Microwave Interconnect Testing For 12G SDI Applications

Jim Nadolny, Samtec

Corey Kimble, Craig Rapp - Samtec
OJ Danzy, Mike Resso - Keysight
Boris Nevelev - Imagine Communications
Microwave Interconnect Testing For 12G SDI Applications

Jim Nadolny, Samtec

Corey Kimble, Craig Rapp – Samtec
OJ Danzy, Mike Resso – Keysight
Boris Nevelev – Imagine Communications
Jim Nadolny
Principle SI and EMI Engineer, Samtec
jim.nadolny@samtec.com | samtec.com | @SamtecInc

Jim Nadolny received his BSEE from the University of Connecticut in 1984 and an MSEE from the University of New Mexico in 1992. He began his career focused on EMI design and analysis at the system and component levels for military and commercial platforms. For the last 20 years his focus has shifted to signal integrity analysis of multi-gigabit data transmission systems. Jim is chair of IEEE P370 TG1 a task group focused on standardized S-parameter testing of passive structures to 50 GHz and a frequent contributor to DesignCon and other conferences.
Outline

- Introduction
- Evolution of Video Transmission
- Electrical Requirements for 12G SDI
- Legacy Test Methods
- Improved Test Method
- Conclusions
Significant contributions to this research included my colleagues from Samtec, Corey Kimble, Craig Rapp, David Blankenship and Chris Shelly.

Boris Nevelev from Imagine Communications provided insight to the video broadcast industry as well as technical requirements above and beyond those defined in the SMPTE specification.

Finally OJ Danzy and Mike Resso contributed on the proper use of PLTS, AFR and related instrumentation details.
Introduction

- Video transmission is evolving
  - 6 MHz analog bandwidth in the 1960’s
  - 12 channels in VHF band
  - HDMI 2.0 up to 18 Gbps

- Key points
  - Video is now high speed digital
  - Interconnect requirements more challenging to meet
• Focus of this paper is broadcast video
  • Video over satellite, cable and terrestrial infrastructure
  • Think “recording studio”
  • Not HDMI to your “man cave”

• Standardization governed by Society of Motion Picture and Television Engineers (SMPTE)
  • Serial Data Interface (SDI)
  • 3G SDI, 6G SDI, 12G SDI
Evolution of Video Transmission

- SDI video retains legacy characteristics
  - 75 ohm coaxial connectors/cables
  - Single ended signaling

- Contrast with Ethernet
  - 100 ohm twinax cable
  - High density multipin connectors
  - Differential signaling

Courtesy of Imagine Communications
Electrical Requirements for 12G SDI

- SMPTE ST 2082-1:2015 defines 12G SDI performance
  - Binary encoding
  - Up to 40 dB of insertion loss at 6 GHz
  - Connectors and cables shall have an attenuation curve that follows $1/\sqrt{freq}$
  - Reflection loss should be “small” to achieve this attenuation curve
Electrical Requirements for 12G SDI

12G SDI Return Loss Requirement

Return Loss (dB)

freq, GHz
Electrical Requirements for 12G SDI

- “long” coax cables are required in video broadcast
  - Cable equalizers used to compensate for frequency dependent loss
  - Up to 40 dB of loss at Nyquist is expected

- Test question 1 –
  - How much crosstalk can be tolerated in video broadcast equipment?
Electrical Requirements for 12G SDI

Is this adequate isolation for 40 dB of cable loss?
Electrical Requirements for 12G SDI

• “all we have to do is”
  • test a 75 ohm coaxial connector
  • up to 12 GHz
  • mounted on a PCB

How hard can it be?
Electrical Requirements for 12G SDI

- **Challenges**
  - Limited availability of 75 ohm calibration kits and adapters with 12 GHz bandwidth
  - The need to include the PCB footprint in the RL measurement

- **Approach**
  - Custom calibration standards
  - Fixture removal techniques
Electrical Requirements for 12G SDI

- Footprint optimization
  - Full wave simulation
    - Pad size
    - Ground plane cutout (antipad)
    - Drill size
    - PCB stackup
- Testing also required to validate footprint design
Electrical Requirements for 12G SDI

- Desired reference plane location
- SOLT calibration plane
- 75 ohm 12G SDI BNC Connector and Footprint
- 50 ohm coaxial test point (3.5mm)
- 75 ohm adapter

Test PCB 1

Test PCB 2
Legacy Component Test Methods

• Time domain gating
  • Transform to time domain
  • Apply gates to remove fixture effects

• Limitations
  • Can be difficult to replicate results without precise definition of gate location
  • Only obtain RL, not IL or [S]
  • Need “appreciable” separation between gate location and desired reference plane
**Improved Test Method**

- Two tier VNA calibration
  - Tier 1 is a traditional 50 ohm SOLT calibration
  - Tier 2 measures “2X thru” for fixture removal
Improved Test Method

- Fixture design begins with a stackup that supports a 75 ohm trace impedance

By starting with a wide 50 ohm trace we can reduce the width to achieve 75 ohms.
Improved Test Method

- Fixture Design – location of impedance transition near 75 ohm connector
Improved Test Method

- Fixture Design – Calibration structure(s) depends on de-embedding algorithm. In this case a single 2x thru calibration structure is required.

50-75 ohm transition in 2x thru calibration structure
Improved Test Method

- Test Process Advancement
  - Keysight Physical Layer Test System (PLTS) with Automatic Fixture Removal (AFR) option
  - Automates the matrix math associated with S-parameter de-embedding
Improved Test Method

- Options exist to further shift the reference plane locations
  - Allows for a precise measurement of a single 75 ohm connector and it’s footprint
Improved Test Method

Apply the AFR bifurcation algorithm a 2nd time to obtain the S-parameters for a single 75 ohm video connector and footprint.
Improved Test Method

- Calibration structure insertion loss and return loss determine bandwidth of S-parameters
  - Need ~5 dB separation
Improved Test Method

• Results before Tier 2 calibration
Improved Test Method

- Results after Tier 2 calibration
Improved Test Method

Edge Mount 75 Ohm BNCs and Adapter

freq, GHz

RL (dB)

Edge Mount 75 Ohm BNC

freq, GHz

RL (dB)

75 ohm adapter
75 ohm 12G SDI BNC Connector and Footprint
Reference plane location
Bifurcation

Reference plane location
Conclusions

- The single largest reflection in most video broadcast interconnects is the connector to PCB interface
- This interface needs to be included in PCB mount connector characterization
- An improved test method has been demonstrated which permits precise reference plane adjustment using a simple 2x thru calibration structure
Thank you!

---

QUESTIONS?