach to full DTV operations. The basic building blocks include a transport multiplexer and standalone encoders. The elements seamlessly fit together to facilitate cost-effective compliance and rapid deployment of new services.



An application-rich local network broadcast affiliate incorporates network feeds, local created content, data services, server content and supports separate private networks and cable distribution pipes.

The Motorola Broadband Communications Sector's (Motorola BCS) TMX-2010 transport multiplexer is built upon a flexible, module-based chassis, providing basic multiplexing, ATSC standard PSIP handling (A/65) and IP data encapsulation (A/90), and bitrate transcoding. Additional functionality such as statistical multiplexing and

digital program insertion are optional upgrades. Motorola BCS' SE-2000 digital video encoder is a one rack unit high device providing high quality standard definition encoding and audio processing. The high definition encoder contains all of the input/output connections necessary for converting incoming, full bandwidth HD video, audio and data into the ATSC-compliant MPEG-2 bitstream.

2 TMX-2010 Multiplexer

The TMX-2010 Transport Multiplexer is Motorola BCS' new generation modular solution for MPEG-2 cable, satellite and broadcast transport distribution architectures.

It supports many features to tailor MPEG-2 streams.

- <u>Service Multiplexing</u>: Basic combining of multiple streams into one multiplex.
- <u>Grooming</u>: The ability to select (add/drop) the streams that will appear in the output transport.



The TMX Element Manager provides user friendly GUIs for simple and flexible selection from the input MPEG-2 services into one or more customized transport stream outputs.

 <u>Video bit-rate transcoding</u>: Transcoding is a method of partially decoding a MPEG-2 video elementary stream followed by a re-encode for the purpose of reducing the video bitrate. The TMX-2010 supports transcoding of constant or variable bitrate inputs into statistically multiplexed groups.



Statistical Multiplexing (Stat Mux) examines all of the incoming video feeds as a group and automatically (and frequently) assigns compression bitrates based upon the complexity and motion in each feed. The basic premise of Stat Mux (and the reason for the word "statistical") is that - at a given point in time- there will be some feeds that have a lot of motion, some with very little, and some are "average".

Stat Mux works by having all of the Single Channel Encoders(SE) that are included in a Stat Mux group report their compression demands (need parameter) to one decision maker - the TMX-2010. The TMX considers all of the demands (including each SE's minimum bitrate setting, maximum bitrate, and priority), decides on the bitrate to assign to each SE, and then communicates that decision back to each SE via the SE/TMX Ethernet connection. This "negotiation" for bitrate takes place at least once per video frame to ensure that even the slightest change in scene complexity becomes part of the decision making process.

 <u>Splicing</u>: MPEG-2 video splicing is defined as the seamless replacement of one MPEG-2 video packetized elementary stream with another. Performing a replacement in the compressed MPEG-2 domain has cost benefits for digital networks, especially when the video services are not encoded locally. MPEG-2 video slicing involves I-frame insertion, bitrate adjustments and, in some cases, resolution changes.

Motorola BCS' standards-based approach to digital program insertion (DPI) supports the transmission of DVS 253 DPI messages across a digital network. The TMX-2010 is used to interpret such messages and subsequently perform an MPEG-2 video splice with a local digital server. Utilizing DVS-380, the standards-based application program interface (API) between the server and TMX-2010, the digital splice is synchronized to sub-frame accuracy. The TMX-2010 translates MPEG PTS timing to common time-base (i.e. NTP) to ensure accurate insertion.



- <u>Encoder management</u>: The TMX Element Manager provides easy-to-use configuration of the SE-1010/2000 encoders via SNMP.
- <u>IP data encapsulation</u>: For datacasting applications, the TMX-2010 can accept and encapsulate externally supplied UDP/IP Multicast data into MPEG-2 packetized transport streams via standard transport input interfaces – and include those data streams as part of the output ATSC-compliant DTV multiplex.
- <u>PSIP handling</u>: The TMX-2010 supports the pass-through of PSIP tables supplied by an external PSIP Generation system, or can internally create the minimum A65 Program Specific Information Protocol (PSIP) data for a compliant ATSC broadcast.
- <u>Multiple output formats</u>: Provides standard transport interfaces DVB-ASI, DS-3, DHEI, and SMPTE-310 for interoperability across a variety of applications. The TMX-2010 also generates a simultaneous DVB-ASI output for monitoring purposes when another output port is chosen.

The TMX-2010 transport multiplexer's option module architecture allows for flexible feature customization and future expandability.





3 SE-2000 Single Channel Encoder

The Motorola BCS SE-2000 digital video encoder is ideally suited for the cable headend, broadcast, and high bandwidth contribution applications.

The SE-2000's key features include:

- <u>High quality video processing</u>: Motorola BCS's fifth generation video compression technology. Accepts either analog composite or digital CCIR-601 video. The compact SE-2000 employs advanced processing techniques including; dual-pass encoding, scene change detection, adaptive quantization level processing, adaptive temporal noise filtering and frame synchronization to ensure high quailty results while conserving bandwidth.
- <u>Flexible audio processing</u>: Two stereo audio channels are compressed with either Dolby® brand AC-3® encoding or AC5.1 pass through support. Supports inputs from embedded audio from D1 video, external digital audio and analog audio.
- <u>Flexible input and output options</u>: The Motorola BCS SE-2000 provides three types of outputs, DVB-ASI, digital headend expansion interface (DHEI), and DS-3, for easy interoperability with cable headends and broadcast equipment.
- <u>ATSC closed-caption support</u>: NTSC and 525D1 modes. Line 21 (field 1) and line 22 (field 2) per the EIA-708 standard format.

The Motorola BCS SE-2000 digital video encoder offers front panel controls, factory presets and user modifiable configurations.



Figure 3 - SE-2000 Single Channel Encoder

4 High Definition Encoder

The DigiCipher® II high definition encoder is part of Motorola BCS' MPEG-2 encoding system and incorporates sophisticated video processing algorithms that are the results of more than eight years experience with three generations of high definition systems. Advanced techniques that carefully subdivide the full bandwidth HD signal for efficient processing, process the individual "panels", then re-combine for a seamless, high quality ATSC-compliant signal are the basis of the HD system. The HD encoder's sophisticated video processing include:

- <u>Panel Overlap Processing</u>: Allows the passing of motion vectors between adjacent horizontal panels. Eliminates artifacts caused by motion across panel boundaries.
- <u>Inter-panel statistical multiplexing</u>: Different bitrates are automatically assigned to individual panels based on picture complexity. Overall consistent picture quality instead of artifacts occurring in demanding portions of the picture.
- <u>Scene-Change Detection</u>: System can differentiate between adjacent video frames that are parts of different scenes, vs. adjacent frames with high motion. The MPEG group of pictures (GOP) is gracefully closed and a new one is started – resulting in higher video quality, since bandwidth is used for frame content vs. motion.
- <u>Fade-Detection</u>: System differentiates between "fade-to-black" sequence vs. motion sequence. Bitrate is used to represent picture content (different luminance values) instead of motion – resulting in higher quality video.

The HD encoder chassis contains all of the input/output connections necessary for converting incoming, full bandwidth HD video, audio and data into the ATSC-compliant MPEG-2 bitstream.

- Internal AC-3 stereo processing: The HD encoding system can multiplex up to three stereo pairs into the output transport stream. These three audio "programs" can be a mix of externally pre-compressed audio and internally compressed AC-3 audio, selected from the six (6) audio input ports. Additionally, audio can be accepted as embedded in the serial digital stream in compliance with SMPTE 299M. Supports surround and stereo audio compression bit rates of 96kbps to 640kbps, default to 384kbps for surround-sound coding and 192kbps for stereo coding. Supports audio sampling rate of 44.1ksps and 48ksps for stereo audio coding and 48ksps for surround-sound coding.
- Complies with MPEG-2 Main Profile/High Level (MP @ HL) video syntax. Performs film mode (inverse telecine) processing. Provides switch-to-black capability upon video loss. Supports I-frame refresh with selectable refresh rates. Supports fully encrypted video at bit rates of up to 40Mbps. Supports MPEG-2 processing: I-frame, P-frame, and B-frame

5 ATSC Architectures

From the most simple to the most complicated ATSC architectures, Motorola BCS' multiplexers and encoders will provide a building block approach allowing the broadcaster to grow a system seamlessly as the business model evolves over time.

Single Network Feed Pass Through

For basic ATSC broadcast compliance a broadcaster can opt to re-purpose their network feed. With only minor alterations, a satellite feed can be re-purposed for local broadcast. In this model (figure 4), there is no investment in equipment to create new DTV content. The TMX-2010 transport multiplexer accepts the ASI output from a digital satellite receiver and provides bitrate transcoding and PSIP handling functionality.



FIGURE 4: Network Pass through with local PSIP branding

The TMX-2010 can be used to pass through or create the minimum ATSC compliant A65 PSIP information. It provides the ability to change master guide tables (MGTs), system time tables (STTs), terrestrial virtual channel tables (TVCTs), rating region tables (RRT), and 12-hour blocks of event information tables (EIT) which can assist broadcast affiliates in re-branding network content for their local market.

Program Editor	x x	1	Program Editor	_			
Name	News Channel	Í	General Events				
Drogram Id	1		Event	Rating	Seconds	Start	
riogramia			The First Game	PG-13	7200	Fri 09/20/2002 19:00:00	•
escription			Local News	No Rating	1800	Fri 09/20/2002 21:00:00	388
anscode	Disable		Football Follow Up	No Rating	1800	Fri 09/20/2002 21:30:00	122
CD DID	20		Late Night Movie	TV-MA-L	6930	Fri 09/20/2002 22:00:00	-
CRIPID	20			0.4	d Dolote		
IT PID	19			Au	u Delett	3	
jor Channel	0	· _					_
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		ſ I	Used Bit Rate (Mbp	IS) 0			
Used Bit Rate ((Mbps) 0		Available Bit Rate (Mbps) 9.393000				
Available Bit R	ate (Mbos) 19 393000						
							. 1
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The TMX Element Manager "program editor" GUIs .

Local Encoding (Figure 5)

Another approach to rapidly deploy a DTV channel would be to digitalize an existing analog broadcast channel. A locally produced analog channel can be fed to a SE-2000 digital video encoder to create a high quality compressed MPEG-2 stream. The TMX-2010 multiplexer is used to create PSIP information.



FIGURE 5: Local SD Encoding with local PSIP branding

Multi-Channel Broadcasts

As shown in figure 6, by combining a network feed and a local encoded channel, a broadcaster can rapidly move into a multi-channel environment. The TMX-2010 multiplexer is used to combine the two streams into a single output transport, provide any necessary bitrate transcoding and coordinate basic PSIP information. In addition to the SMPTE310 output, an ASI output is automatically generated by the TMX-2010 which can be used for local monitoring.



FIGURE 6: Single Network Feed With One Local Encoded Channel

<u>Grooming Of Multiple Content Sources and Distribution to Multiple Networks (Figure 7)</u> As a broadcaster chooses to increase the number of standard definition channels included in an ATSC broadcast, bandwidth usage is pushed to the maximum. The Motorola BCS SE-2000 encoders and the TMX-2010 multiplexer can work in concert to

efficiently manage bandwidth consumption. The TMX-2010 multiplexer supports both standard definition statistical multiplexing and add/drop service grooming. Motorola BCS' SE-2000 local encoders excel at advanced compression techniques to ensure high quality video at lower bit rates. The end result is mix of network and local encoded content, groomed to fit the 19.393 Mbps distribution pipe provided to ATSC broadcasts. The TMX-2010 supports the creation of multiple output streams to manage different business scenarios, such as, different daytime and primetime programming, HD vs. SD broadcasts and direct feeds to cable plants and private networks.



FIGURE 7: Multi-Channel SD/HD Distribution To Multiple Networks

The TMX-2010 multiplexer can deliver up to 6 different output streams in a variety of ASI, DHEI, SMPTE-310 and DS-3 combinations. For example, a broadcaster may choose to send the HD multiplex direct to a cable headend through a separate ASI or DS3 output multiplex. Alternately, another multiplex of multiple SD channels may be created to support a private education or government network.

Advanced Applications (Figure 8)

Motorola BCS' modular broadcast solution is designed to provide quick integration of data services and advanced applications.

Datacasting: The TMX-2010 provides standards-based A/90 UDP/IP multicast data encapsulation into the output ATSC bitstream. Applications such as file transfer, interactive television, or streaming video are just a few ways broadcasters are considering such a data pipe.

External PSIP Generation: At any time, external PSIP generators may be added to increase the ability to provide days worth of program guide information to the TMX-2010 output multiplex.



FIGURE 8: Datacasting and External PSIP Generation

6 Summary

Motorola BCS has designed a modular ATSC system to best meet evolving business models and demographics. The basic building blocks include a transport multiplexer and standalone encoders. The elements seamlessly fit together to facilitate cost-effective compliance and rapid deployment of new services.

Encoder features

- > SE-2000 compact 1 rack unit SD encoder design
 - Analog or digital inputs
 - Dolby brand AC-3 and AC5.1 pass-through support
 - Dual-pass video encoding
- Full featured HD encoder
 - Advanced video panel processing
 - Internal audio support

TMX-2010 Multiplexer features

- Modular 3 RU design
- MPEG-2 service multiplexing
- ➢ IP Encapsulation (A/90)
- > 10 (up to 30) ASI input for extensibility to multicasting
- > 2 (up to 6) ASI and SMPTE-310 output
- > Simple to use TMX-Element Manager
- > ATSC PSIP service table generation (A/65)

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