# Technical Feasibility of Sending Common Mode Power on the Signal Pairs

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# Presentation Overview

**Two parts**

**Part 1 - High Level Overview**

- **No Questions please**

**Part 2 - Technical Detail**

- **250 hrs of investigation**
- **90 Slides**
- **Questions OK**

# Criteria for Technical feasibility

1. **Signal Integrity, 10 Mbps**
2. **Signal Integrity, 100 Mbps**
3. **Effects on Magnetics**
4. **Operational characteristics**

- **Isolation is important but common to all solutions – will not be addressed here**

# Criteria 1 - details

- **Signal Integrity, 100 Mbit/s**
  - **Differential Signal 0-Pk**
  - **Amplitude Symmetry**
  - **Rise/Fall Time**
  - **Duty Cycle Distortion**
  - **Transmit Jitter**
  - **Overshoot**
  - **Differential Input Impedance**
  - **Common Mode Rejection**

# Criteria 2 - details

- **Signal Integrity, 10 Mbit/s**
  - Peak Differential Output Voltage on TD(Transmit Data)
  - Harmonic Content, All Ones
  - Output Waveform vs Template
  - Start of TP_IDL(End of 10Base-T Packet) waveform vs Template
  - Link Test Pulse vs Template
  - TD circuit Differential Output Impedance
  - Transmitter added Jitter
  - TD common mode output voltage
  - TD common mode rejection
  - RD(Received Data) Signal Acceptance
  - Receiver Jitter Acceptance
  - Receiver Added Jitter
  - RD Differential Input Impedance
  - RD Common Mode Rejection

# Criteria 3 and 4 – details

- **Effects on Magnetics**
  - **Return Loss**
  - **Common Mode to Differential Mode Conversion**
- **Operational Characteristics**
  - **BER Effects**
  - **Switching Noise and BER**

# Test methodology

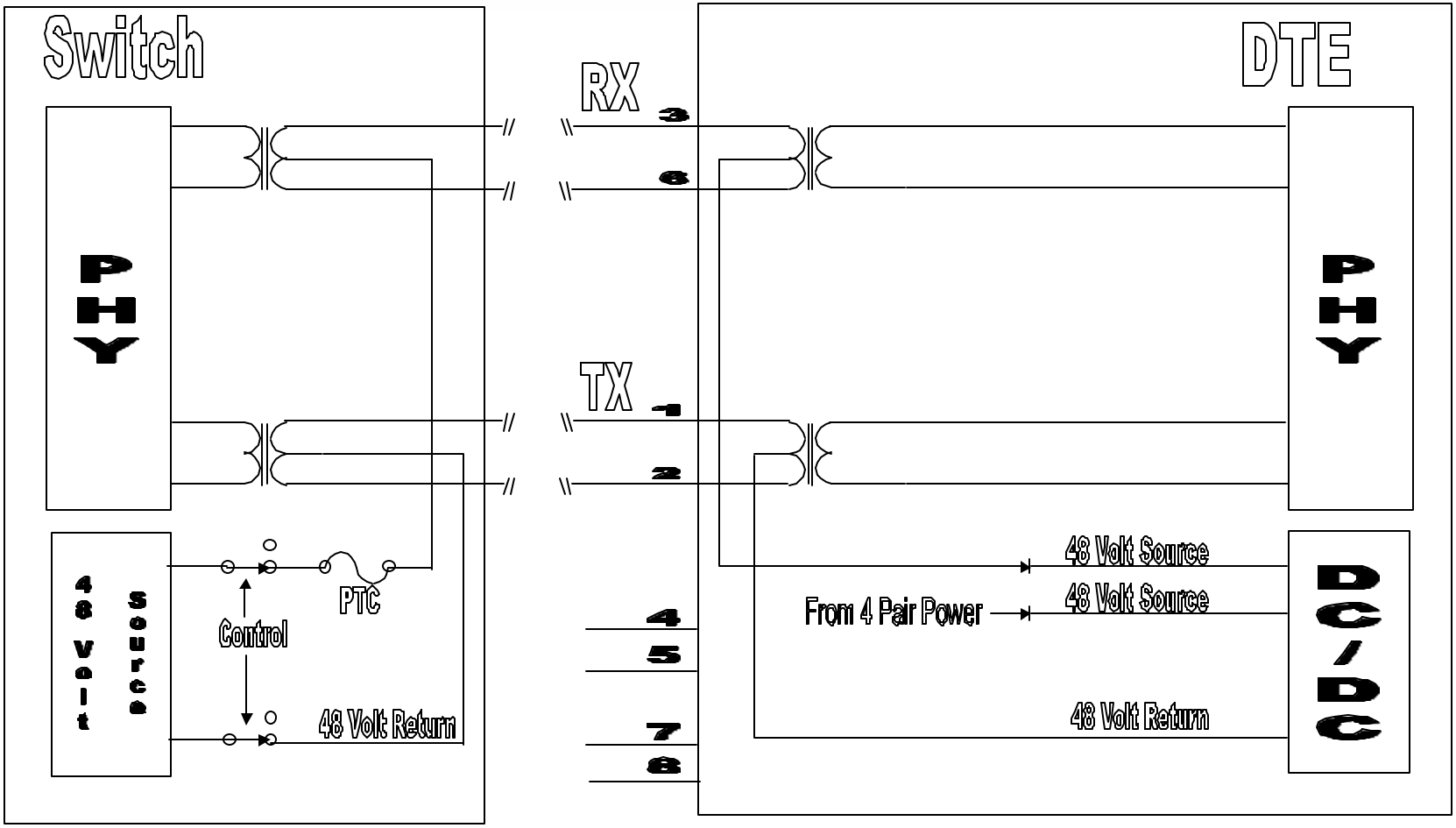
- All tests conducted with and without power
- Test results compared to determine effect

# Technical Feasibility Conclusion

- **Power over Signal Pairs is Technically Feasible**
- **Power noise must be controlled for EMI regardless of which pair set is used for power. Once controlled:**
- **No measurable difference between the Tx or Rx Characteristics with and without power**
- **No link degradation due to power**


Technical Detail

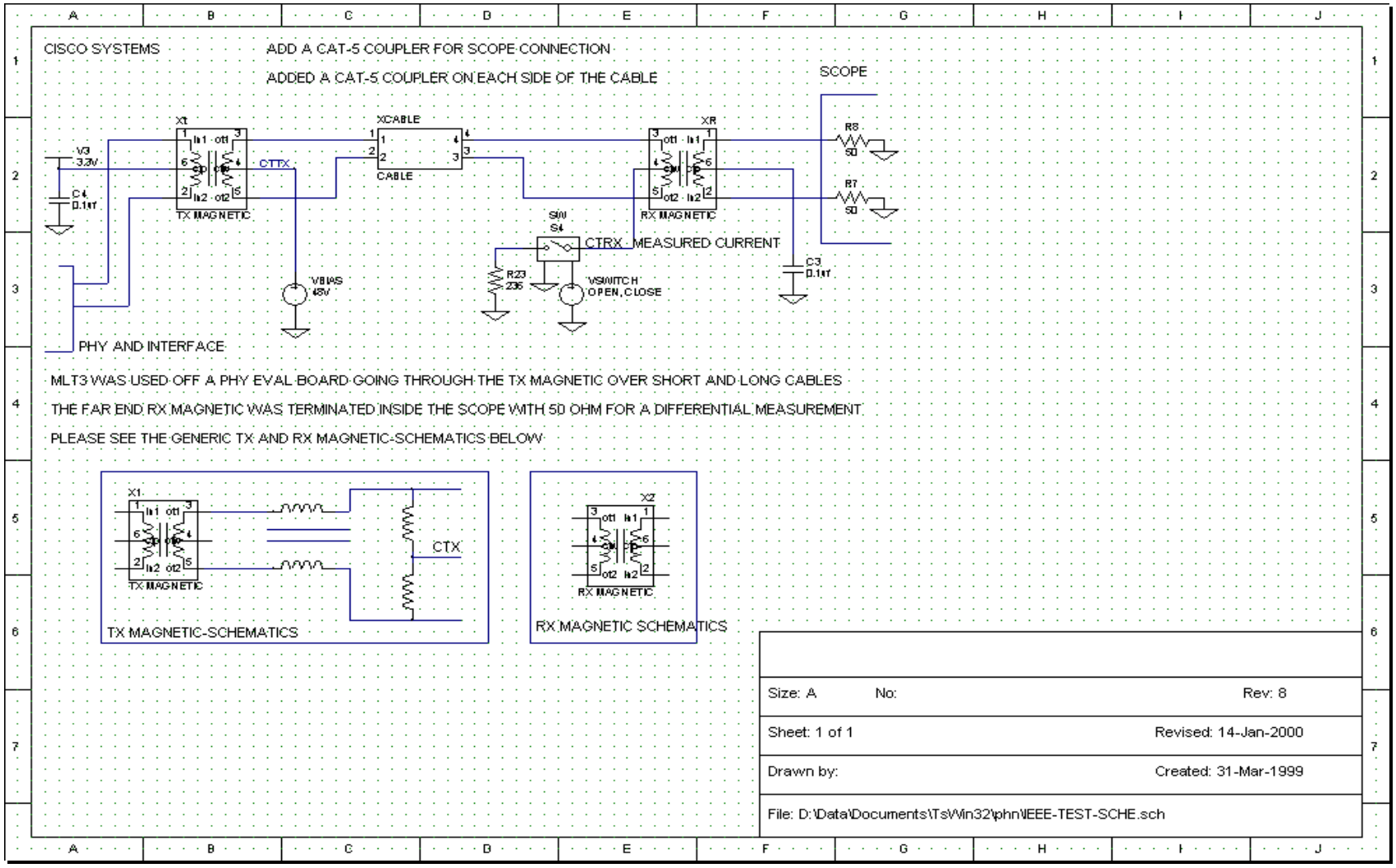
# Power over Signal Pairs Schematic



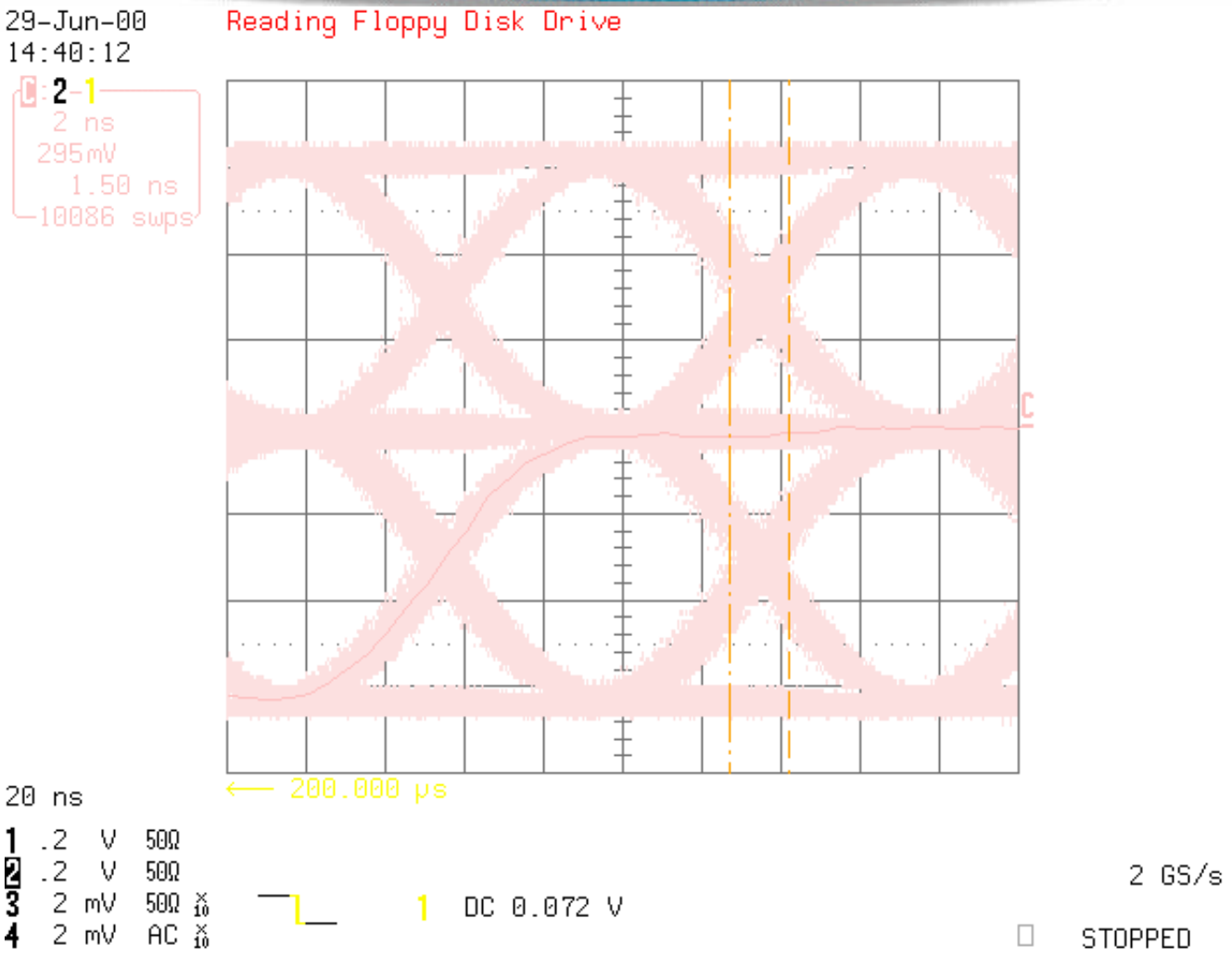
# Power of Signal Pairs Assumptions

- SELV DC Power (40-54 Volts DC)
- ~15 Watts (300mA) over 100 Meters, Cat-5 Cable
- Switching Power Supplies at the Source and DTE

# Signal Quality Measurements
# 100 Mbit/s

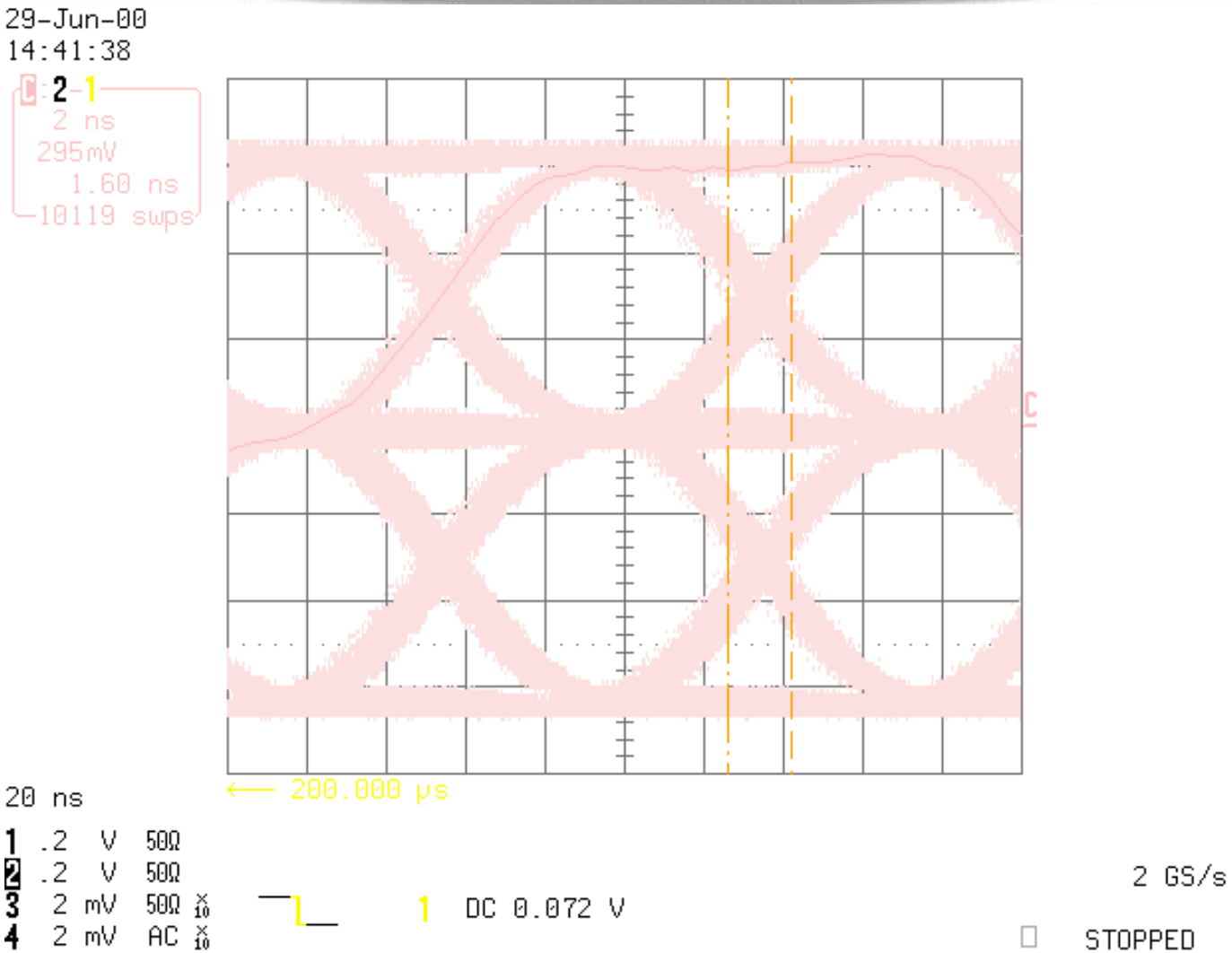


# Signal Quality Measurements
# 100 Mbit/s



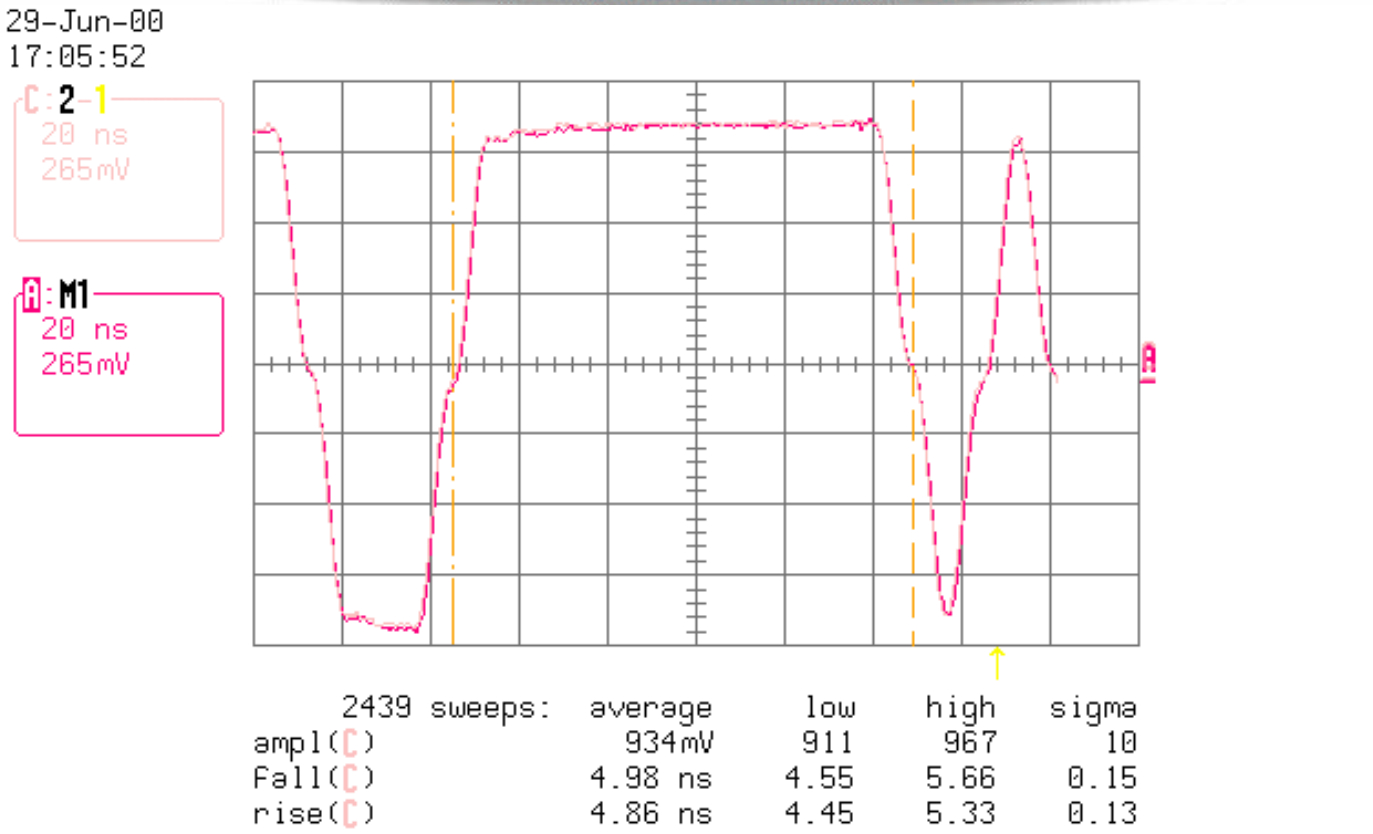

**Tx Eye and Jitter, I = 0**

# Signal Quality Measurements
# 100 Mbit/s



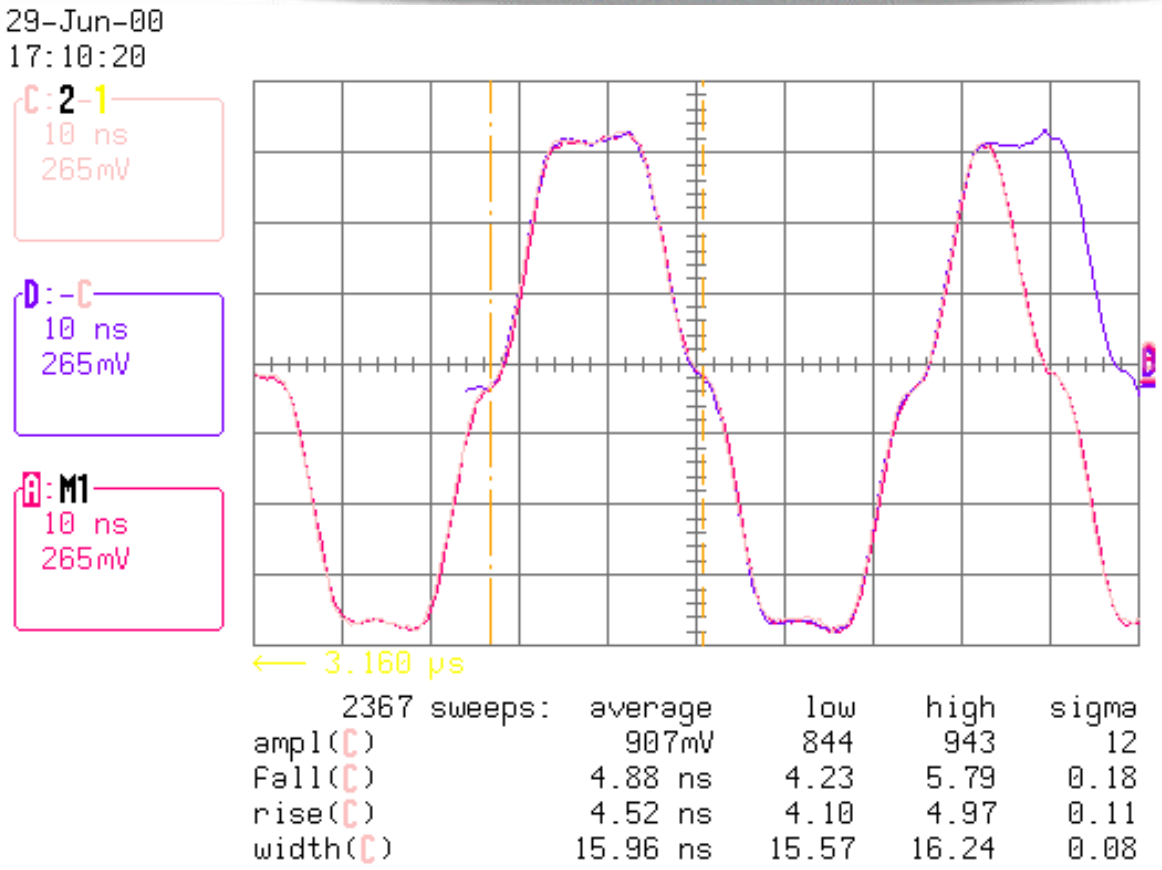

**Tx Eye and Jitter, I = 300 mA**

# Signal Quality Measurements 100 Mbit/s




**Tx Overshoot, I = 0, 300 mA**

# Signal Quality Measurements 100 Mbit/s

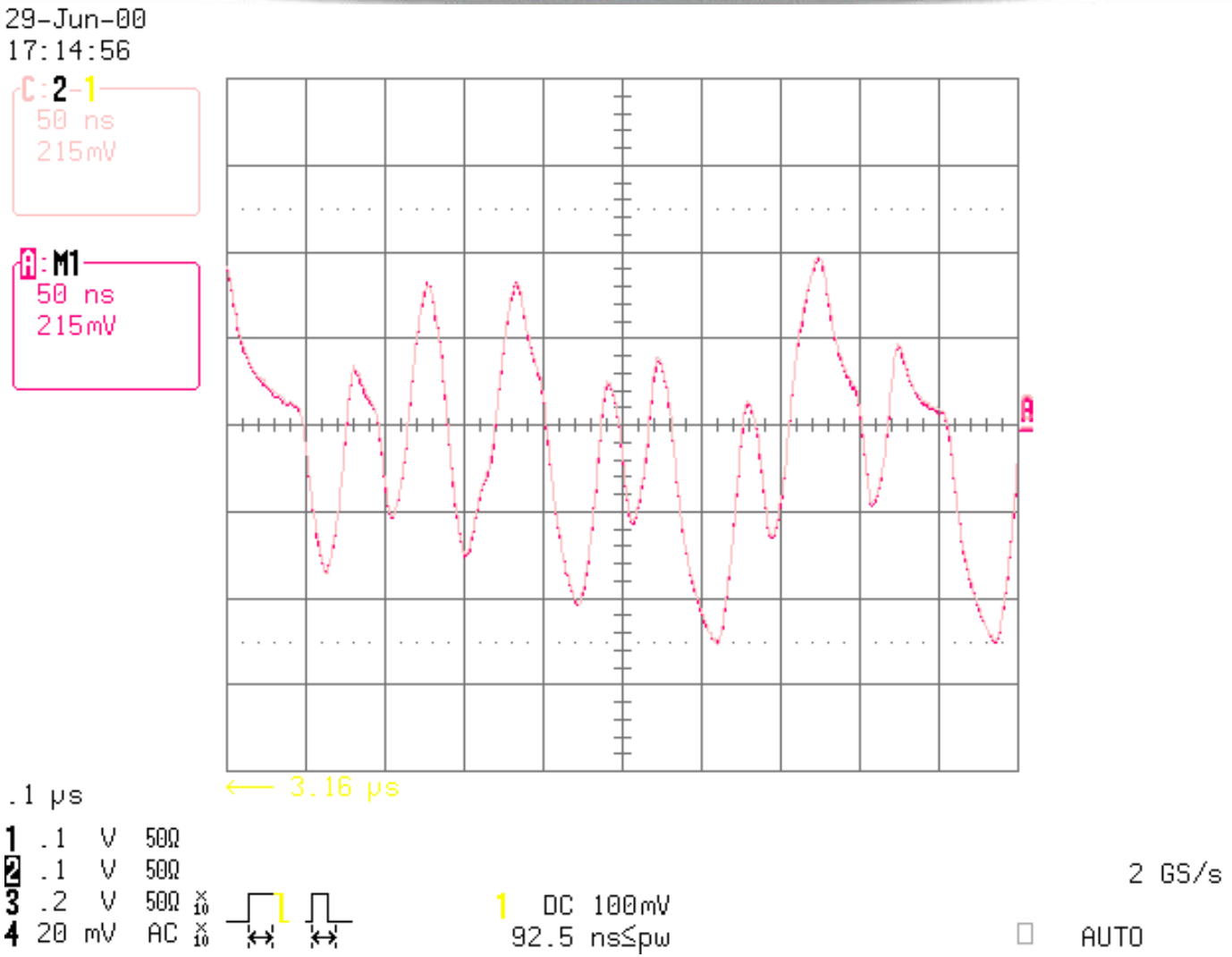



**Negate and Compare:**

**No Change at all**

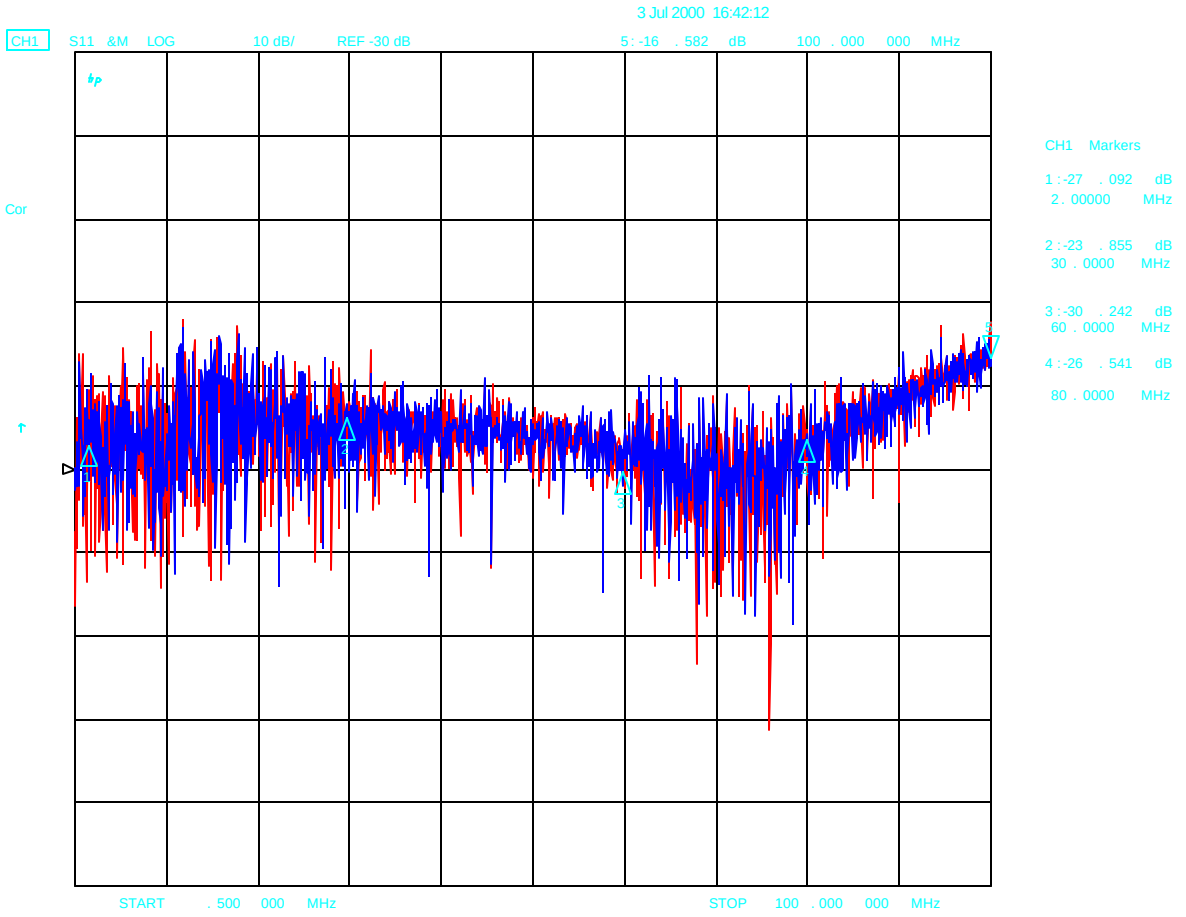
**Tx (DCD)Duty Cycle Distortion I = 0, I = 300 mA**

# Signal Quality Measurements 100 Mbit/s



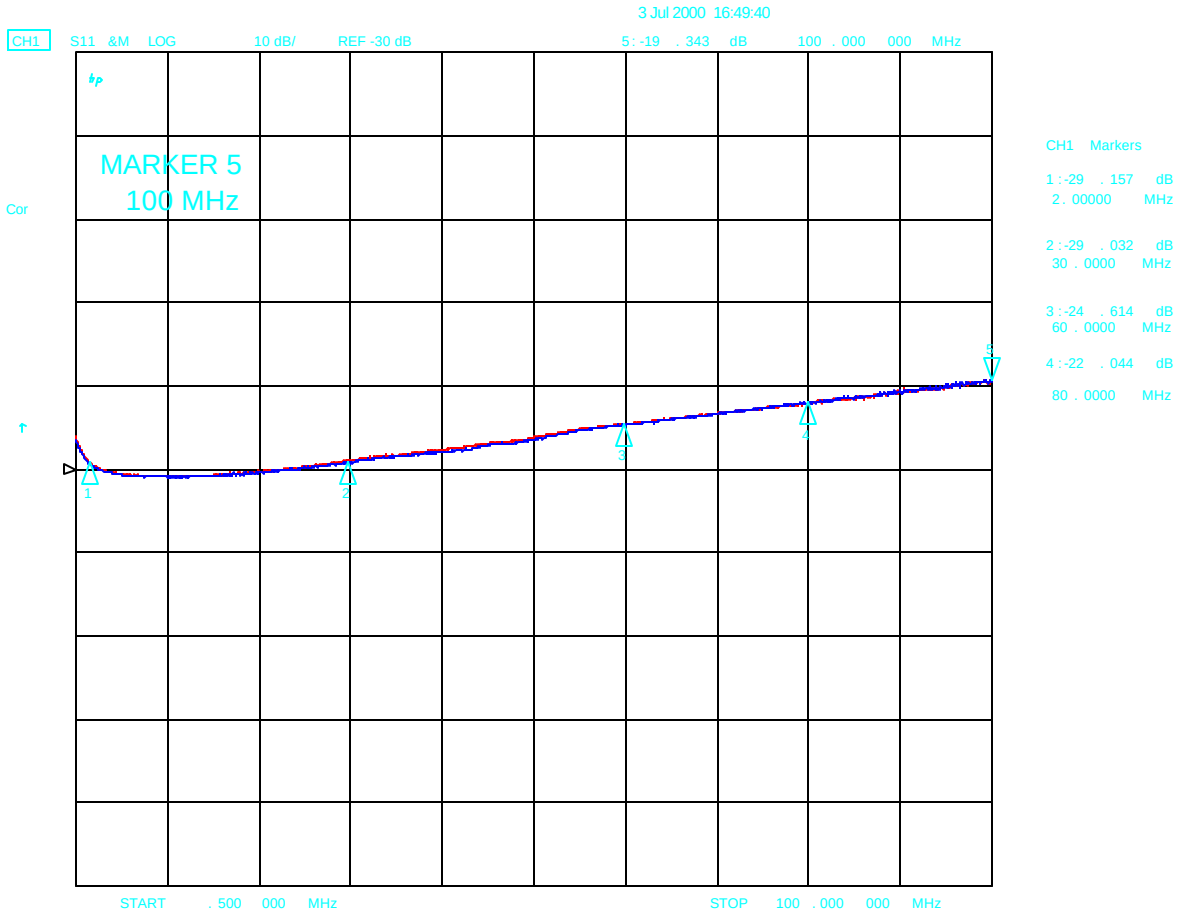

**Tx Waveform at 124 Meters I = 0, I = 300 mA**

# Signal Quality Measurements 100 Mbit/s



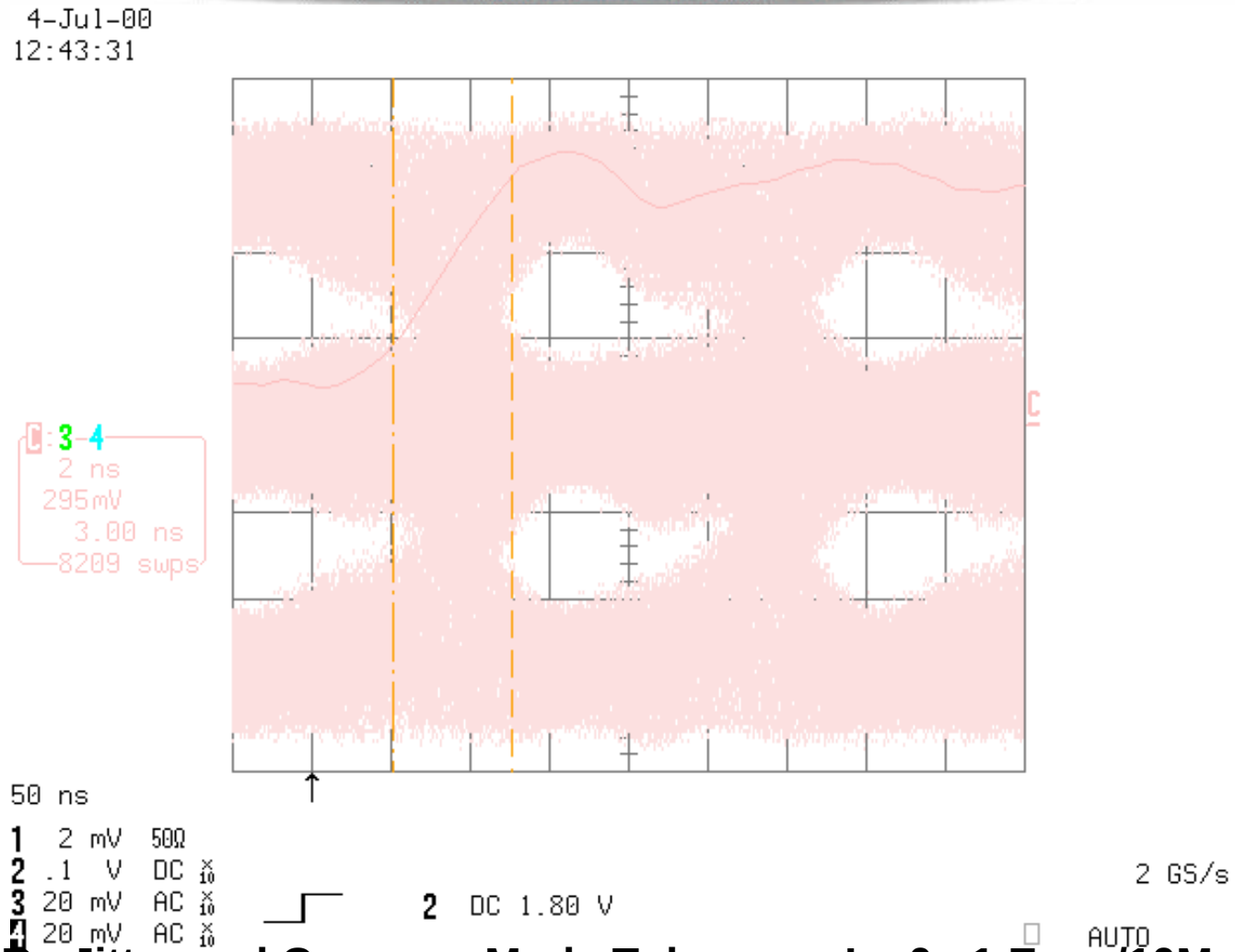

**Tx Return Loss I = 0, I = 300 mA**

# Signal Quality Measurements
# 100 Mbit/s



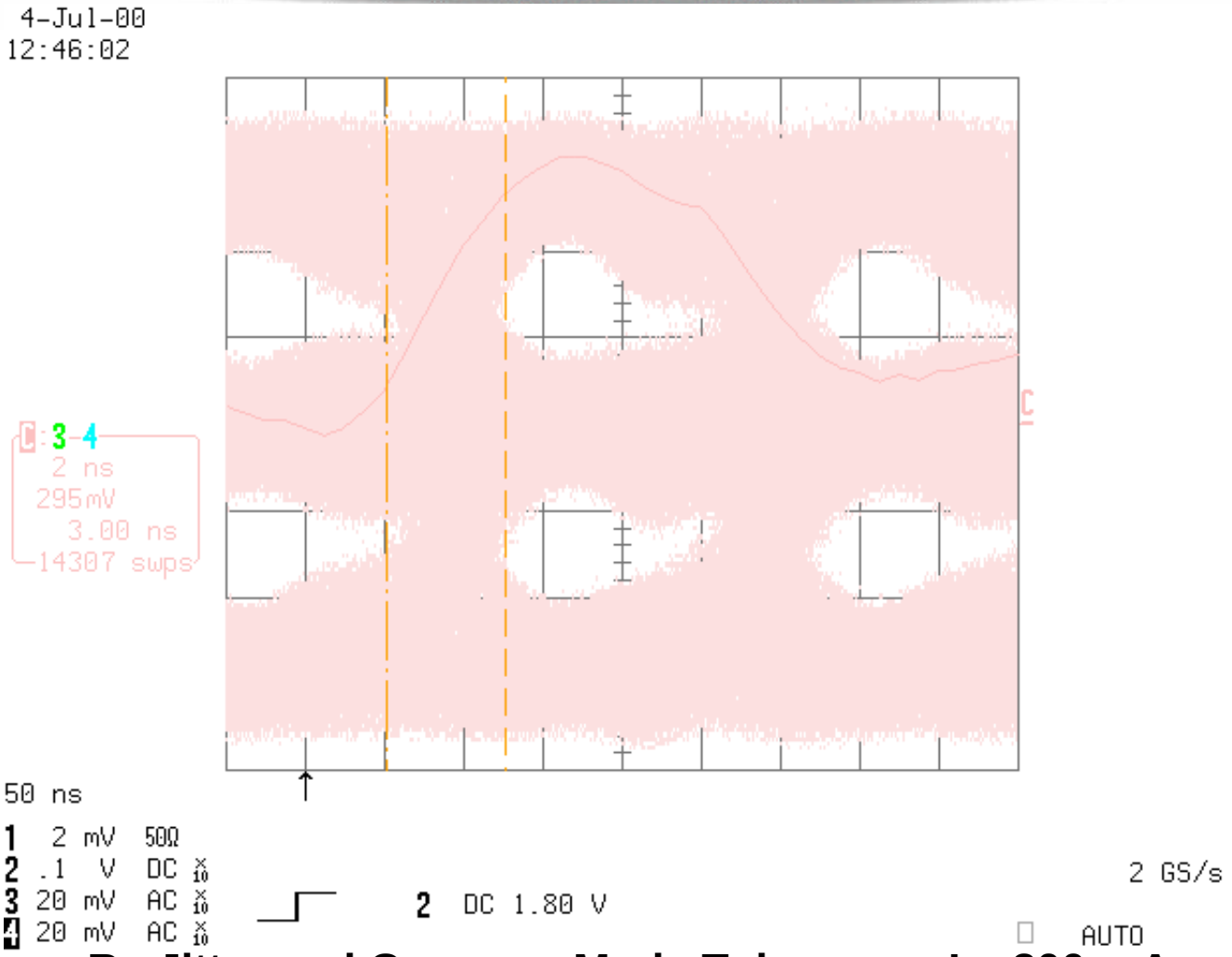

**Rx Return Loss I = 0, I = 300 mA**

# Signal Quality Measurements 100 Mbit/s




**Rx Jitter and Common Mode Tolerance, I = 0, 1 Error/10M Packets @ 30 Meters**

# Signal Quality Measurements 100 Mbit/s

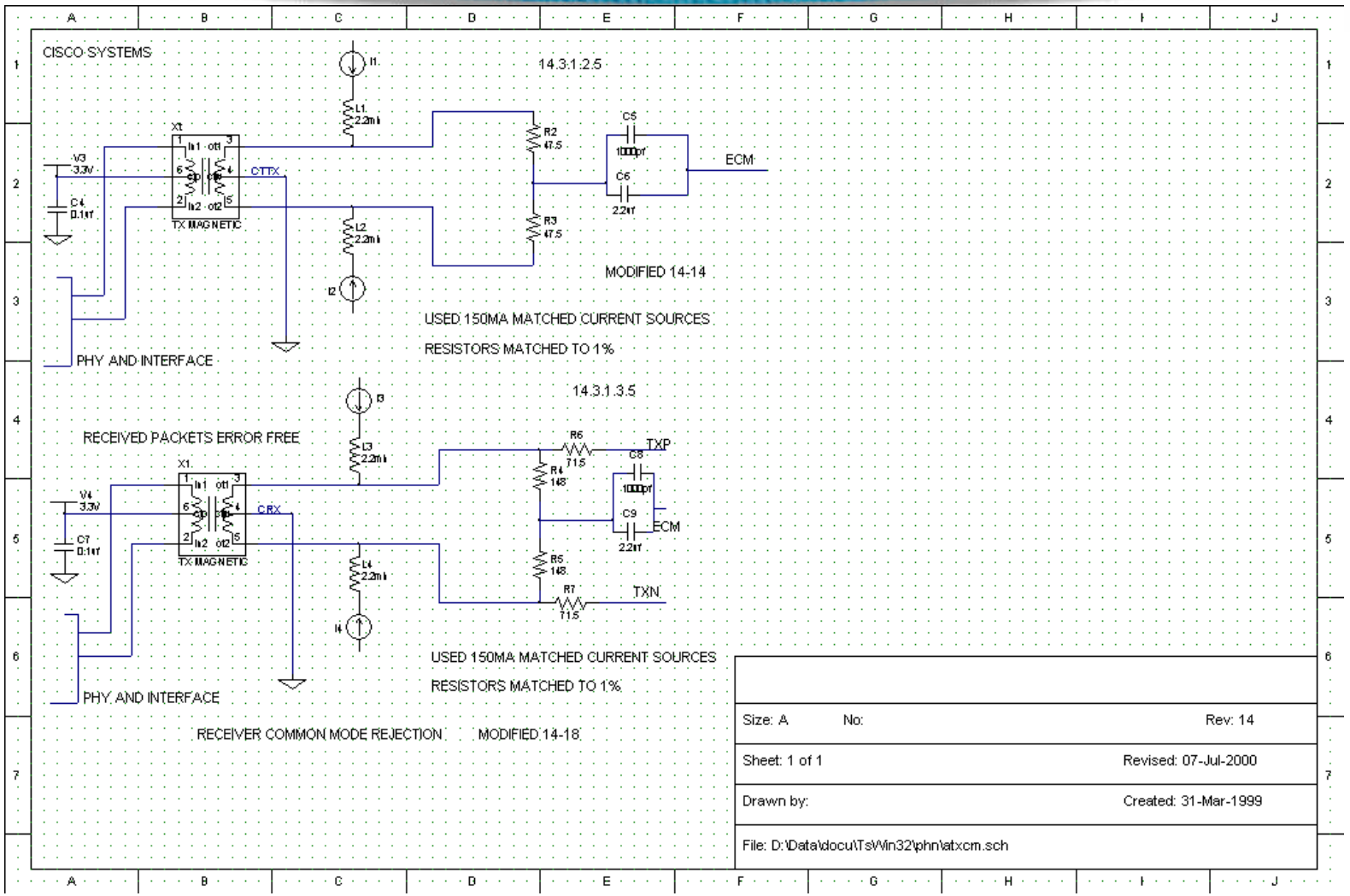



**Rx Jitter and Common Mode Tolerance, I = 300 mA, 1 Error/30M Packets @ 30 Meters**

# 100 Mbit/s, Summary

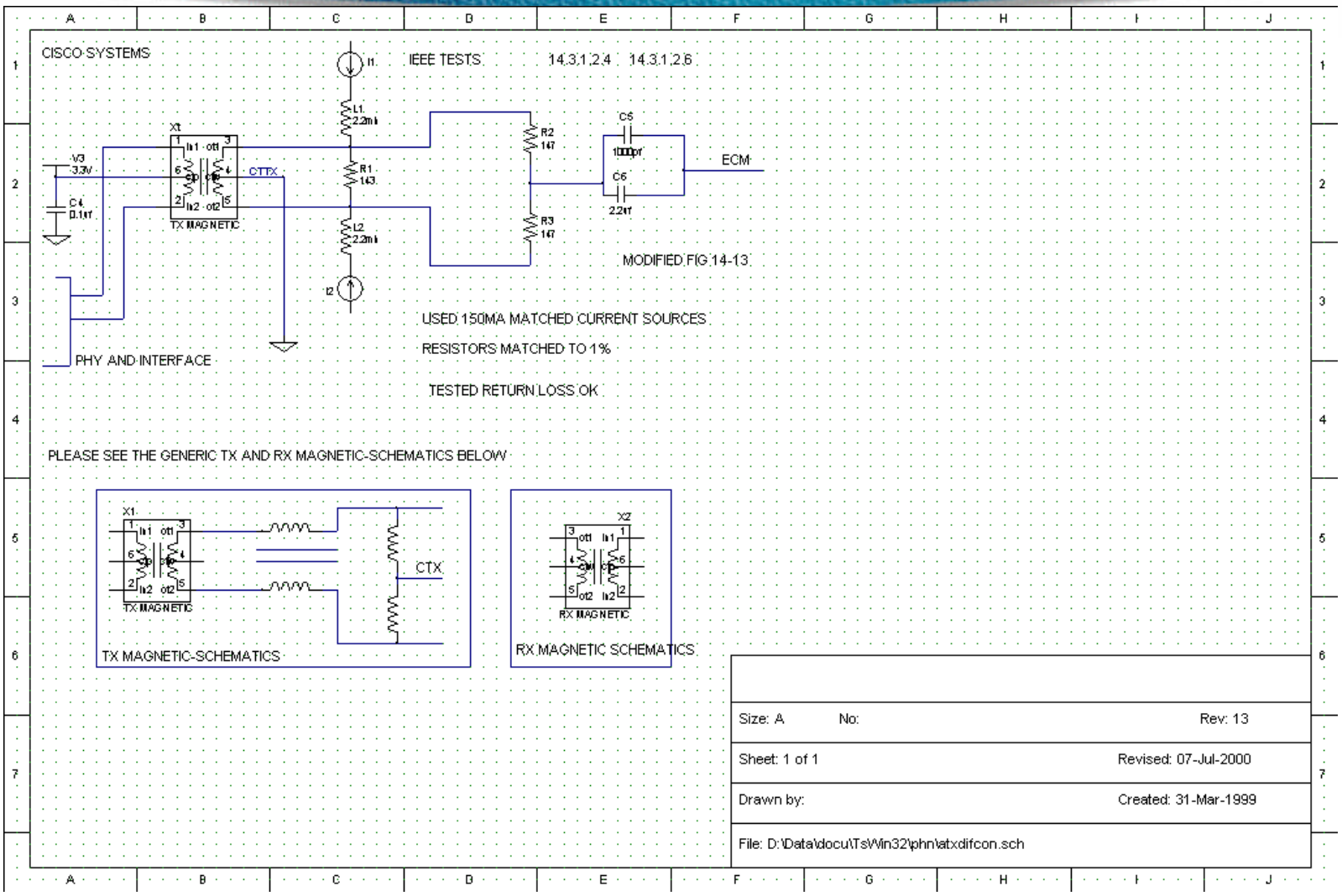
| Characteristic | No Power | With Power |
|---|---|---|
| Differential Signal 0-PK | 934 mV | 934 mV |
| Amplitude Symmetry | 1% | 1% |
| Rise/Fall Time | 4.98/4.86 | 4.98/4.86 |
| Duty Cycle Distortion | .04 nSec | .04 nSec |
| Transmit Jitter (measured triggering on the data) | 800 pSec | 800 pSec |
| Overshoot | <3% | <3% |
| Differential Input Impedance Tx @ 2, 30, 60, 80 Mhz | -27, -24, -30, -27 dB | -27, -24, -30, -27 dB |
| Differential Input Impedance Rx @ 2, 30, 60, 80 Mhz | -29, -29, -25, -22 dB | -29, -29, -25, -22 dB |
| Received Jitter Tolerance | See Slides | See Slides |
| Common Mode Rejection | See Slides | See Slides |

# Signal Quality Measurements
# 10 Mbit/s



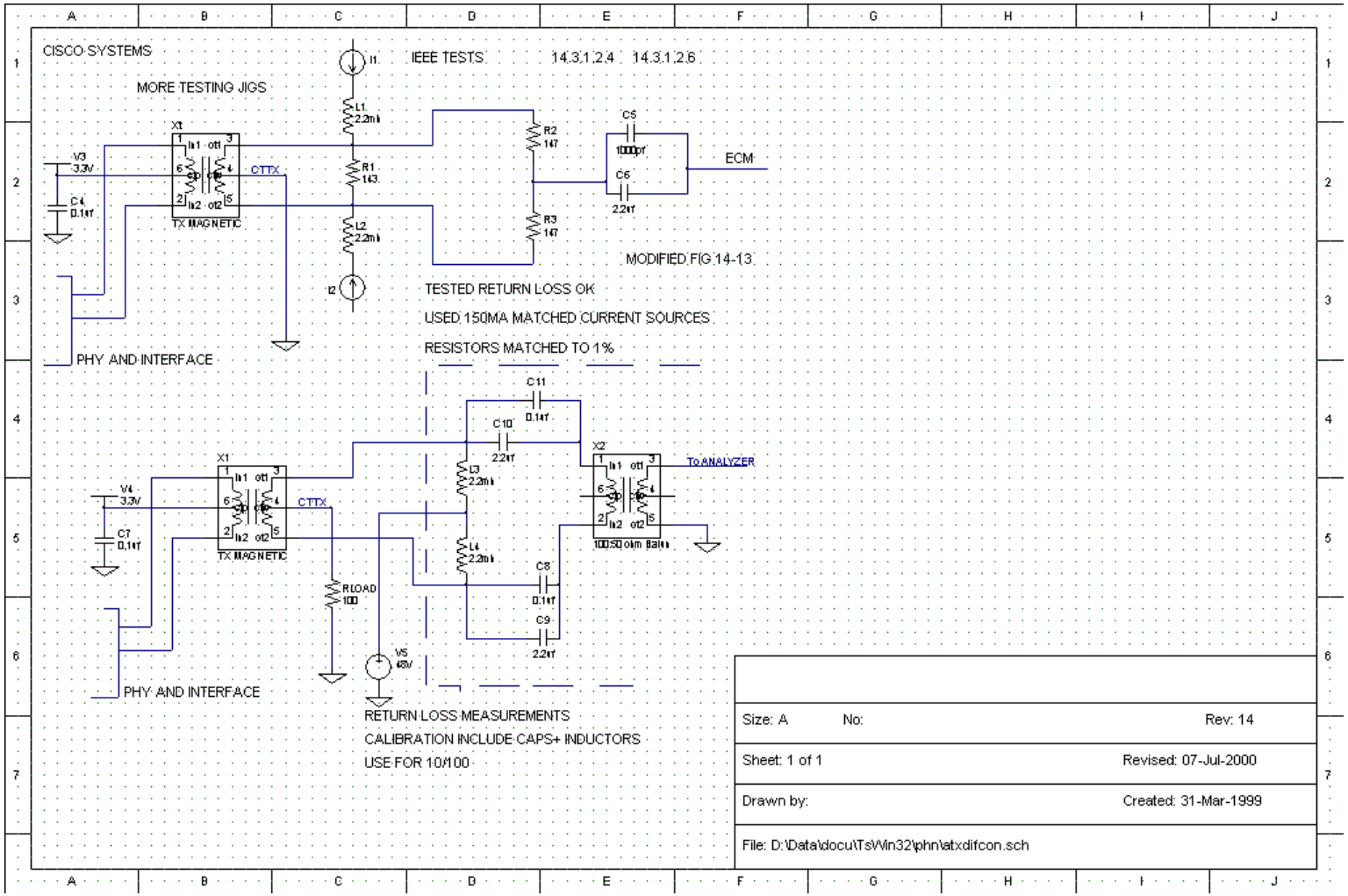

**Test Schematic for 10MBit/s testing**

# Signal Quality Measurements
# 10 Mbit/s



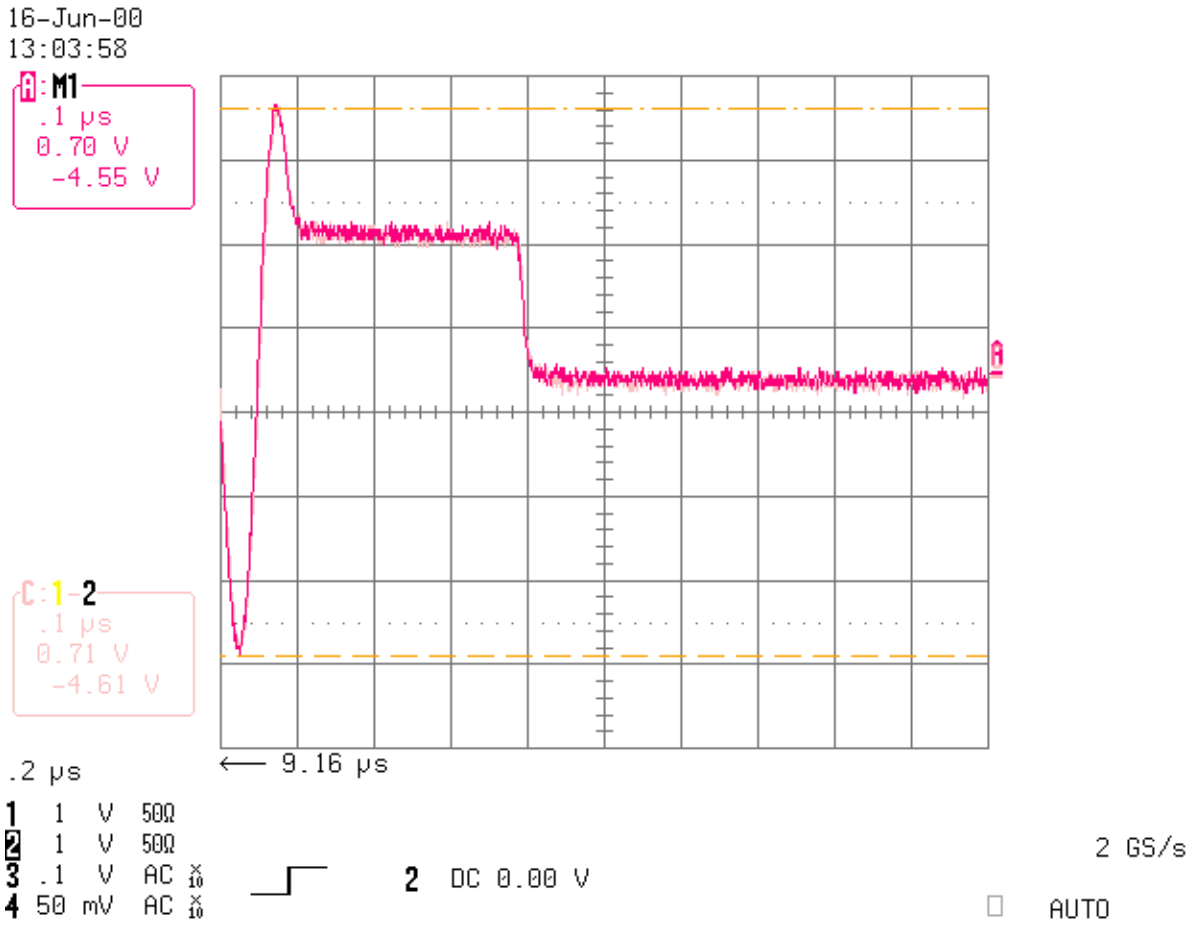

**Test Schematic for 10MBit/s testing**

# Signal Quality Measurements
# 10 Mbit/s



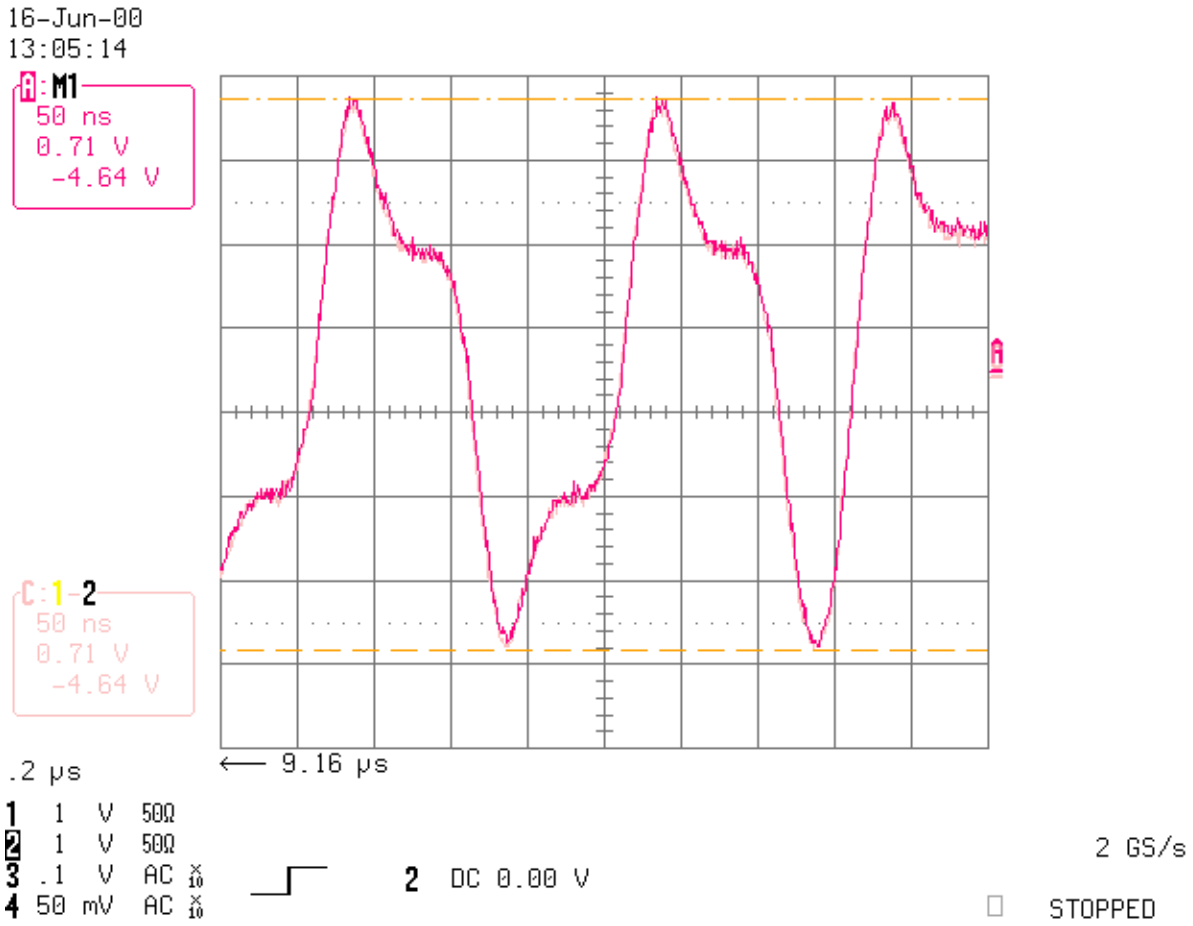

**Test Schematic for 10MBit/s testing**

# Signal Quality Measurements
# 10 Mbit/s



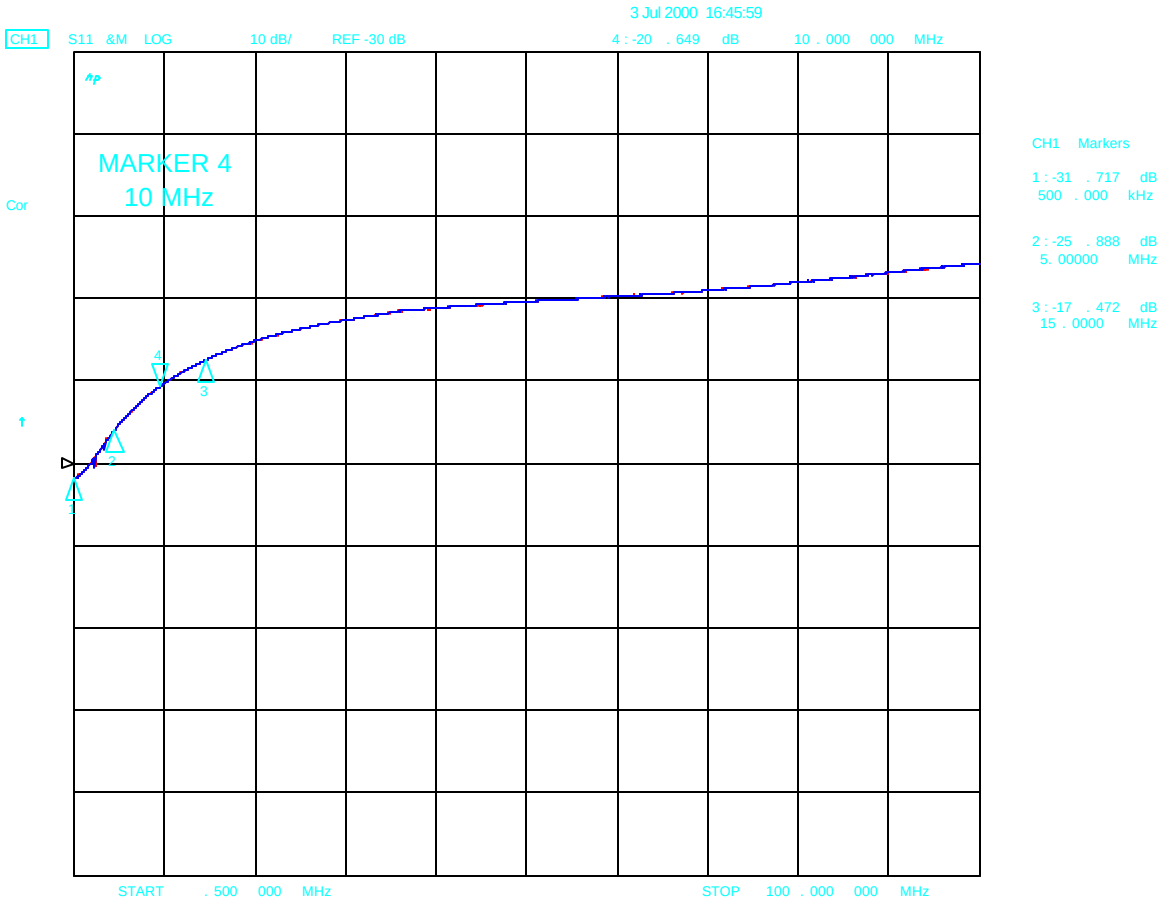

**10 Mbit/s EOP(End of Packet or Start of TP_Idle) I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



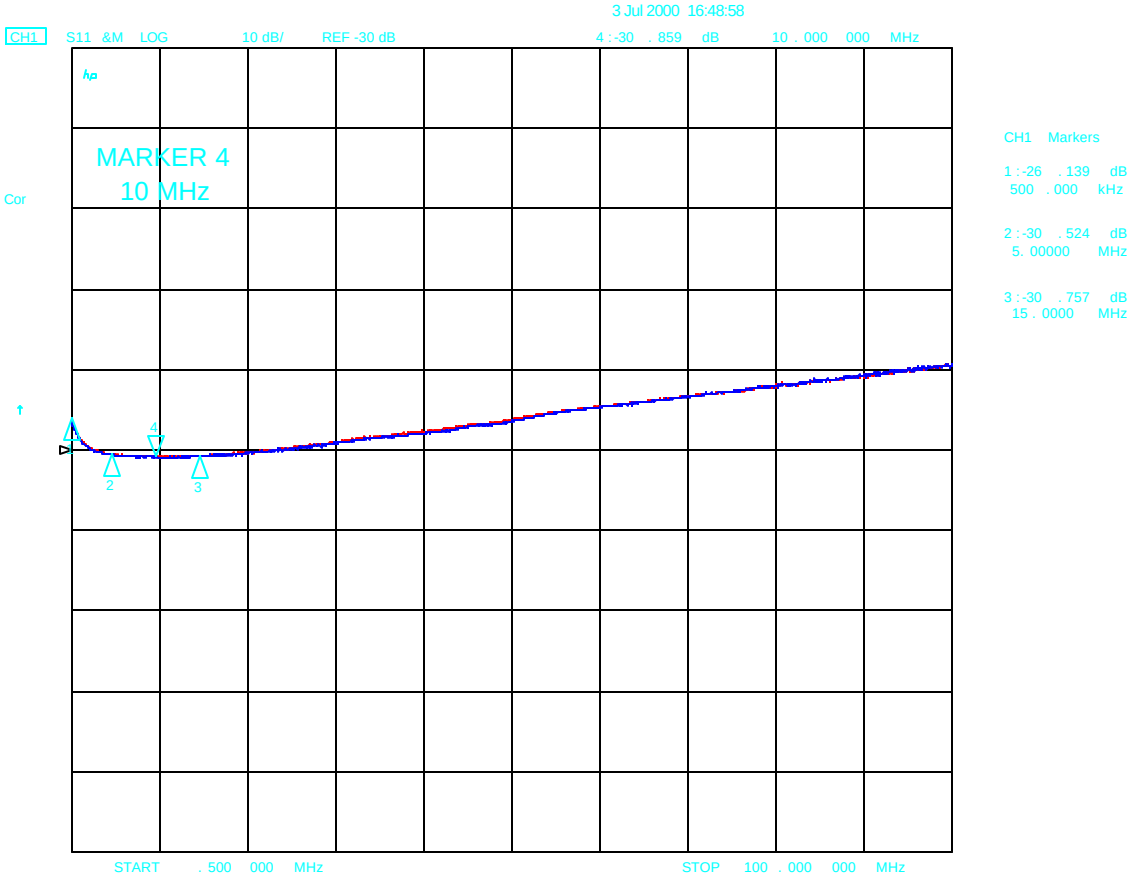

**10 Mbit/s Signal I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



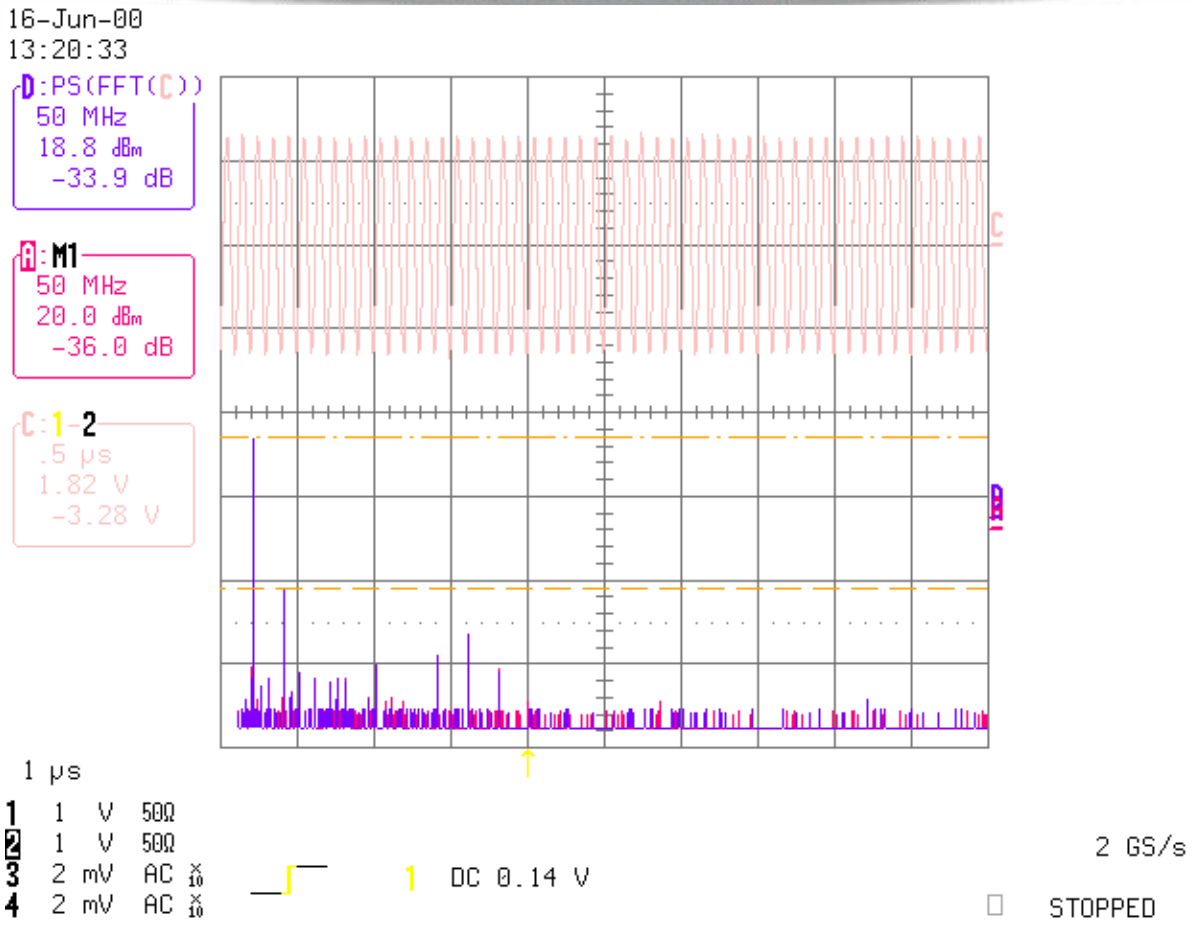

**Transmit Return Loss**
**I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



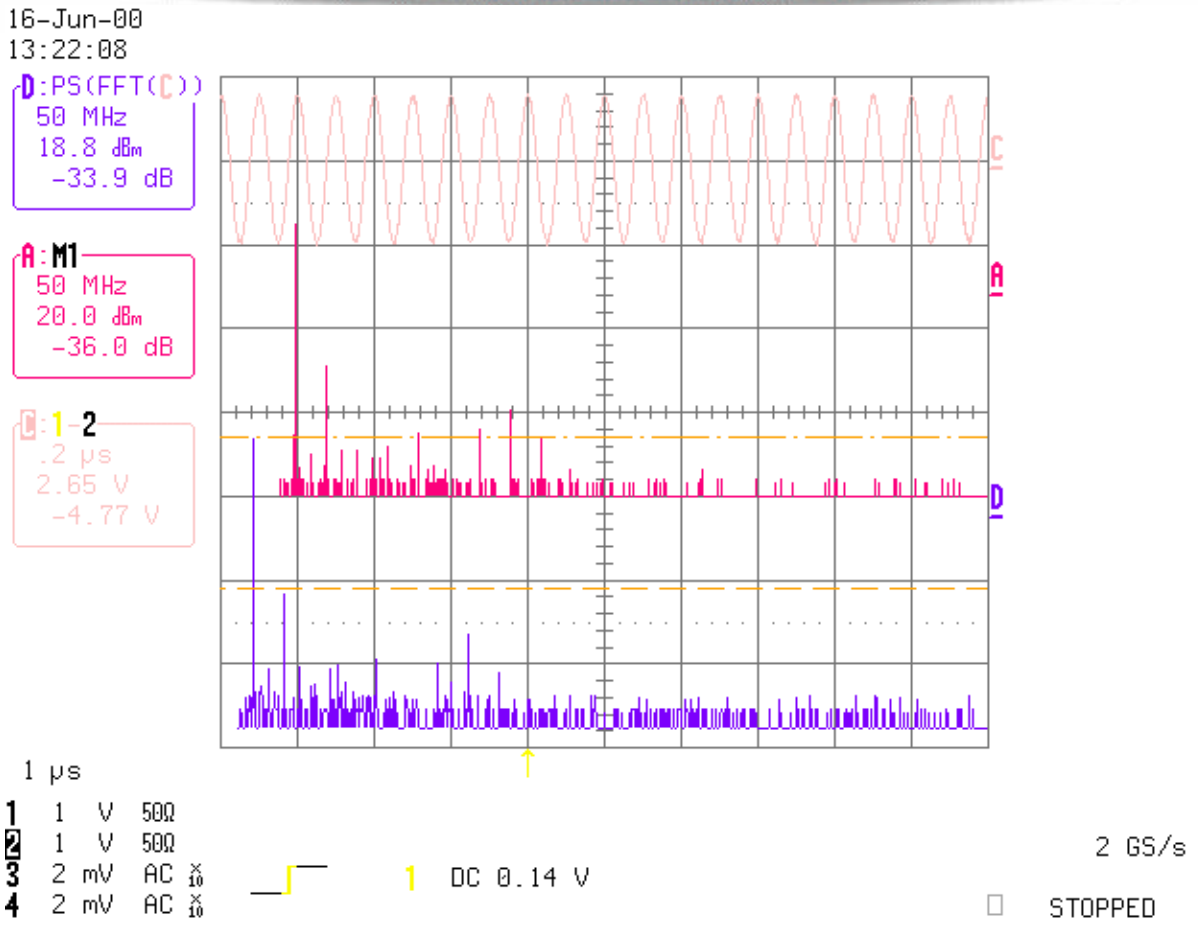

**Receive Return Loss**
**I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



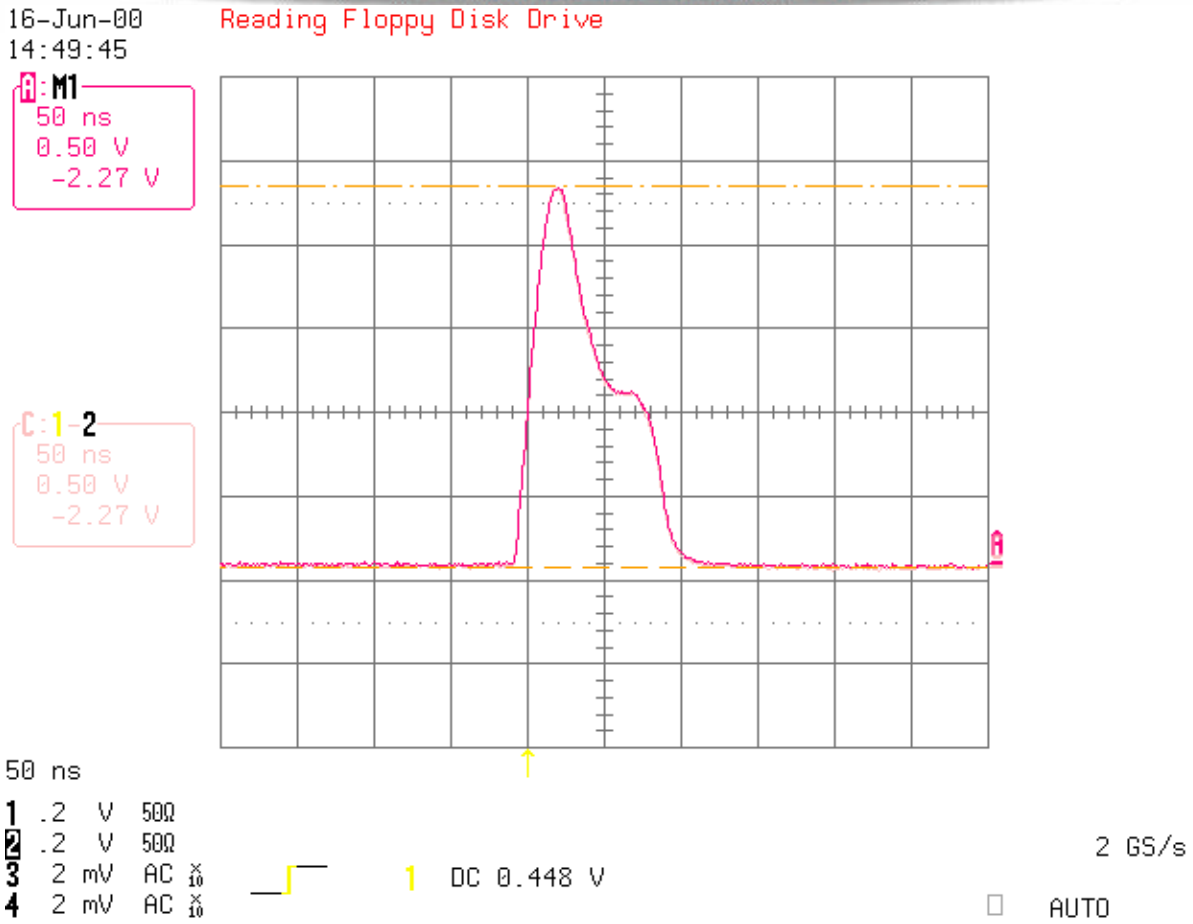

**10 Mbit/s Harmonics I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



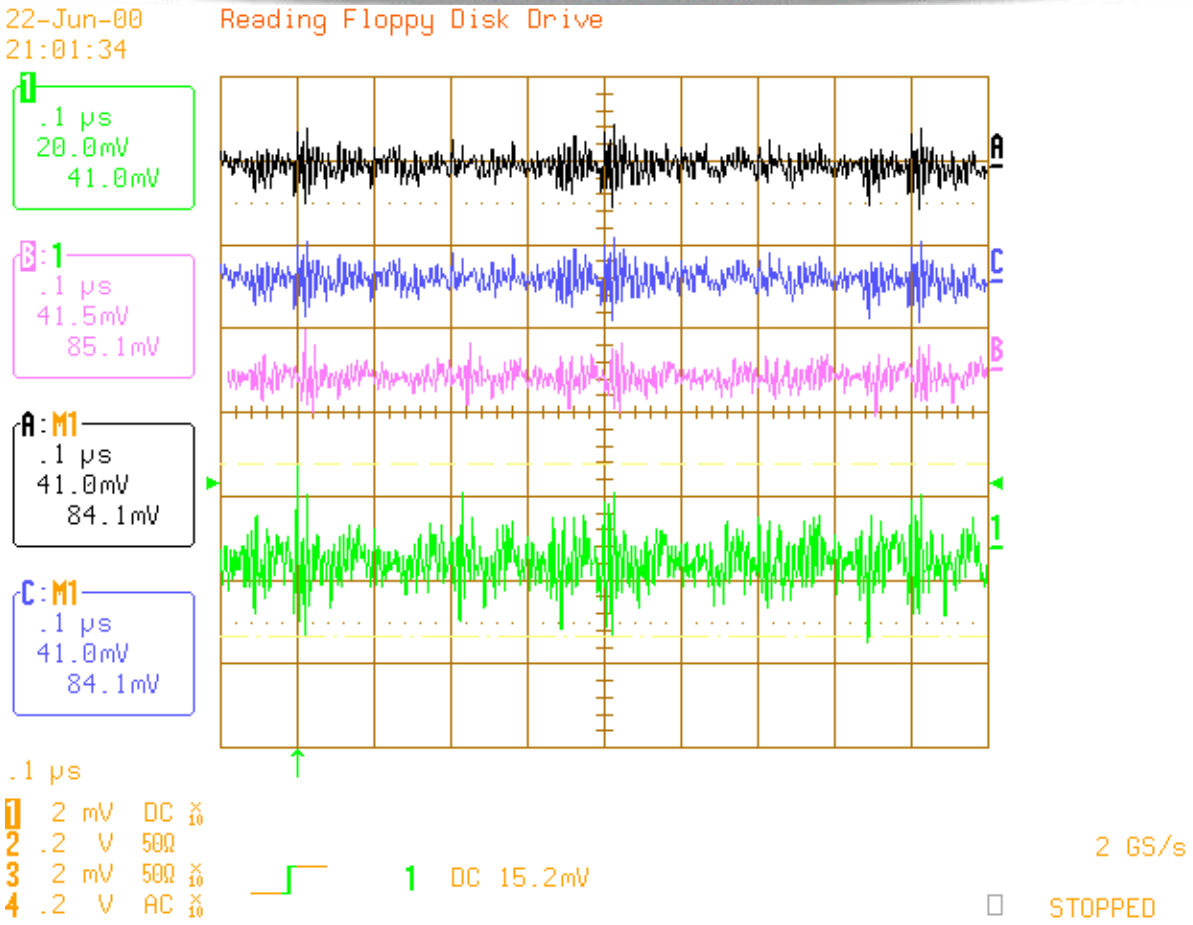

**10 Mbit/s Harmonics, Clearer Scale I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



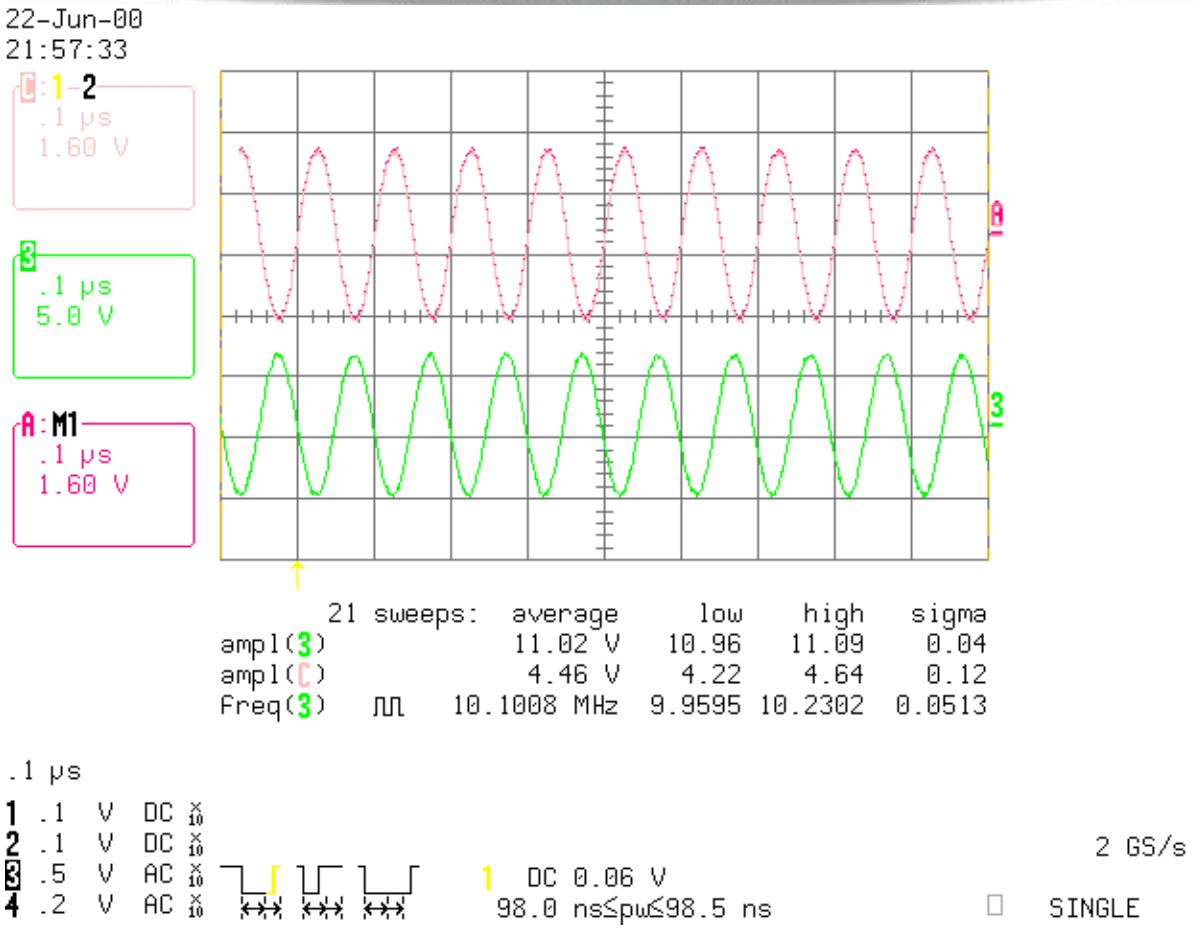

**10 Mbit/s Link Pulses I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



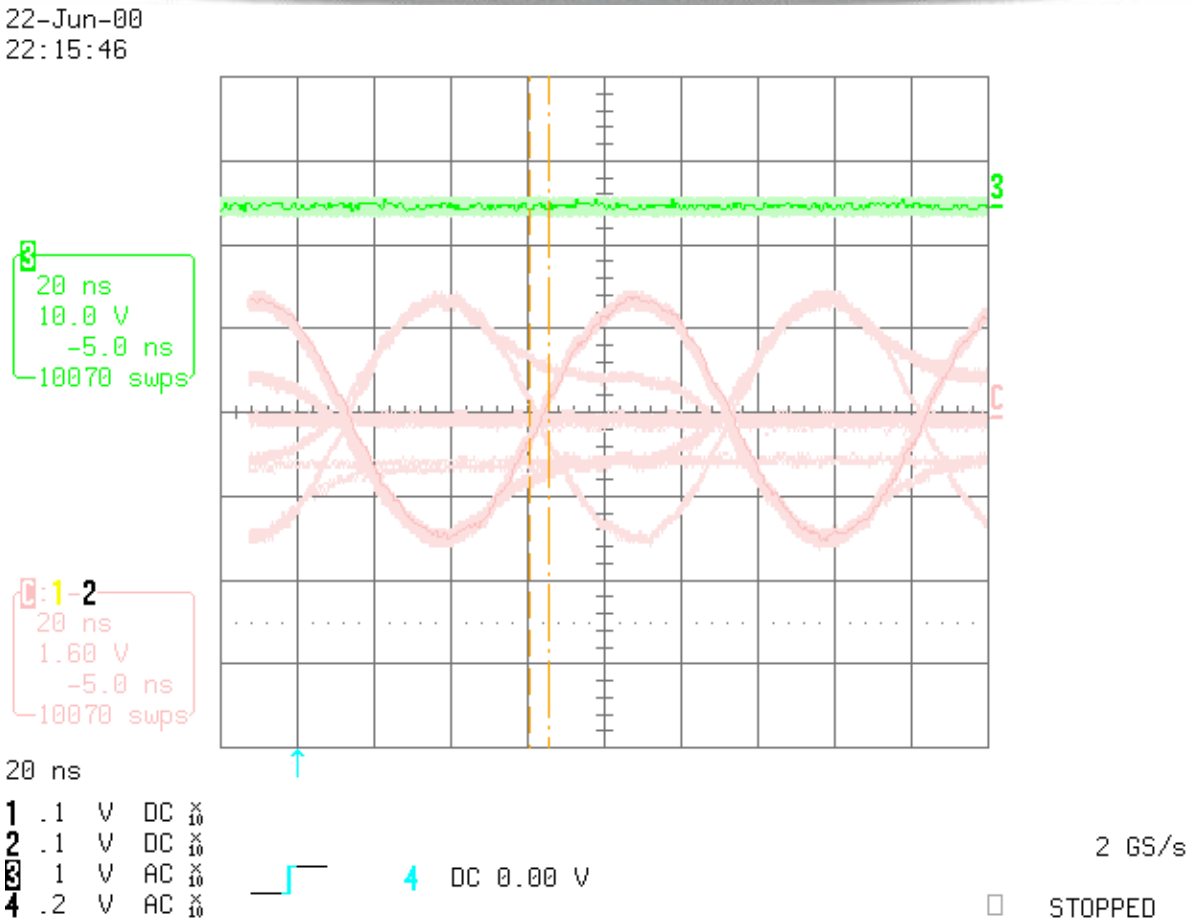

**10 Mbit/s Common Mode Voltage I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s



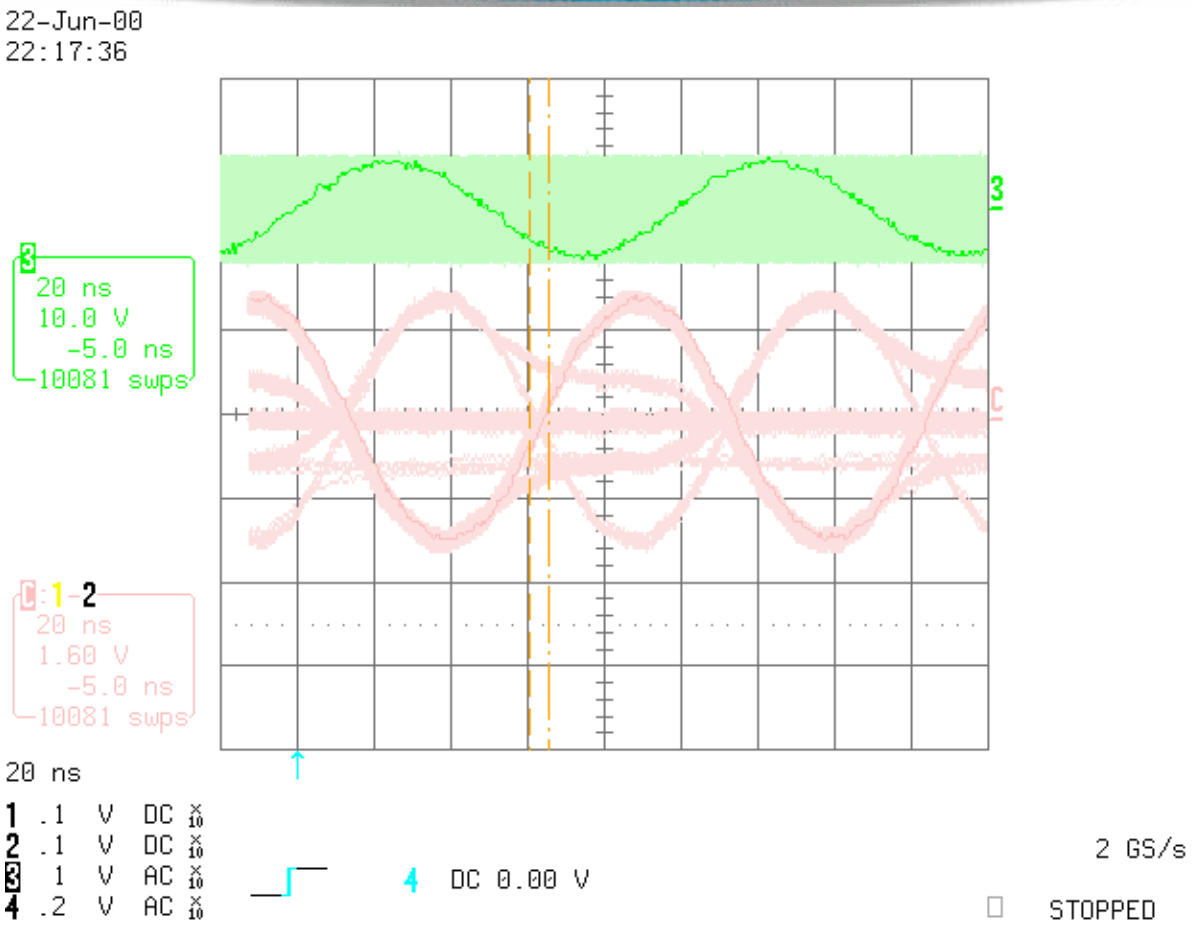

**10 Mbit/s Common Mode Rejection I = 0, I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s




**10.1MHz Sine Wave Injected, No Excess Jitter Present**
**I = 300 mA**

# Signal Quality Measurements
# 10 Mbit/s

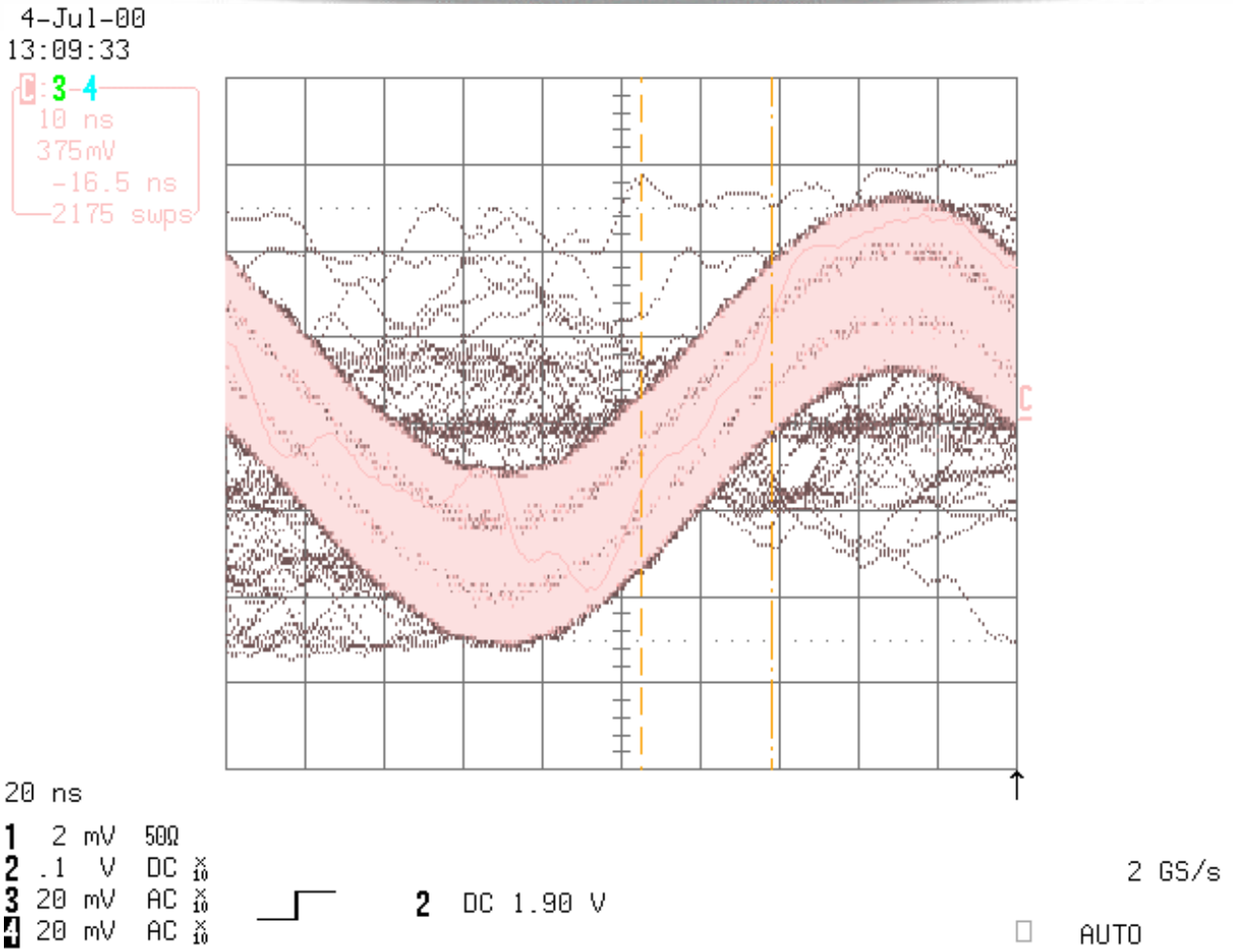



**10.1MHz Sine Wave Injected, No Excess Jitter Present**
**I = 0**

# Signal Quality Measurements
# 10 Mbit/s

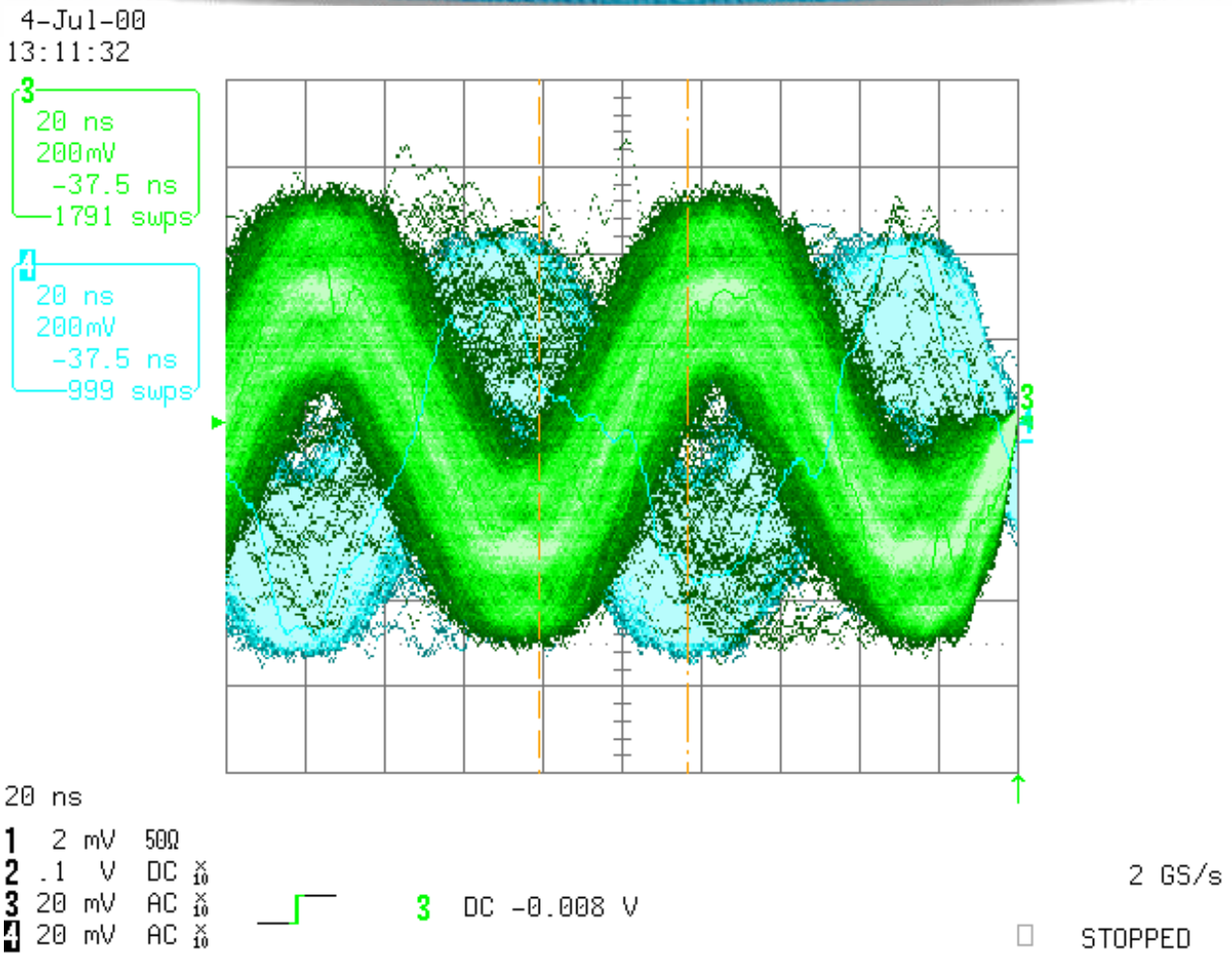
| *Test 14.3.1.2.4* | | CISCO SYSTEMS | | | Common Mode to Differential Conversion | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| **Freq** | **TX** | **calculate** | | | | **no power** | **Calculate** | | | **20*LOG10(VECM/VDIFF)** | | |
| **MHZ** | **BALANCE** | **"29-17*LOG10(FREQ/10)** | | | **I=0** | **20*LOG10(VECM/VDIFF)** | | | Meas | | **Calculate-I=300ma** | |
| | | | | Meas | Meas | | **I=0** | | **I=300ma** | | | |
| | | **SPECIFICATION** | | ***VECM*** | ***VDIFF*** | | **Calculate** | | ***VDIFF*** | | **Calculate** | |
| 1.00E+00 | | 4.60E+01 | | 11.1 | 0.049 | | 47.10254 | | 0.04 | | 48.86526 | |
| | | | | | | | | | | | | |
| 2.00E+00 | | 4.09E+01 | | 11.1 | 0.055 | | 46.09921 | | 0.047 | | 47.4645 | |
| | | | | | | | | | | | | |
| 5.00E+00 | | 3.41E+01 | | 11 | 0.1 | | 40.82785 | | 0.06 | | 45.26483 | |
| | | | | | | | | | | | | |
| 1.00E+01 | | 2.90E+01 | | 10.9 | 0.153 | | 37.0547 | | 0.1 | | 40.74853 | |
| | | | | | | | | | | | | |
| 1.50E+01 | | 2.60E+01 | | 10.6 | 0.202 | | 34.39909 | | 0.16 | | 36.42372 | |
| | | | | | | | | | | | | |
| 2.00E+01 | | 2.39E+01 | | 10.6 | 0.246 | | 32.68742 | | 0.17 | | 35.89714 | |
| | | | | | | | | | | | | |
| | | | | | WE SEE THE SAME RESULTS WITH | | | | | | | |
| | | | | | CURRENT TURNED ON AT 300MA | | | | | | | |
| | 1- | MY GENERATOR CAN'T DO MORE THAN 11.1V | | | | | | | | | | |
| | | | | | | | | | | | | |
| | 2- | Freq is in Mhz, so I used 1/10 to calculate the LOG of the 1MHZ data point | | | | | | | | | | |
| | | slight change in balance measurement for the better, you would have hoped that | | | | | | | | | | |
| | | my current source would cause an imbalance if anything…. Looks good. | | | | | | | | | | |
| | | | | | | | | | | | | |
| | Done on #19 - bel | | | | | | | | | | | |

# Signal Quality Measurements
# 10 Mbit/s



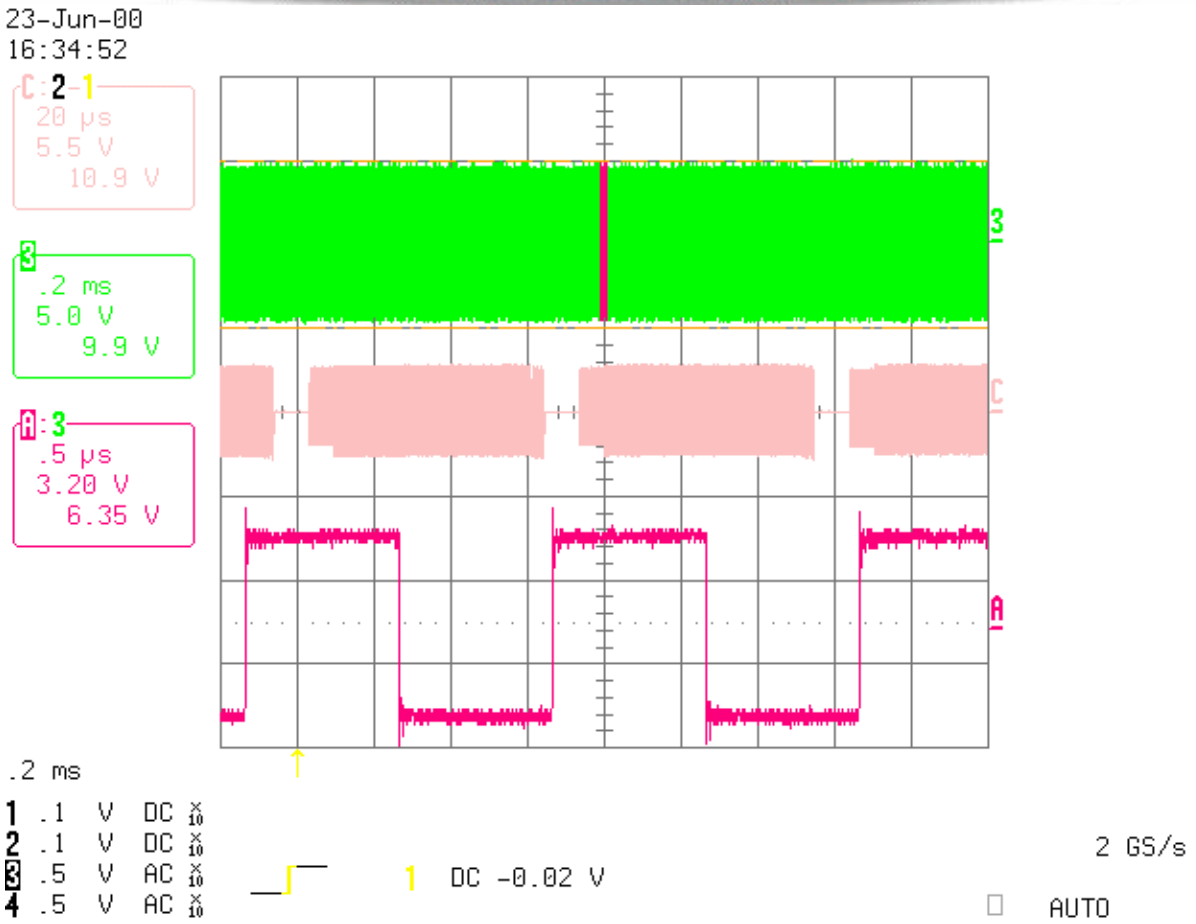

**Receive Jitter and Common Mode Tolerance, I = 300 mA at 128 M, Cat-3, Error Free, 5M Packets**

# Signal Quality Measurements
# 10 Mbit/s




**Receive Jitter and Common Mode Tolerance, I = 300 mA at 128 M, Cat-3, Error Free, 5M Packets, Single Ended**

# Signal Quality Measurements
# 10 Mbit/s

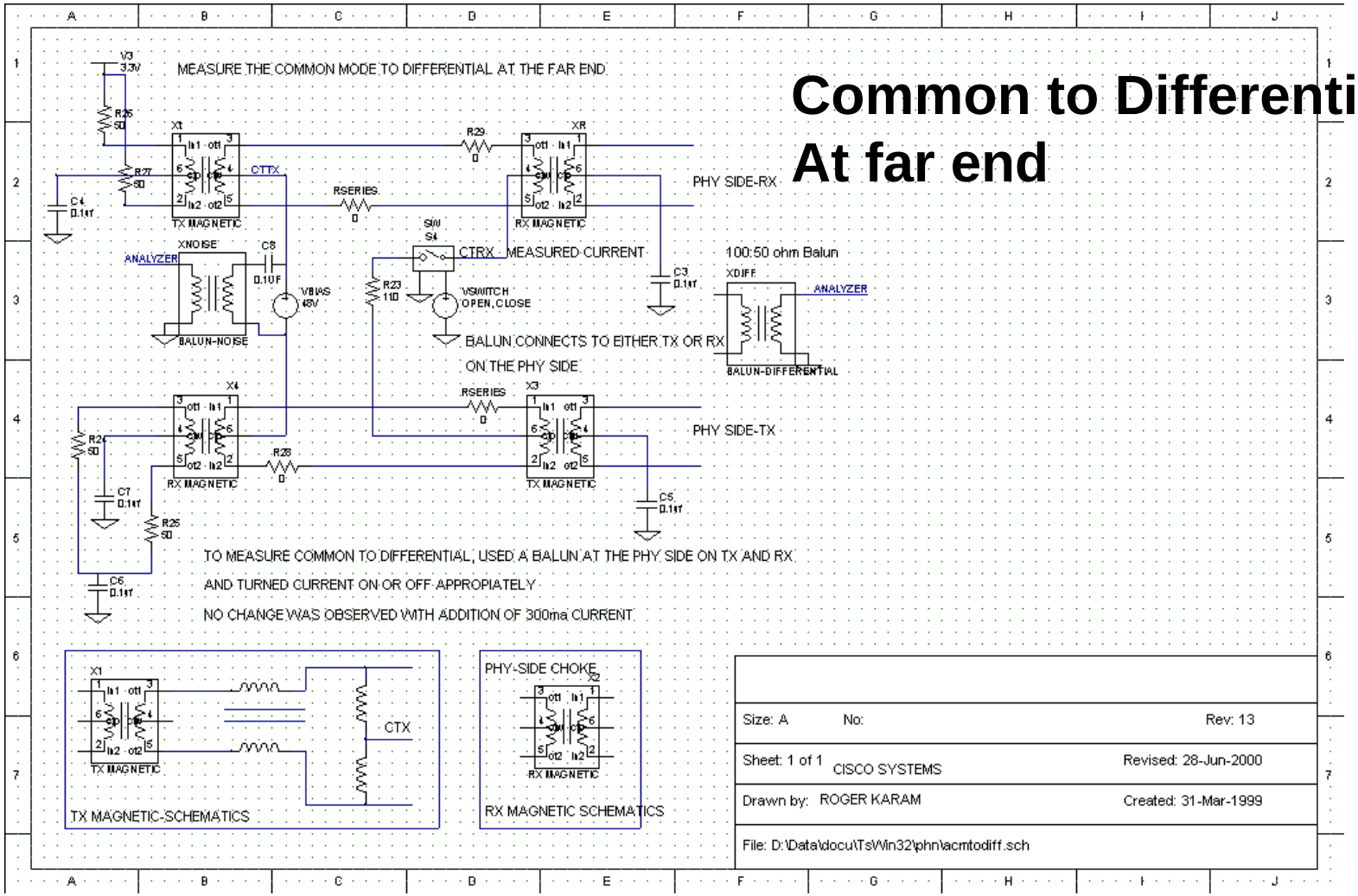



**10 Mbit/s 500 KHz, 25V Square Wave Common Mode Rejection of the RX I = 300 mA**

# 10 Mbit/s, Summary

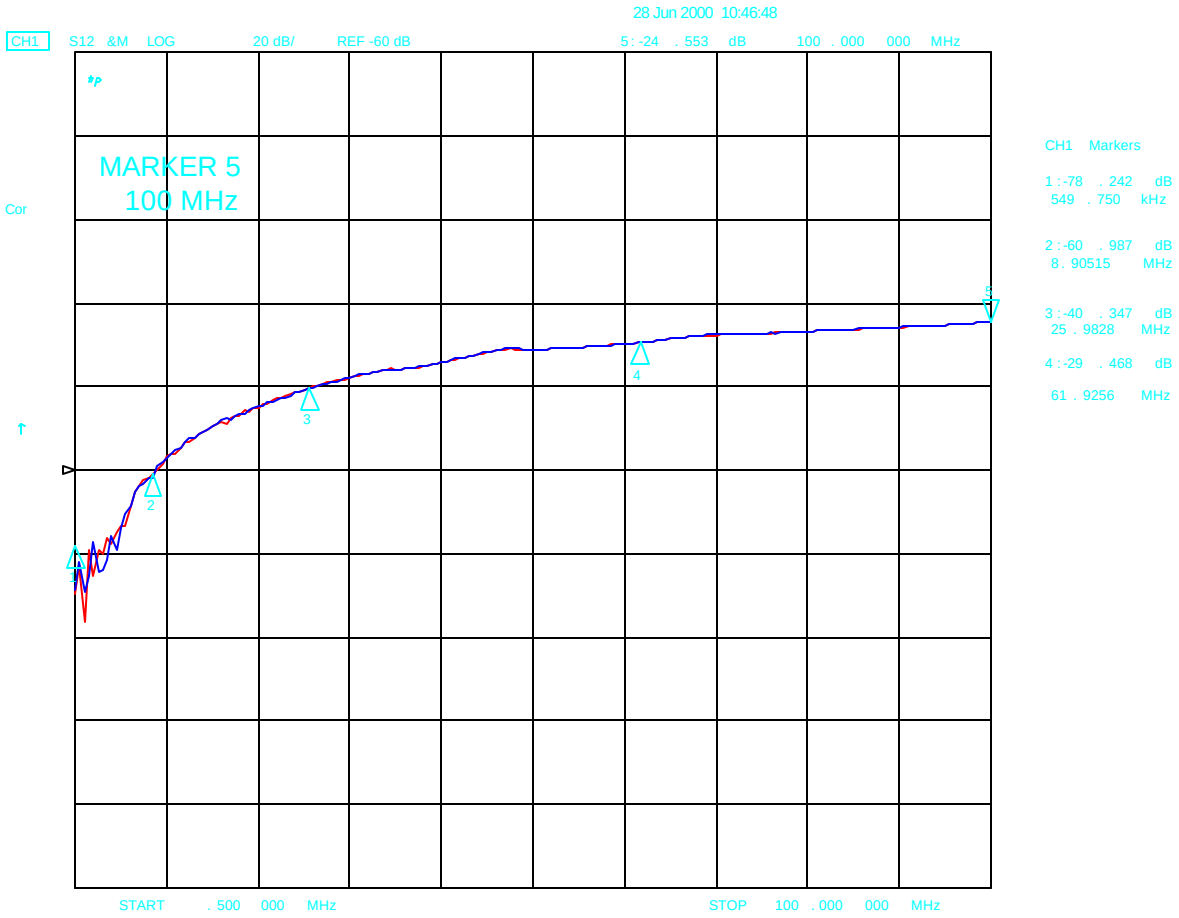
| Characteristic | No Power | With Power |
|---|---|---|
| **Peak Differential Output Voltage on TD** | 4.64/4.64 | 4.64/4.64 |
| **TD circuit Differential Output Tx Impedance @ 5, 10Mhz** | -26, -18 dB | -26, -18 dB |
| **TD circuit Differential Output Rx Impedance @ 5, 10Mhz** | -31, -31 dB | -31, -31 dB |
| **TD common mode output voltage** | < 40 mV | < 40 mV |
| **TD common mode rejection(See Slides 24-26)** | Pass | Pass |
| **RD Signal Acceptance** | 690 mV | 730 mV |
| **Receiver Jitter Acceptance (See Slides)** | >13 nSec | > 13 nSec |
| **Receiver Added Jitter** | < 1 nSec | < 1 nSec |
| **Common Mode to Differential Mode Conversion** | Pass | Pass |
| **RD Common Mode Rejection (See Slide 27)** | Pass | Pass |

# Signal Quality Measurements
# Magnetics



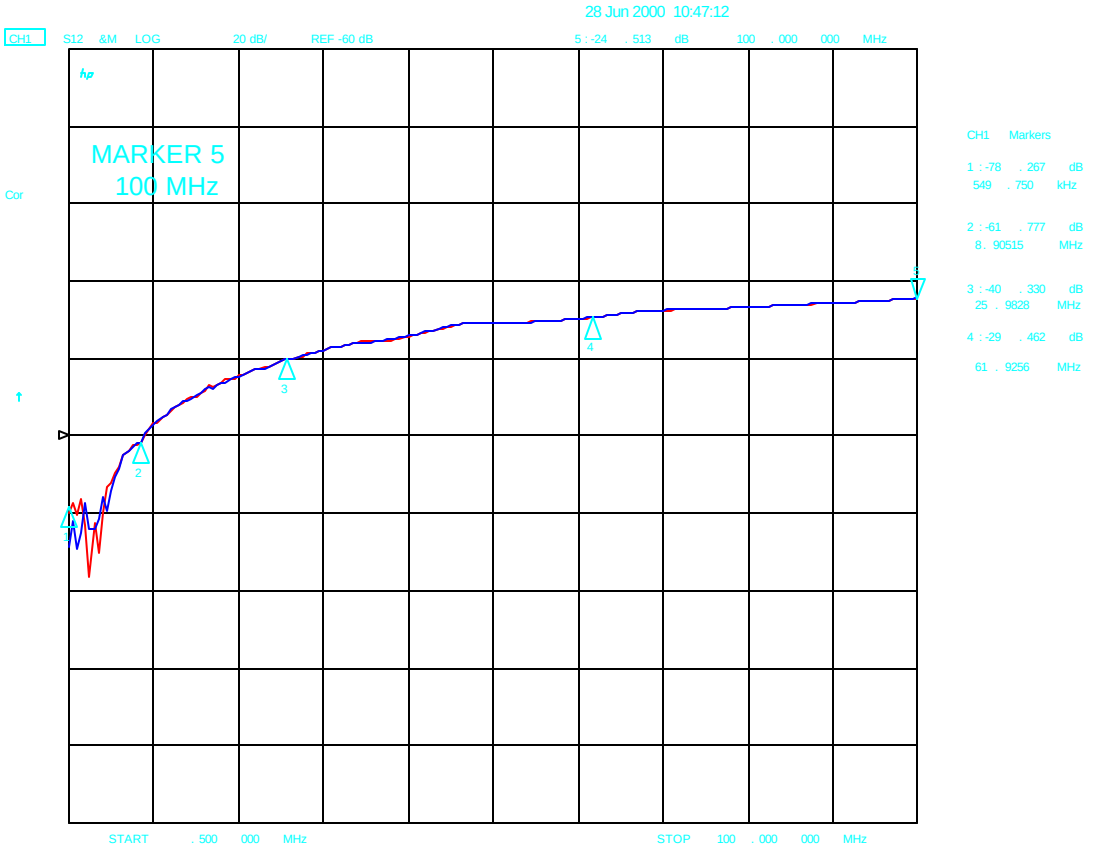

## Common to Differential
## At far end

# Signal Quality Measurements Magnetics



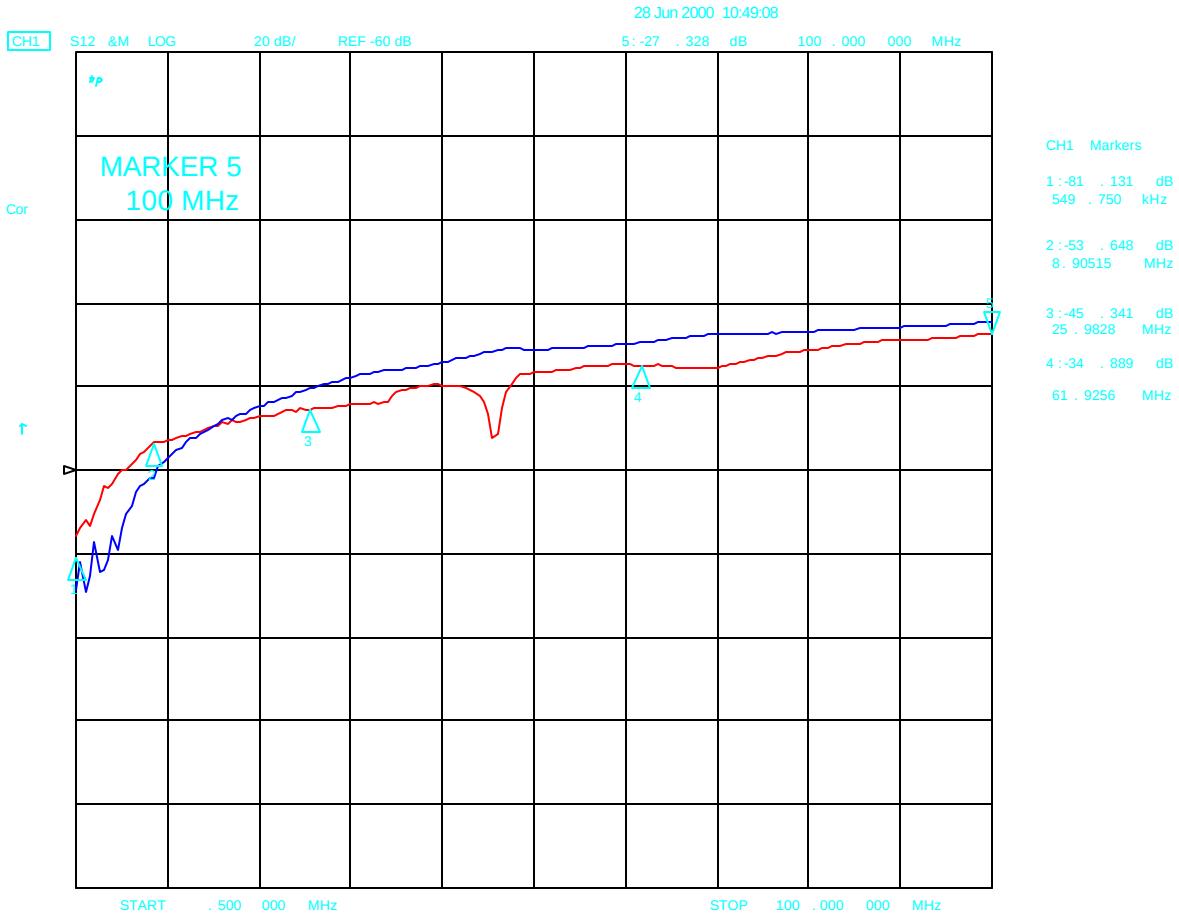

**Common Mode to Differential Conversion, Drove Supply Side, Measure at PHY on the RL Side**

# Signal Quality Measurements Magnetics



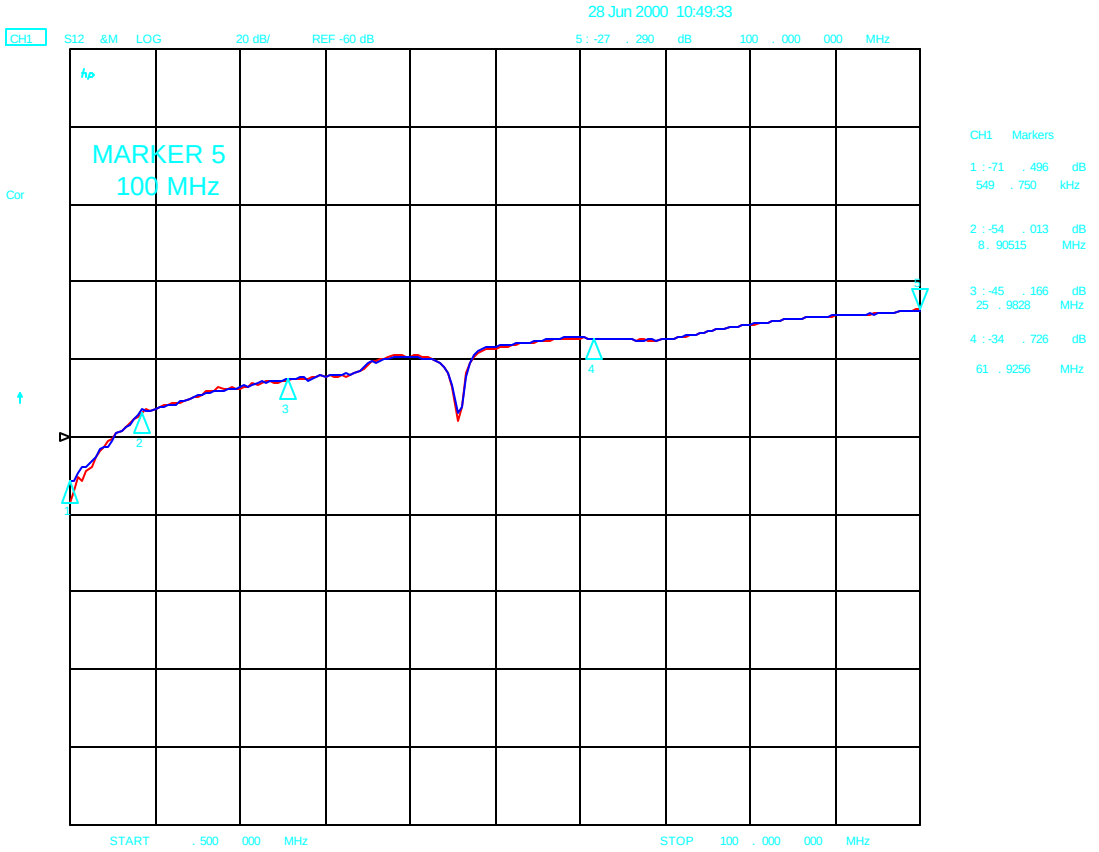

**Common Mode to Differential Conversion, Drove Supply Side, Measure at PHY on the RL Side, I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics



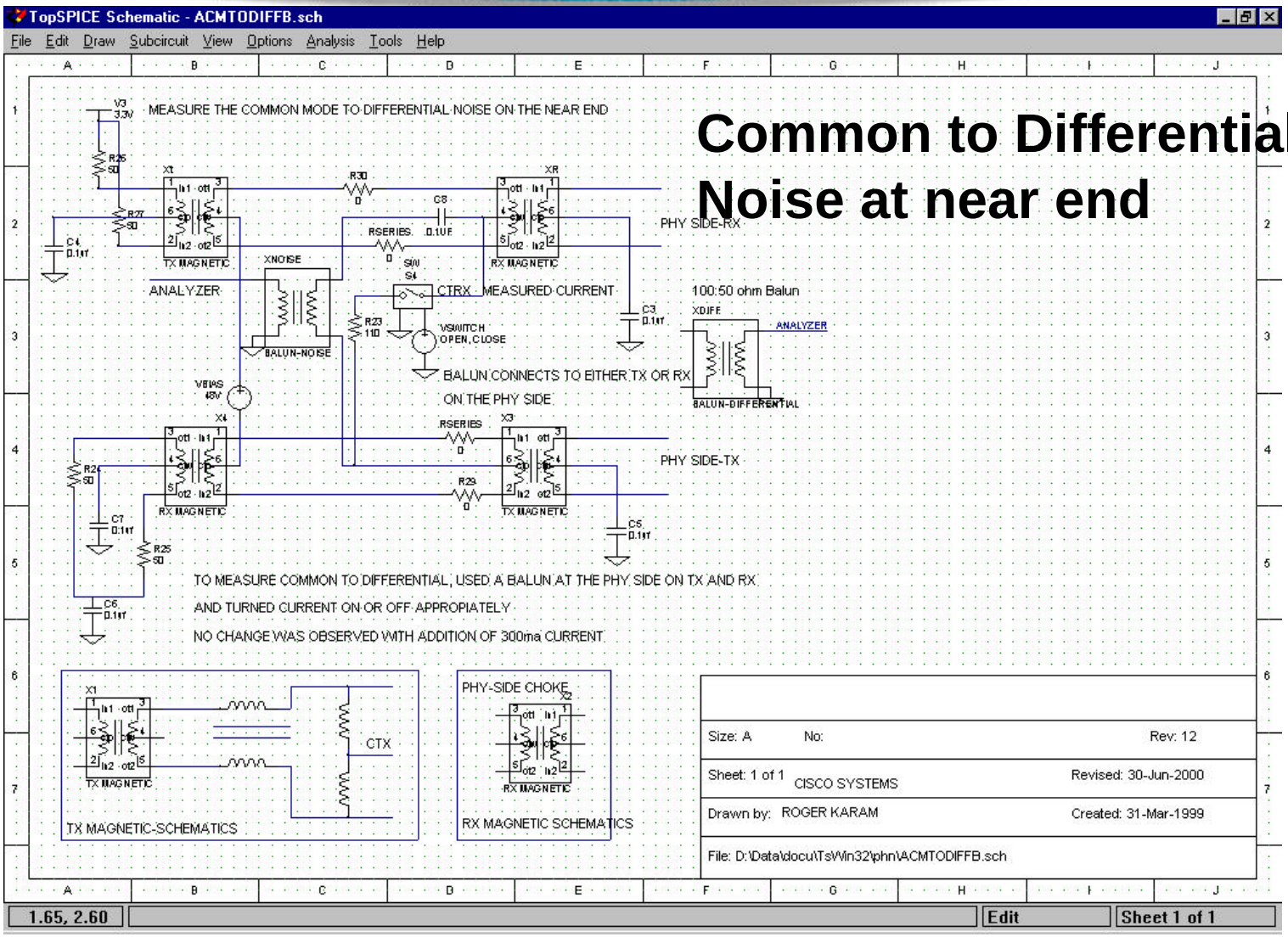

**Compare Tx to Rx, I = 0**

# Signal Quality Measurements Magnetics



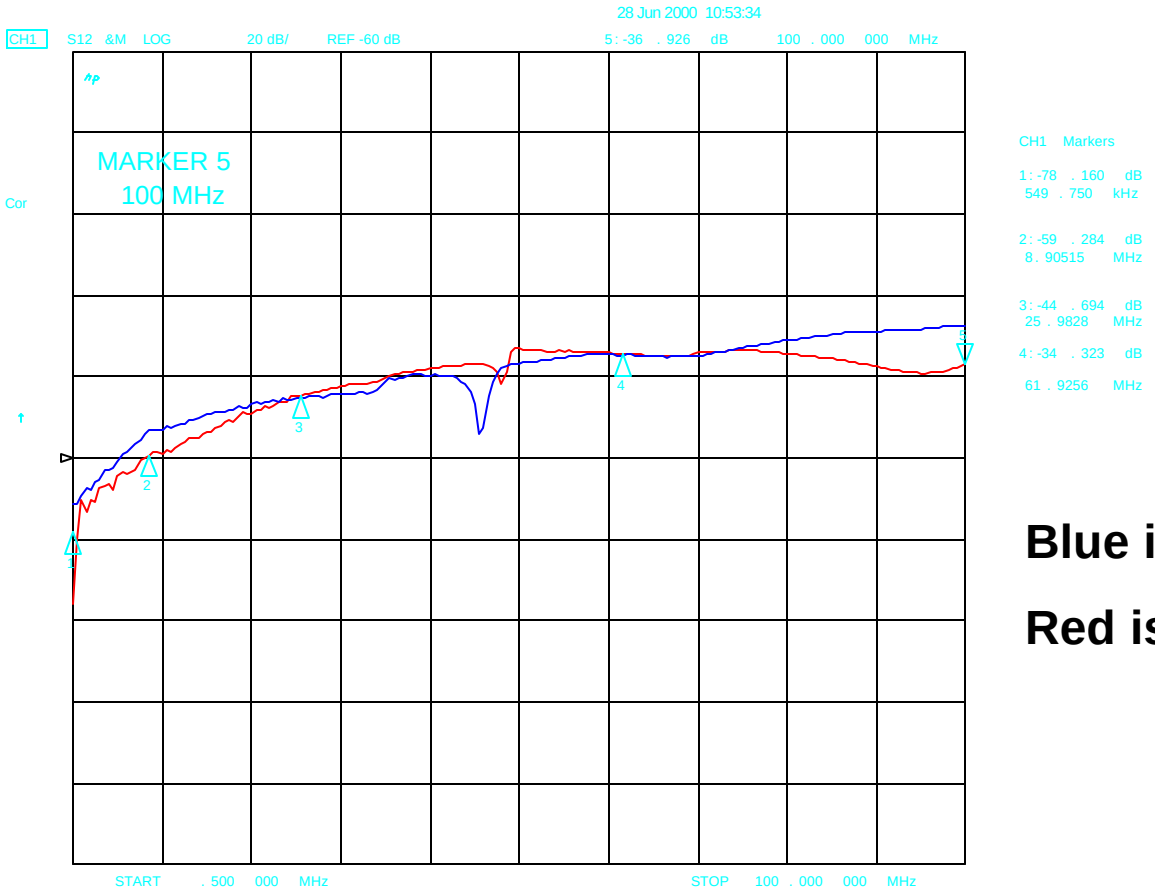

**Tx I = 0, I = 300 mA**

# Signal Quality Measurements
# Magnetics




## Common to Differential Noise at near end

# Signal Quality Measurements Magnetics

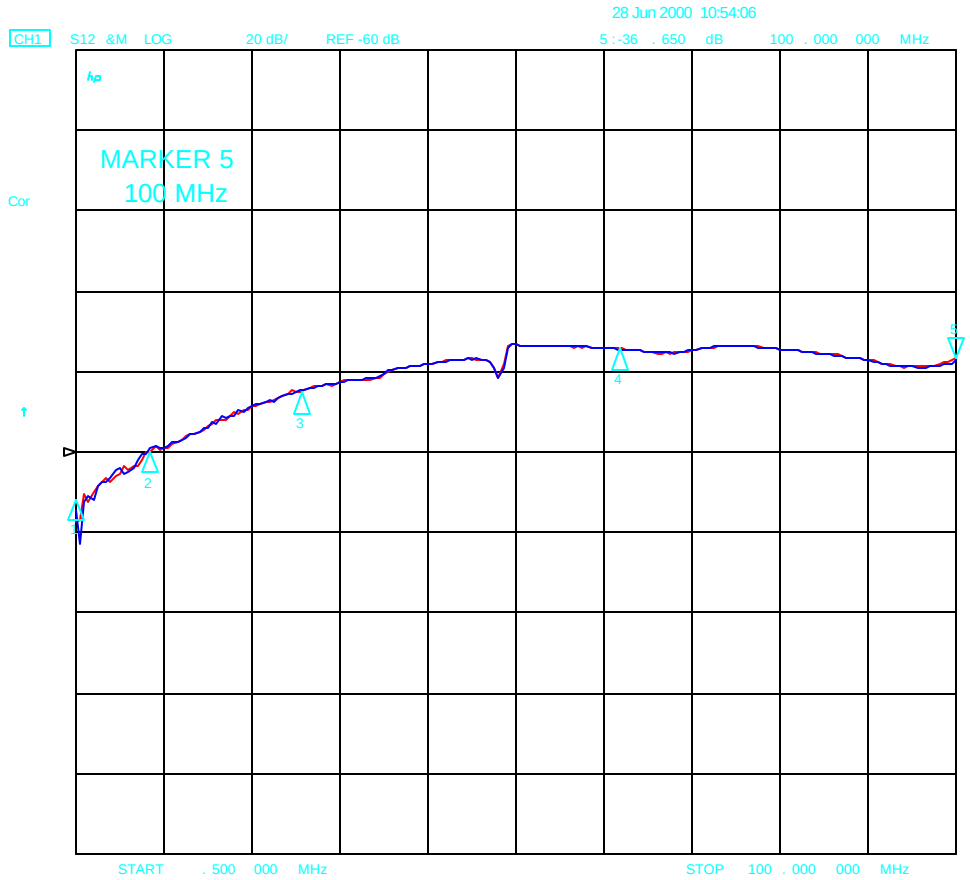



**Blue is PHY Side**

**Red is Wire Side**

**Rx Common Mode to Differential, Drove the Rx side of the RL and measured on the wire side I = 0**

# Signal Quality Measurements Magnetics

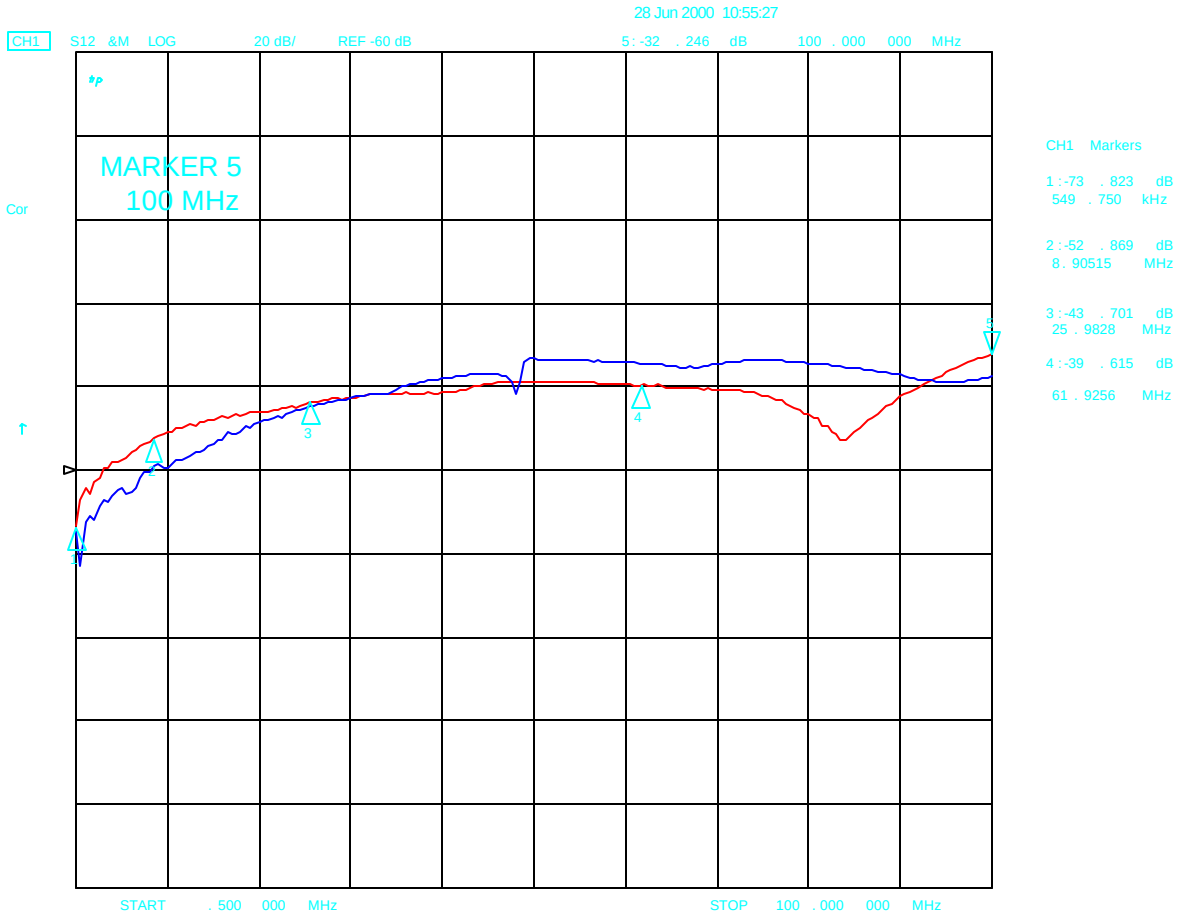



**Red is Wire Side, I = 300 mA**

**Blue is Wire Side, I = 0 from previous slide**

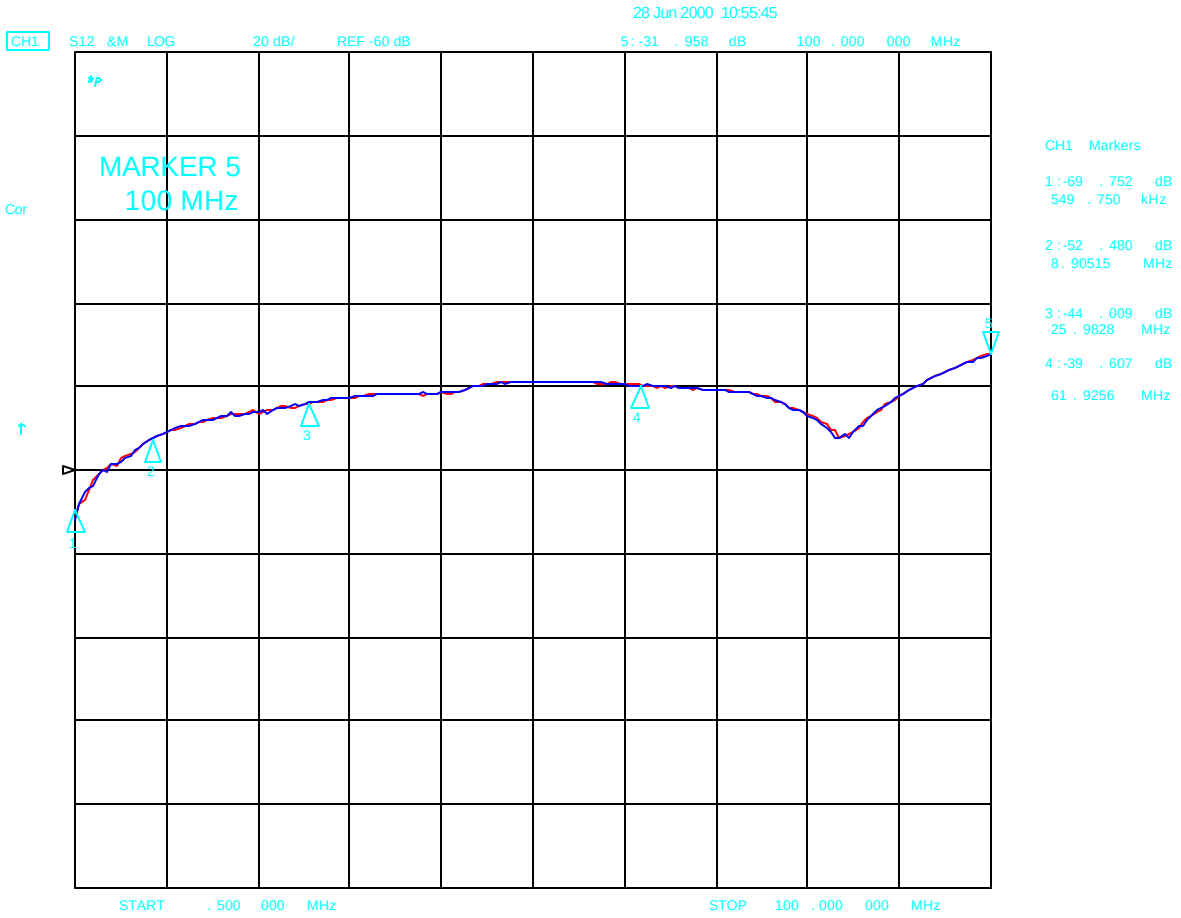
**Rx Common Mode to Differential, Drove the Rx side of the RL and measured on the wire side I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics



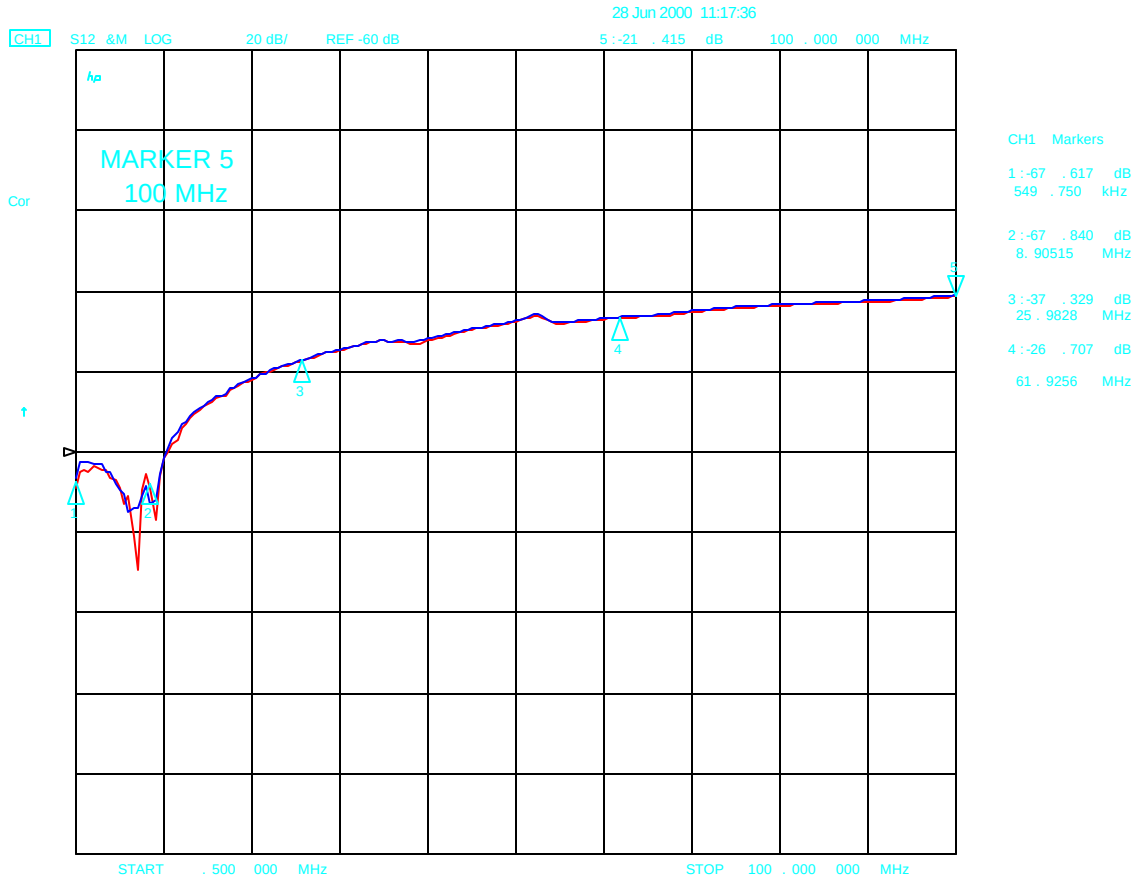

**Compare Tx to Rx, Wire Side, I = 0 mA**

# Signal Quality Measurements Magnetics



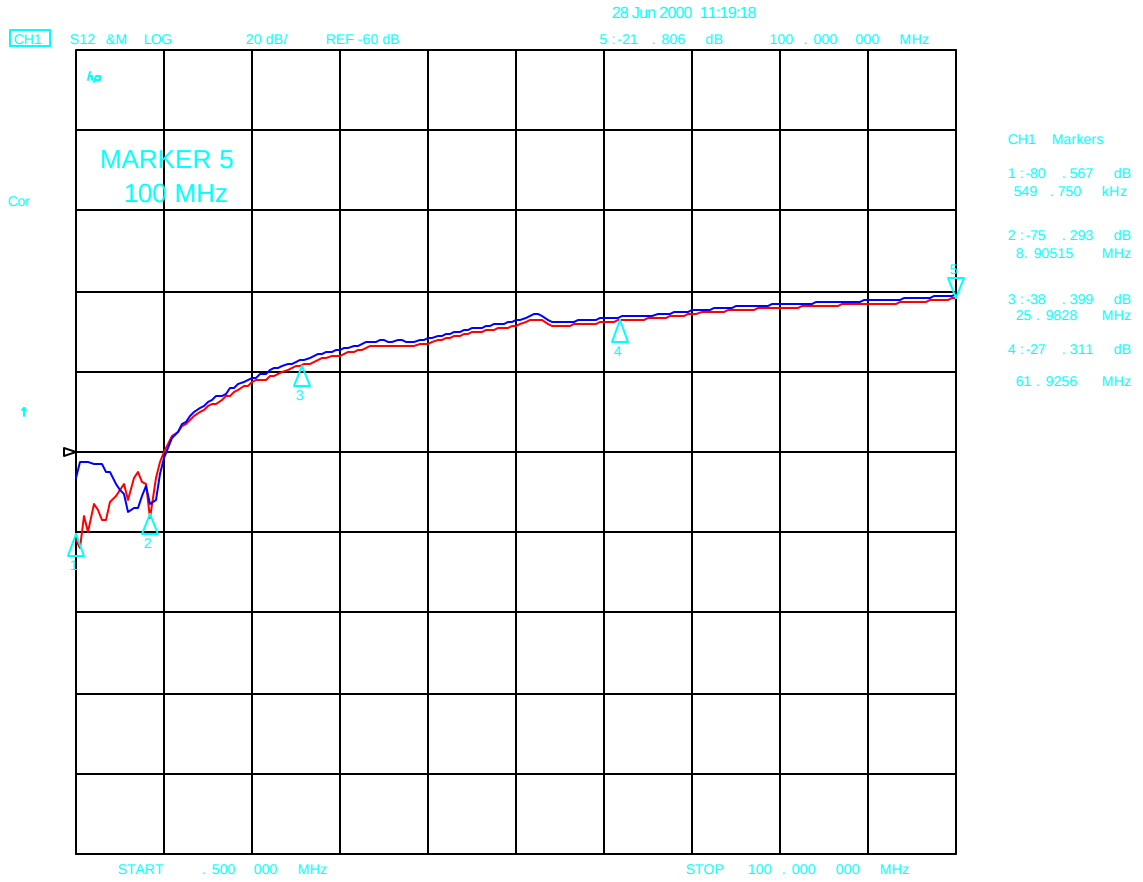

**Tx Common Mode to Differential, Wire Side I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics



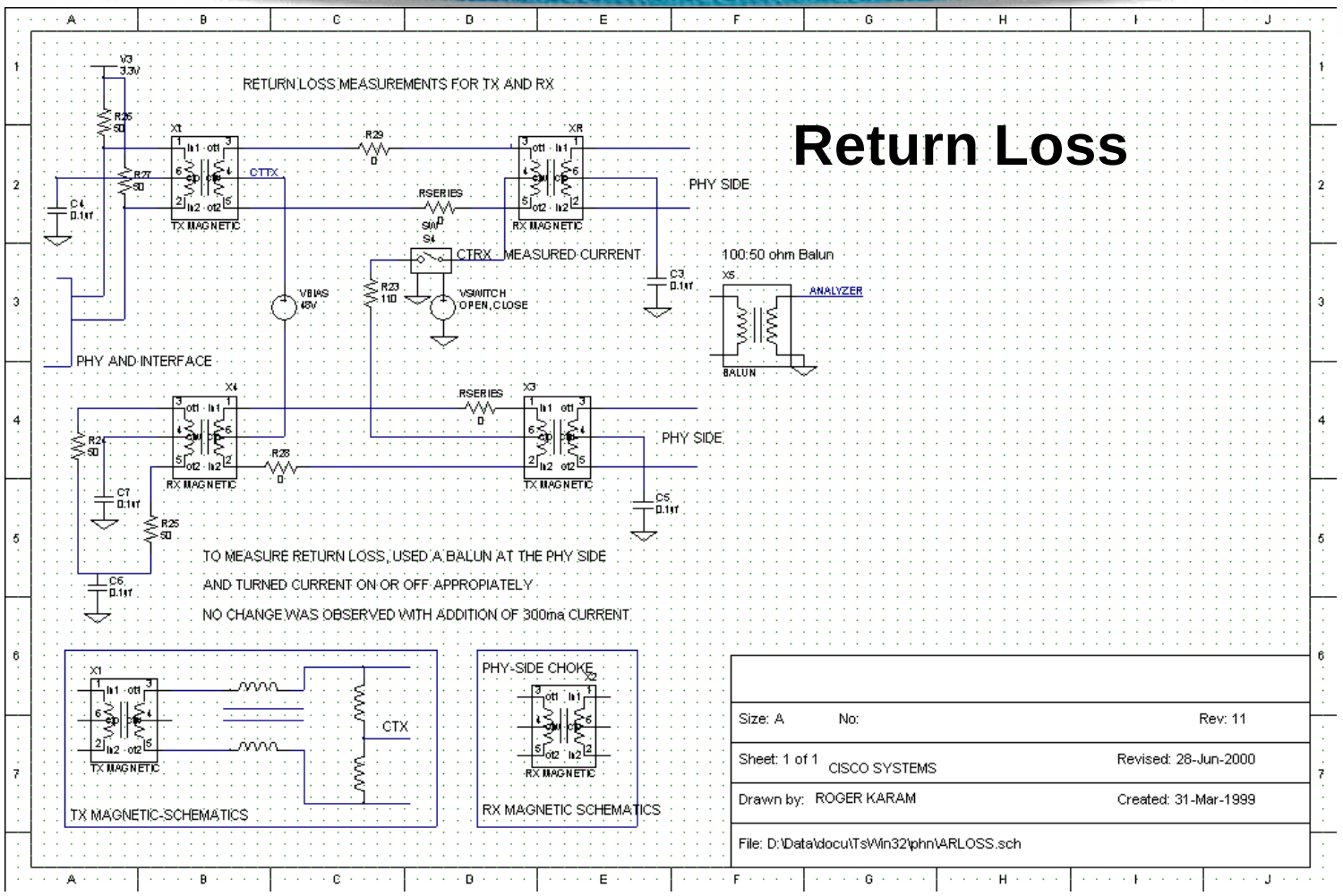

**Tx Common Mode to Differential Conversion, Wire Side, R = 0, R = 2.5 Ohms in series with Rx**

# Signal Quality Measurements Magnetics

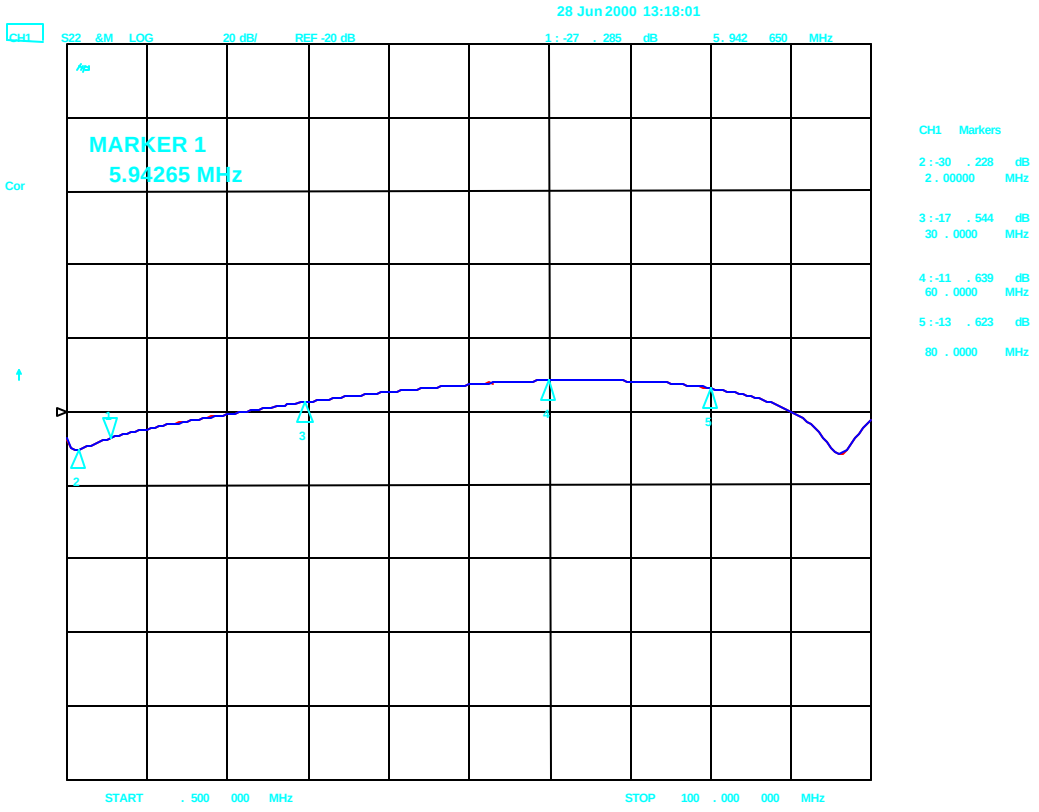



**Tx Common Mode to Differential Conversion, Wire Side, R = 2.5 Ohms in series with Rx, I = 0, I = 300 mA**

# Signal Quality Measurements
# Magnetics

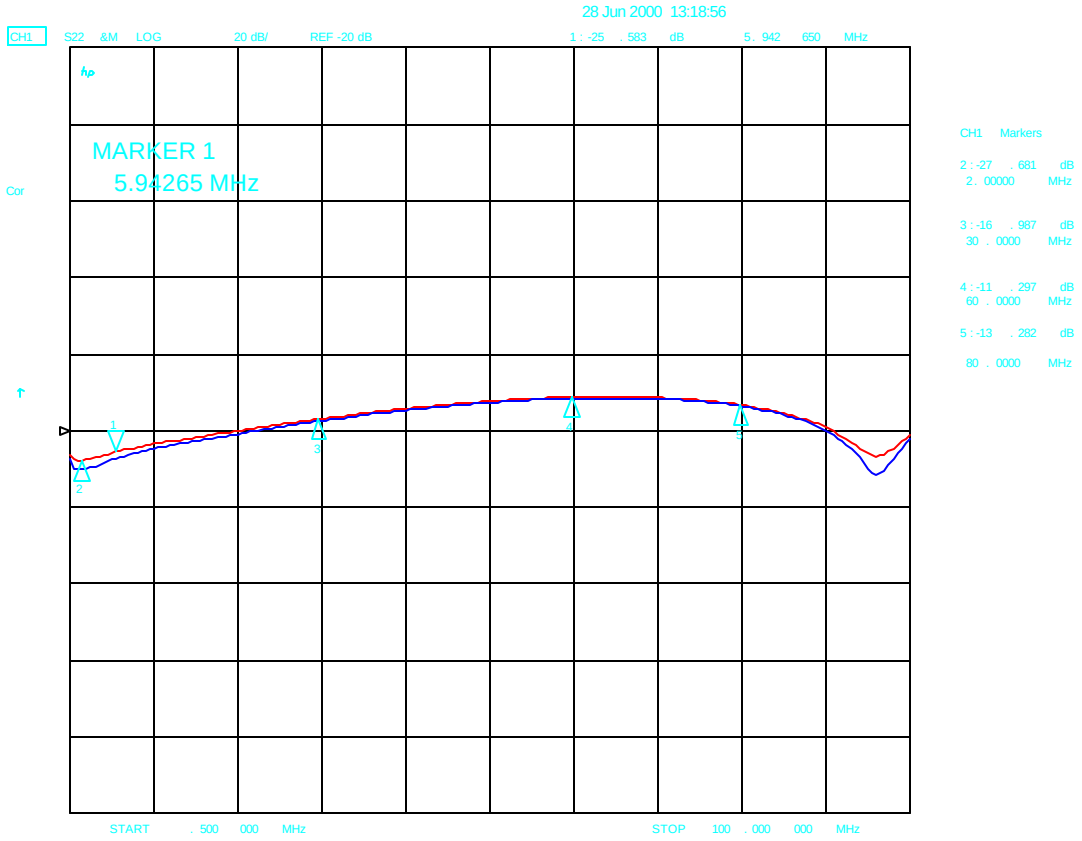


# Signal Quality Measurements
# Magnetics



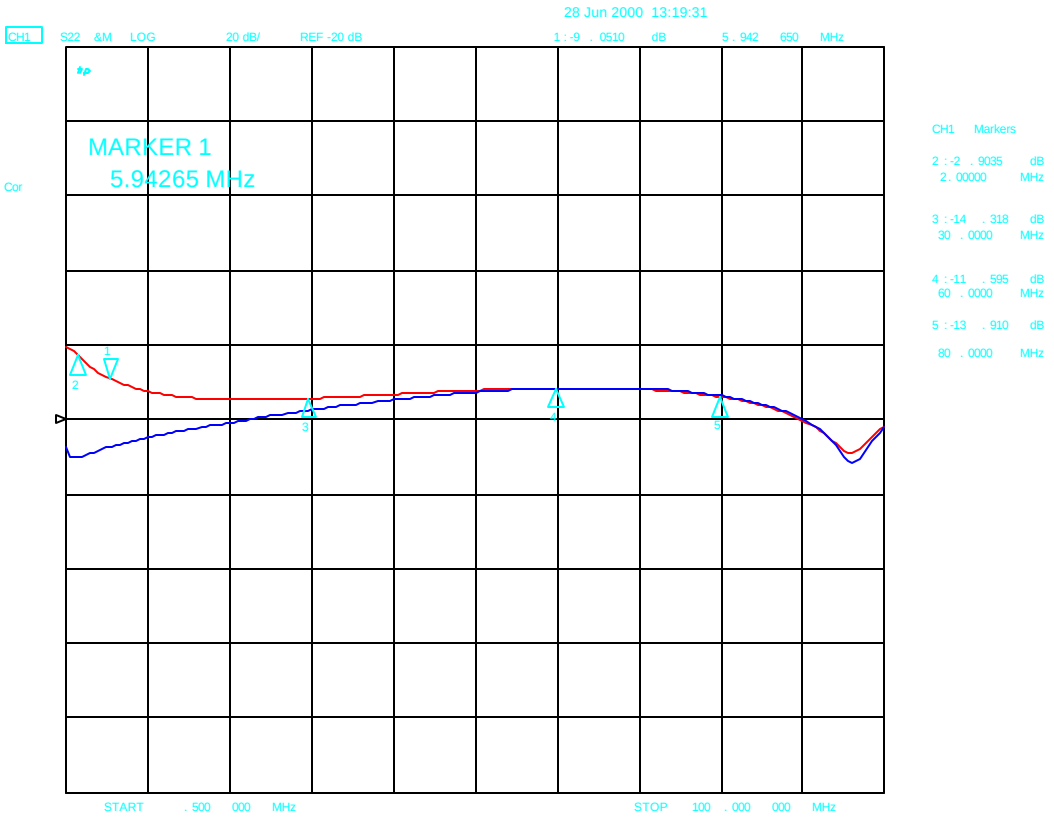

**Return Loss, Rx, Wire Side I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics



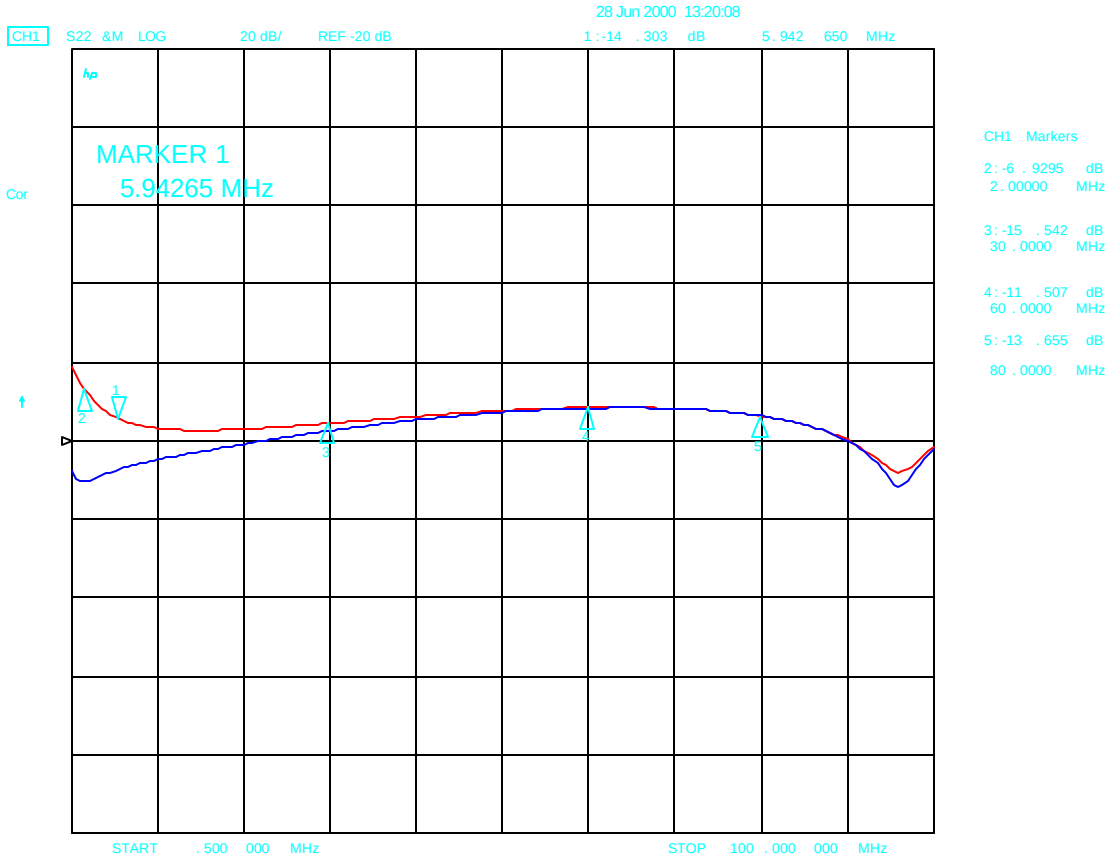

**Return Loss, R = 0, R = 2.5 Ohms Series on RX Wire Side I = 0**

# Signal Quality Measurements
# Magnetics



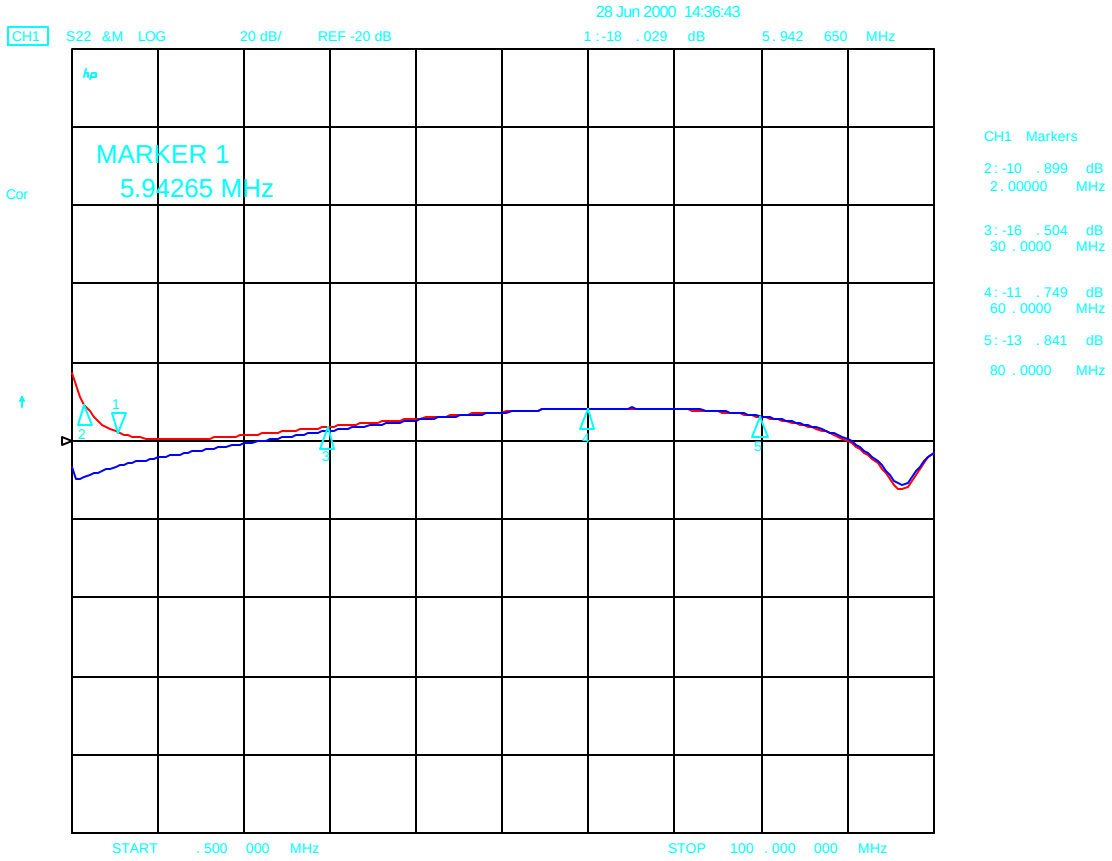

**Return Loss, R = 2.5 Ohm Series on RX Wire Side**
**I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics



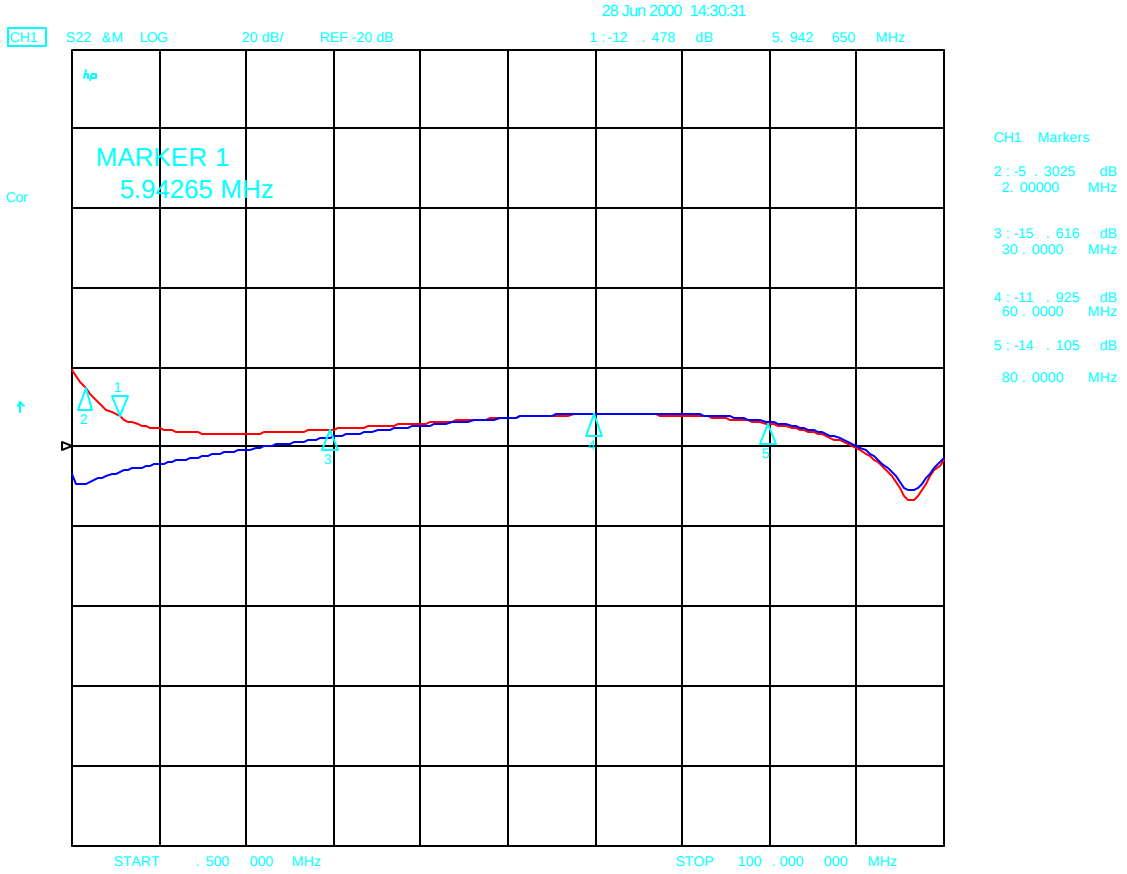

**Return Loss, R = 2.5 Ohms Series on RX Wire Side**
**I = 0, I = 200 mA**

# Signal Quality Measurements
# Magnetics



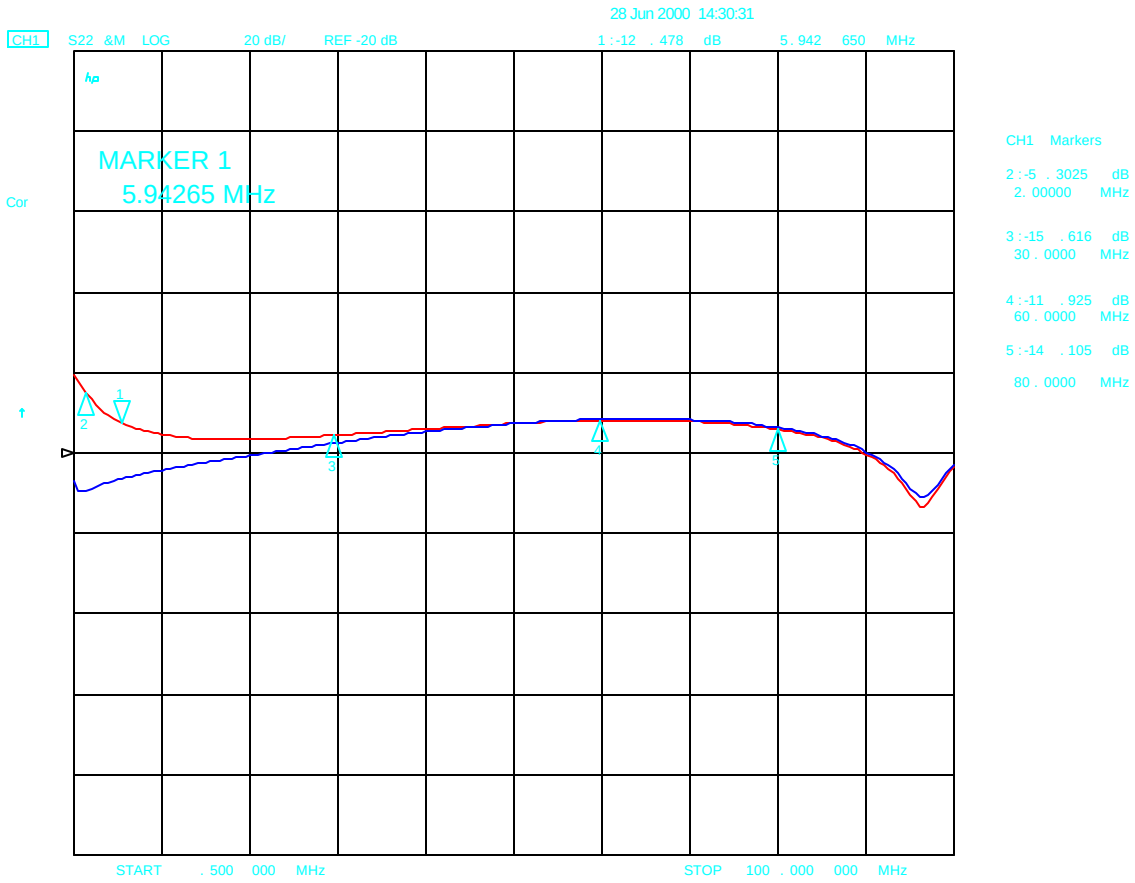

**Return Loss, R = 1.25 Ohms Series on RX Wire Side**
**I = 0, I = 200 mA**

# Signal Quality Measurements
# Magnetics



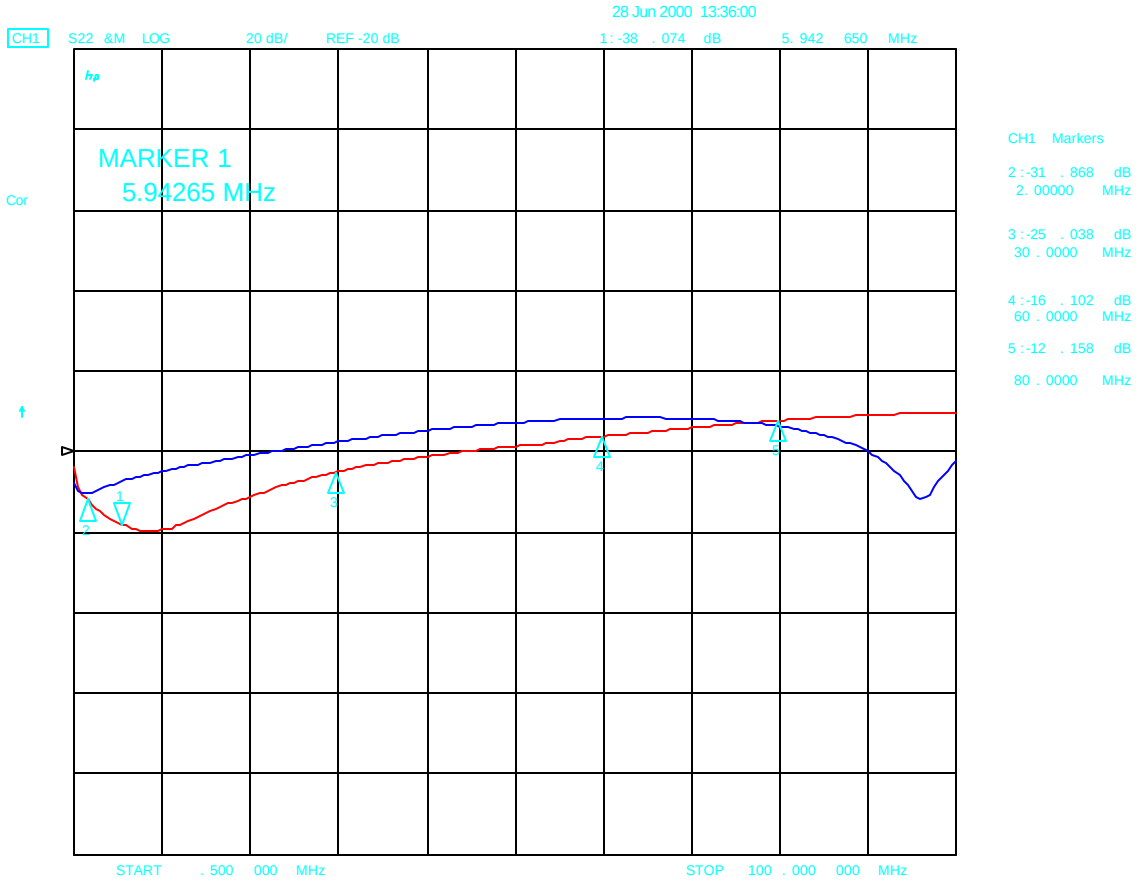

**Return Loss, R = 1.25 Ohms Series on RX Wire Side**
**I = 0, I = 300 mA**

# Signal Quality Measurements Magnetics




**Return Loss, R = 1.25 Ohms Series on RX Wire Side**
**I = 0, I = 300 mA**

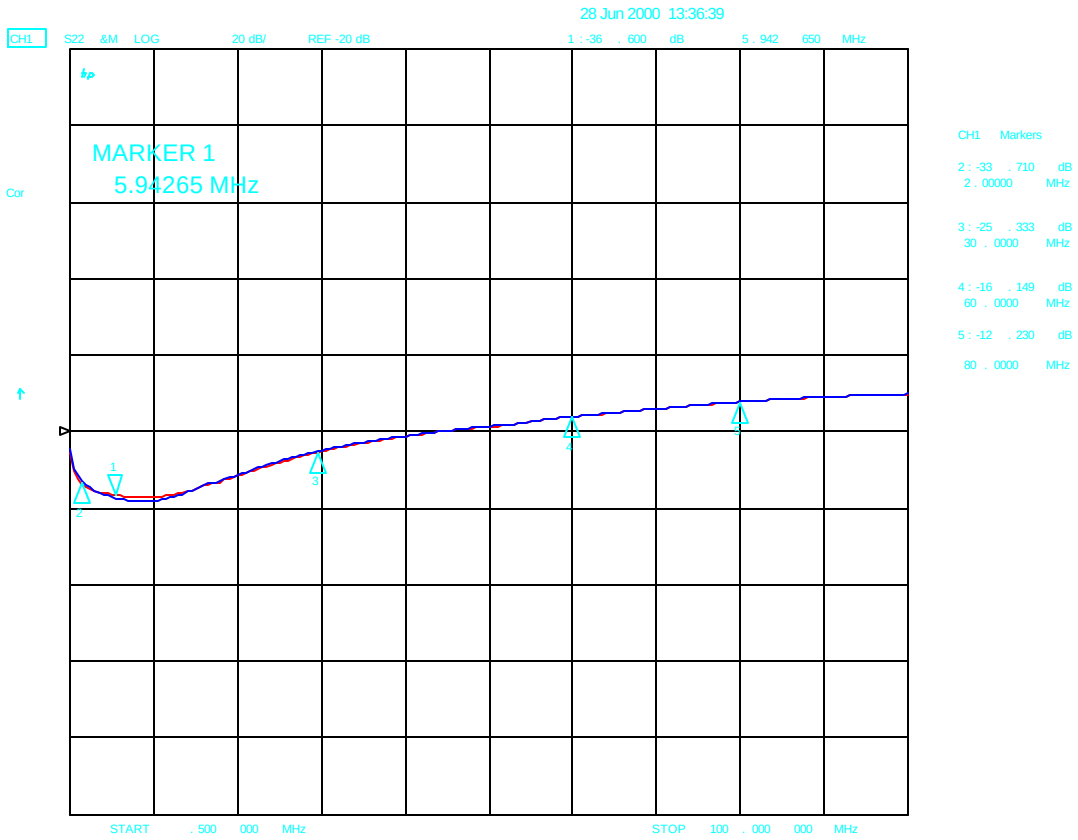
# Signal Quality Measurements Magnetics




**Return Loss Compare TX Wire Side to RX Wire Side**

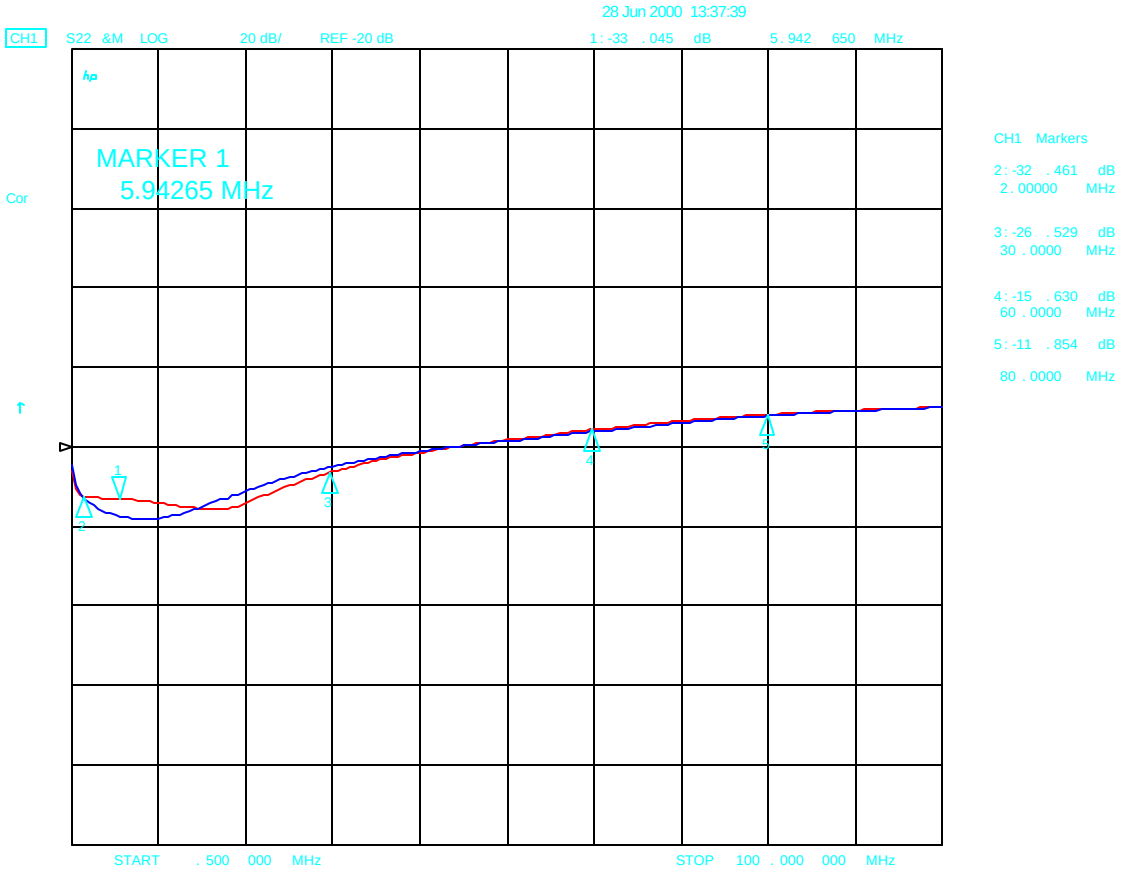
**I = 0**

# Signal Quality Measurements Magnetics



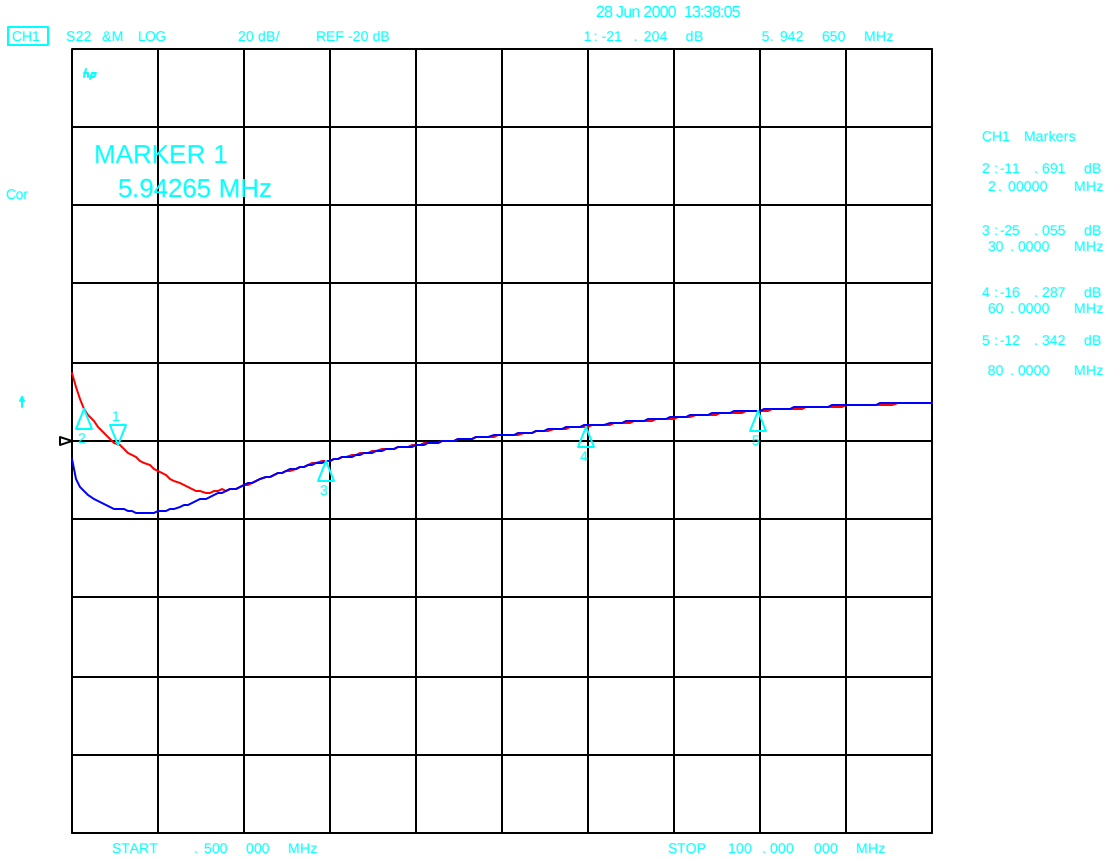

**Return Loss, TX Wire Side, R = 0, I = 0, I = 300 mA**

# Signal Quality Measurements
# Magnetics




**Return Loss, R = 0, R = 1.25 Ohm Series TX Wire Side**
**I = 0**

# Signal Quality Measurements
# Magnetics




**Return Loss, R = 1.25 Ohm Series TX Wire Side**
**I = 0, I = 300 mA**

# Summary of Common mode to differential conversion

| Freq (MHz) | Rxwire (dB) | Txwire (dB) | Freq (MHz) | Pair-Pair (dB) | Pair Common-Mode (dB) | Freq (Mhz) |
|---|---|---|---|---|---|---|
| 1 | -78 | -71 | 1 | -74 | -31 | 29 |
| 8 | -60 | -54 | 16 | -54 | -32 | 37 |
| 25 | -40 | -45 | 40 | -53 | -30 | 64 |
| 63 | -29 | -34 | 70 | -47 | -29 | 72 |
| 100 | -25 | -27 | 100 | -43 | -39 | 86 |

**Having a 2.5 Ohm R series with the Magnetics at 300mA degrades Conversion by 20dB at low frequency. Not an issue at -78dB**

**Pair to Pair Isolation is superior to the Common Mode to Differential conversion of the magnetic**

**Binding the 2 wires in the pair together causes isolation to approach the common mode to differential conversion of the magnetic (proved in following slides)**

# Summary of Return Loss

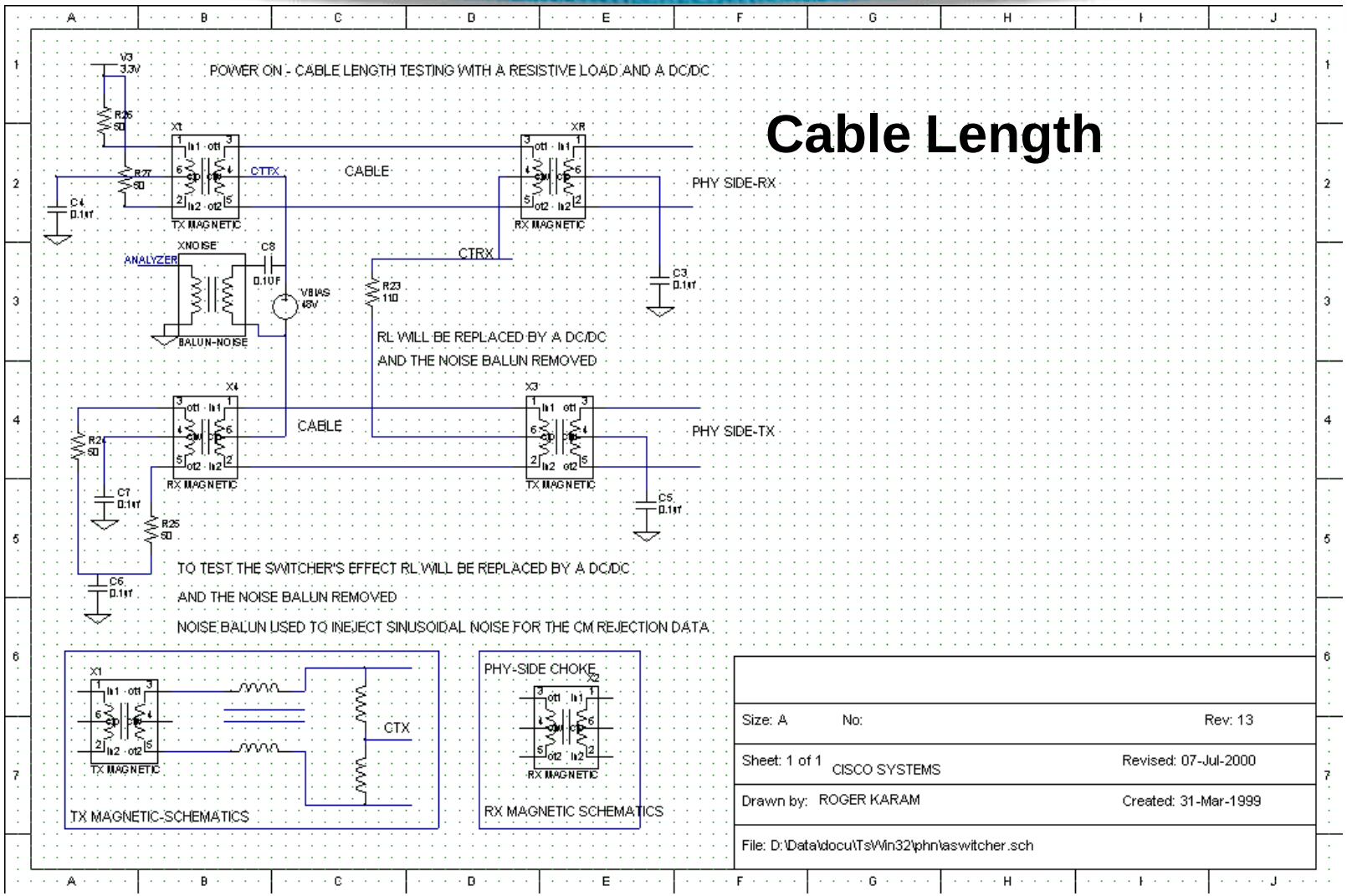
| Freq (MHz) | RX (dB) | | | Tx (dB) | |
|---|---|---|---|---|---|
| | Rseries=0 | Rseries=2.5 | Rseries=1.25 | Rseries=1.25 | Rseries=0 |
| 2 | -30 | -3 | -5 | -33 | -12 |
| 5 | -27 | -9 | -13 | -36 | -21 |
| 30 | -18 | -14 | -16 | -25 | -25 |
| 60 | -12 | -12 | -12 | -16 | -16 |
| 80 | -13 | -14 | -14 | -12 | -12 |

**Question raised "What happens if there is an imbalance in the cable"**

**Findings:**

- **At 1.25 Ohms, 300 mA no errors after 8m length**
- **At 1.25 Ohms, 240 mA no errors after 1m length**
- **For 8m cable 1.25 Ohms is a 50% imbalance**

# Operational Characteristics
# BER and Switching Noise



# Operational Characteristics BER and Switching Noise

- 10 Million Packets per Test
- Covered 2 PHY/ 2 Magnetic Vendors
- 10 and 100 Mbit/s Testing
- Random Data Random Length Packets
- Switching Power Supplies
  - 6 Watt Production 48 V to 3.3/1.8 V Supply
  - 50W 1/2 a Brick  48 V to 5 V Supply
- Testing With and Without Switcher Filtering and EMI results

# Operational Characteristics, Results

| Condition<br>PHY One / Magnetic One | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| Power OFF, RL=110 ohms see **schematic** max cable reach=163M | 163M | 0 | 0 |
| Power ON 300 mA , RL=110 ohms | 163M | 0 | 0 |
| Power ON, RL = 110ohm | 167M | 318 | 0 |
| Power OFF, RL = 110ohm | 167M | 315 | |
| Power OFF, 6 Watt DC/DC replaces RL Note that no Filter exist at the input of the DC/DC in all my testing unless I say. | 167M | 322 | 0 |
| Power OFF, 6 Watt DC/DC Rerun | 167M | 323 | 0 |
| Power ON 6 Watt DC/DC | 167M | 295 | 0 |
| Power ON 6 Watt DC/DC- Rerun test | 167M | 308 | 0 |

**Conclusion: 6 Watt Switcher has no effect with or without Power, without Filter**

# Operational Characteristics, Results

| Condition<br>PHY One/Magnetic One | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| No Power, No Load | 163M | 0 | 0 |
| Power Off, 50 Watt Switcher Load Connected(Test 1/Test 2= a repeat) | 167M | 344 / 334 | 0 / 0 |
| 50 Watt Switcher(No Input Filter) with 300 mA Load (Test 1/Test 2) | 167M | 2599 / 1417 | **108243/ 115988** |
| 50 Watt Switcher(No Input Filter) with 300 mA Load (Test 1/Test 2) | 156M | 0 / 1 | 106 / 126 |
| 50 Watt Switcher(No Input Filter) with 300 mA Load (Test 1/Test 2) | 140M | 0 / 0 | 7 / 5 |
| 50 Watt Switcher(No Input Filter) with 300 mA Load (Test 1/Test 2)<br>So We Lost 28M Due to this Switcher | 135M | 0 / 0 | 0 / 0 |

**Conclusion: 50 Watt Switcher has no effect without Power, Needs Filtering With Power On**

# Operational Characteristics, Results

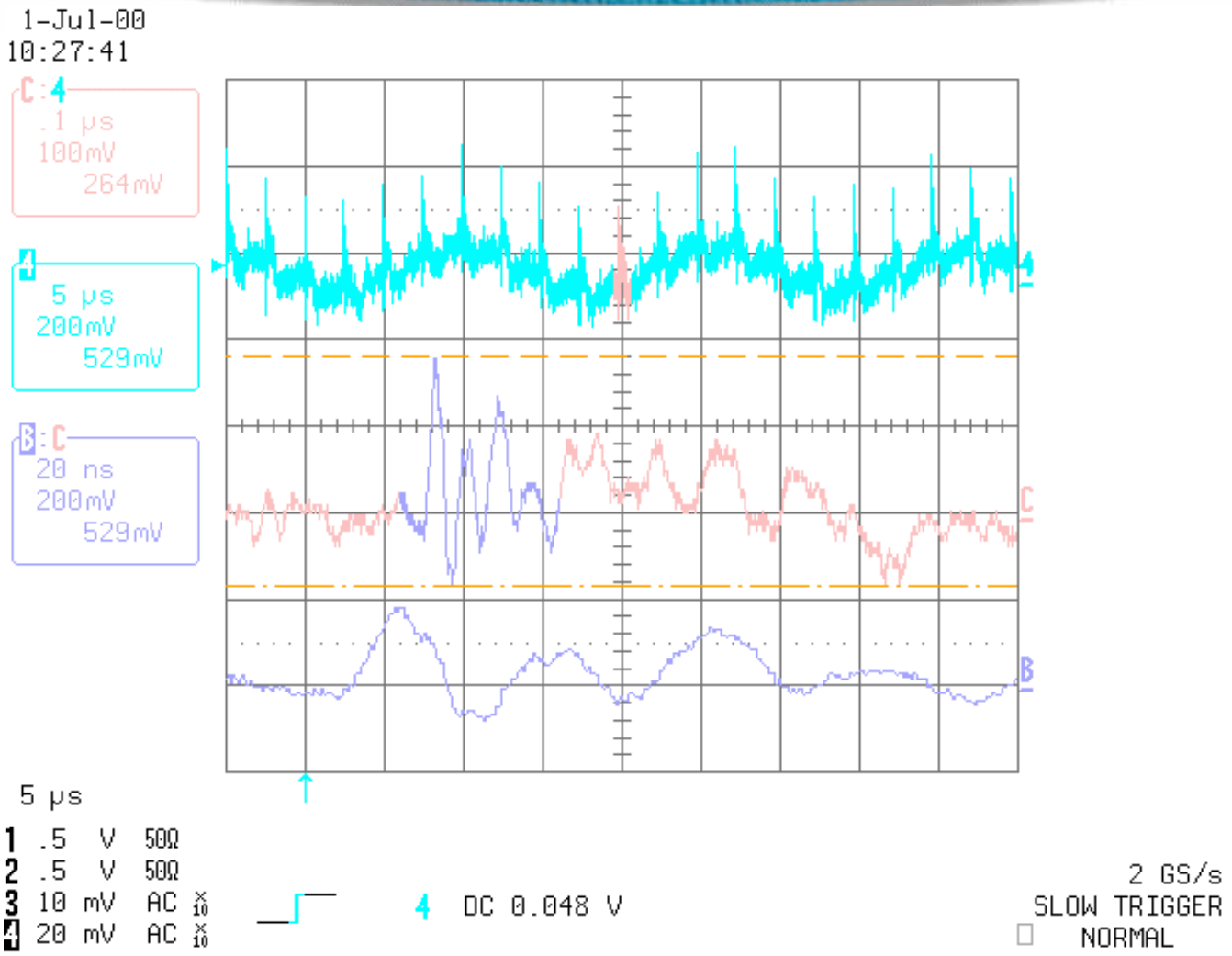
| Condition<br>Phy One, Mag One | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| No Power, No Load | 163M | 0 | 0 |
| Power Off, 50 Watt Switcher Load Connected(Test 1/Test 2) | 167M | 344 / 334 | 0 / 0 |
| 50 Watt Switcher(With Input Filter) with 300 mA Load (Test 1/Test 2/Test 3) | 167M | 100/100 /385 | 0 / 0 / 0 |
| 50 Watt Switcher (With Input Filter) with 300 mA Load (Test 1/Test 2/Test 3) | 163M | 0 / 0 / 0 | 0 / 0 / 0 |

**Conclusion: 50 Watt Switcher With Filtering To Pass FCC Causes No Operational Effects on BER at Long Cable Lengths (28 Meter Loss Restored)**

# Operational Characteristics, Results

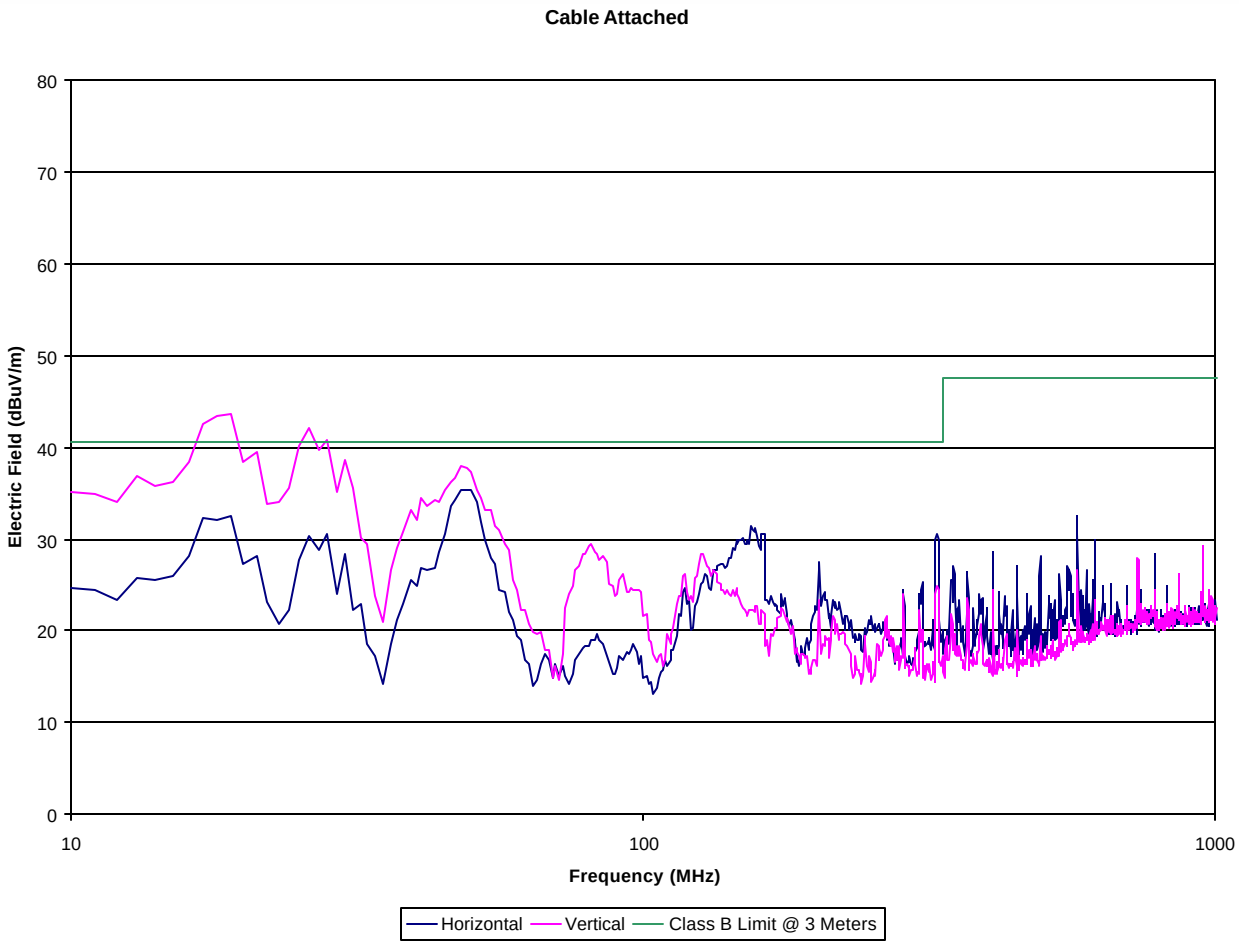
| Condition<br>PHY Two Magnetic Two | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| Power OFF, RL=110 ohms see schematic max cable reach=148m | 148M | 0/0/0 | 0/0/0 |
| Power ON 300 mA , RL=110 ohms | 148M | 1/0/0 | 0/0/2 |
| Power OFF, RL = 110ohms | 156M | 0/0/0 | 0/5/0 |
| Power OFF, RL = 110 ohms | 163M | 0/0/0 | **60/34/15** |
| Power OFF, 6 Watt DC/DC replaces RL Note that no Filter exist at the input of the DC/DC in all my testing unless I say. | 148M | 0/0/0 | 0/0/0 |
| Power ON 6 Watt DC/DC | 148M | 0/0/0 | 1/0/0 |
| Ran 100 Million packets Power OFF/ON | 148M | 0/0 | 0/2 |
| Power ON 6 Watt DC/DC- Rerun test | 163M | 0/0/0 | 32/34 |
| 10BT 5 Million Packets of CAT-3 | 128M | 0 | 0 |
| 10BT Ran 5 million packets CAT-5 | 148M | 0 | 0 |

# Signal Quality Measurements
# BER and Switching Noise




**6 Watt Switching Noise (Unfiltered) at Tx Center Tap**

# Signal Quality Measurements
# BER and Switching Noise




**6 Watt Switching Noise FCC Scan, Fails Class B, with Unchanged BER at Cable Length**

# Operational Characteristics, Results

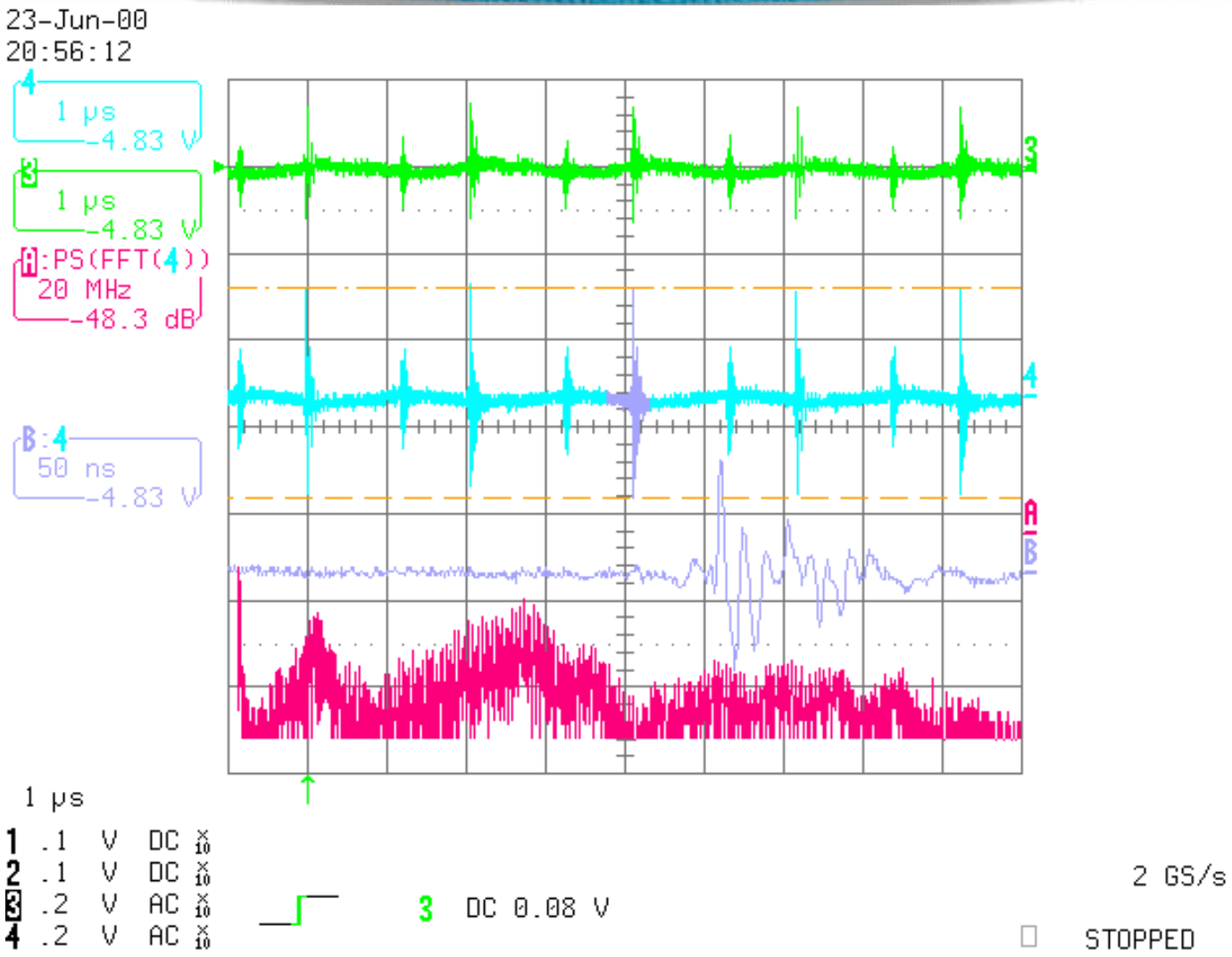
| Condition<br>Phy Two/Magnetic Two | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| No Power, No Load | 148M | 0 | 0 |
| Power Off, 50 Watt Switcher Load Connected(Test 1/Test 2= a repeat) | 148M | 0 / 0 | 0 / 0 |
| 50 Watt Switcher(No Input Filter) with 300 mA Load (Test 1/Test 2/test3) | 148M | 0/0/0 | **136/29/40** |
| 50 Watt Switcher(No Input Filter) with 200 mA Load (Test 1/Test 2) | 148M | 2/0 | **3423/3245** |
| 50 Watt Switcher(No Input Filter) with 200 mA Load (Test 1/Test 2) | 124M | 11/2 | 0/0 |
| 50 Watt Switcher(No Input Filter) with 200 mA Load (Test 1/Test 2 /Test 3) | 103M | 0/00 | 1/0/0 |
| 50 Watt Switcher(No Input Filter) with 200 mA Load (Test 1/Test 2 /Test 3) | 100M | 1/0/0 | 0/0/0 |
| 50 Watt Switcher(No Input Filter) with 200 mA Load (Test 1/Test 2)<br>Decided to Stick with Wcase Noise 200ma load here- we lost a good 48M | 92M | 0 / 0 | 0 / 0 |

# Operational Characteristics, Results

| Condition<br>Phy Two, Mag Two | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| No Power, No Load | 148M | 0 | 0 |
| Power Off, 50 Watt Switcher Load Connected(Test 1/Test 2) | 148M | 0/0 | 0 / 0 |
| 50 Watt Switcher(With Input Filter on one center tap) with 200 mA Load (Test 1/Test 2) Stuck to 200mA- Wcast noise! | 148M | 202/172 | 0 / 0 |
| 50 Watt Switcher (With Input Filter on Both Center taps) with 200 mA Load (Test 1/Test 2) | 148M | 0 / 0 / 0 | 0/0/1 |
| 100 Million Packets at 200ma w/ Filter on both Center taps next to DC/DC | 148M | 0 | 0 |
| 100 Million Packets at 300ma w/ Filter on both Center taps next to DC/DC | 148M | 0 | 1 |

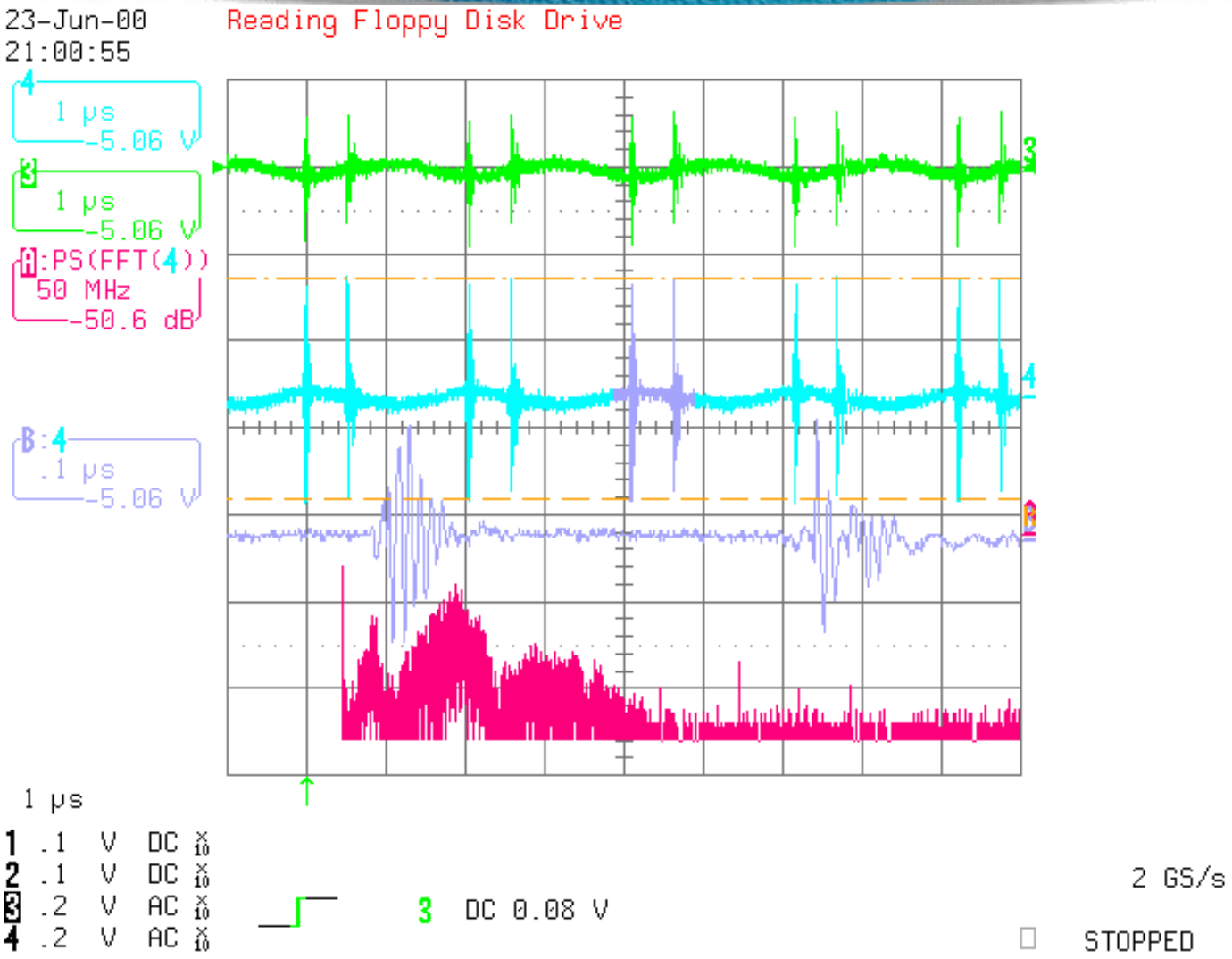
**Conclusion: A Filter on the Switcher Input Restores Link Integrity**

# 50 W Switching Noise, Reference



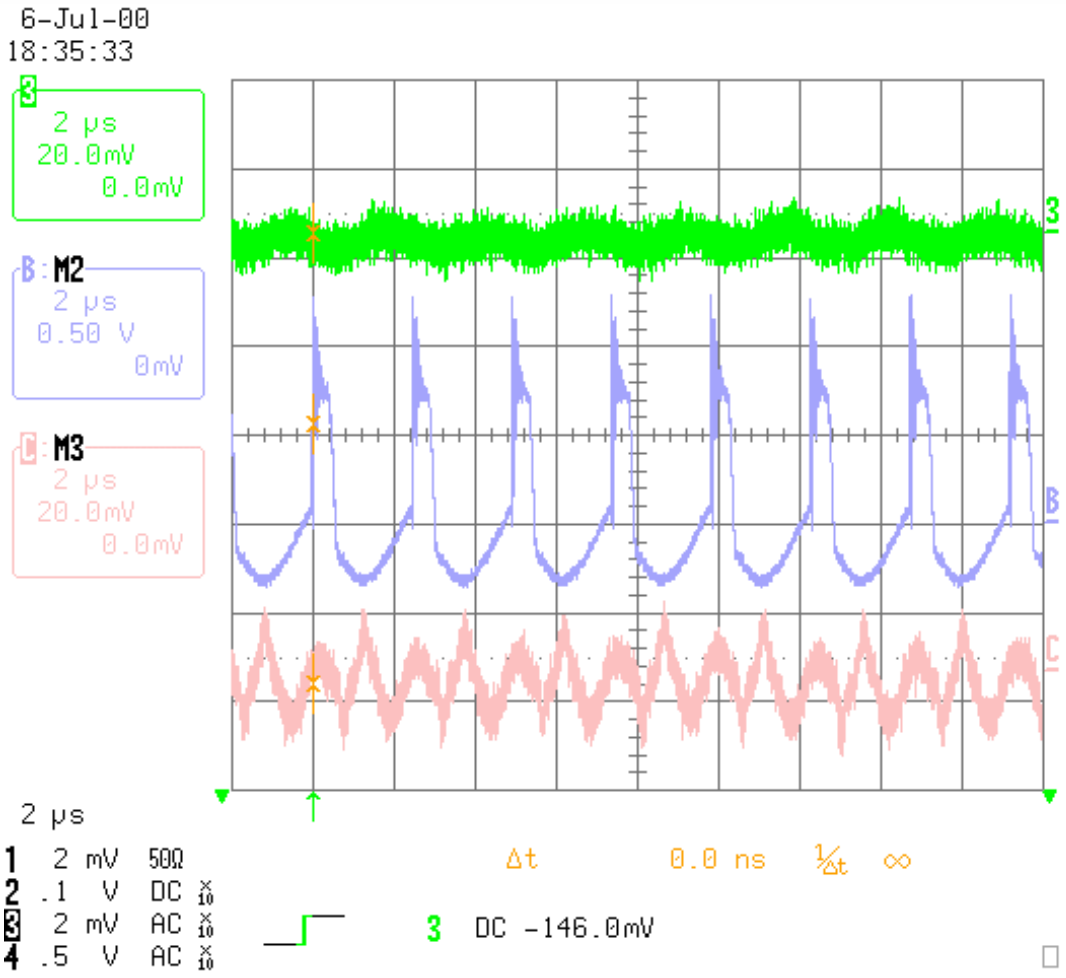

**50 Watt Switching Noise (Unfiltered) at 300 mA**

# 50 W Switching Noise, Reference




**50 Watt Switching Noise (Unfiltered) at 200 mA (There's More Noise)**

# Switching Noise: What's DC?



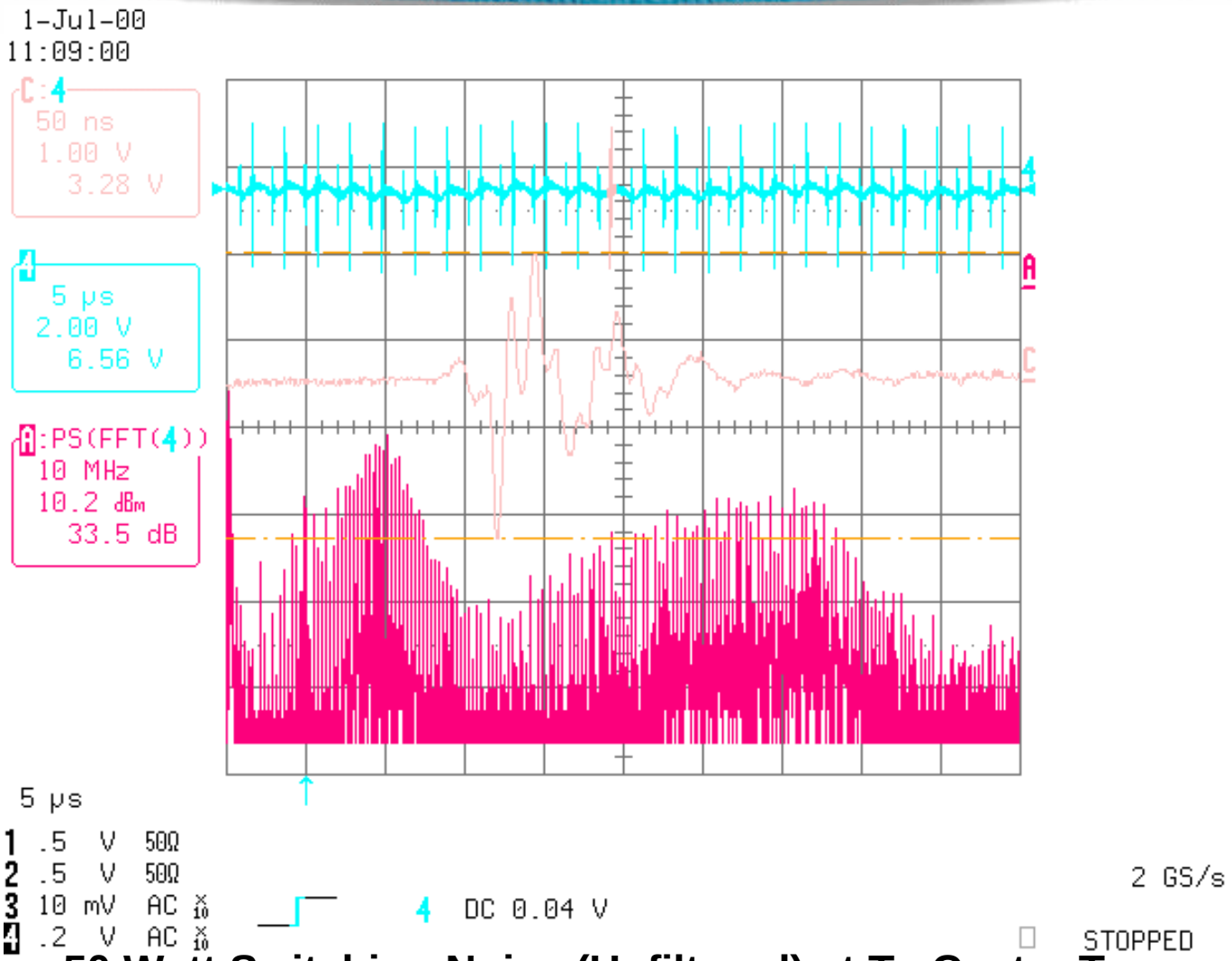

**Green: Choke, Cap, Ferrite Cap**

**Blue: Unfiltered**

**Red: Choke, Cap**

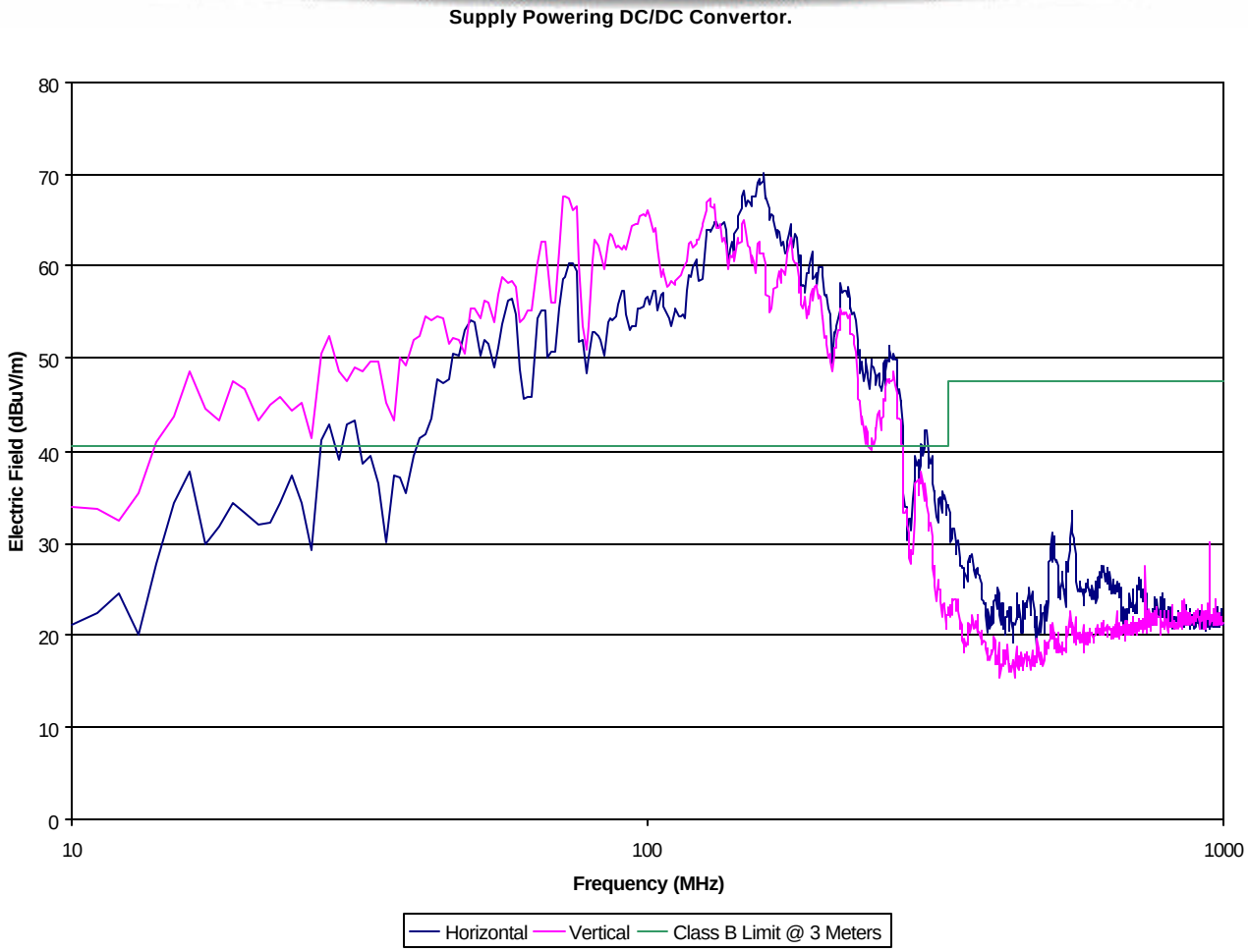
**Switching Power Supply Noise. Red is the likely best case**

# Signal Quality Measurements
# BER and Switching Noise



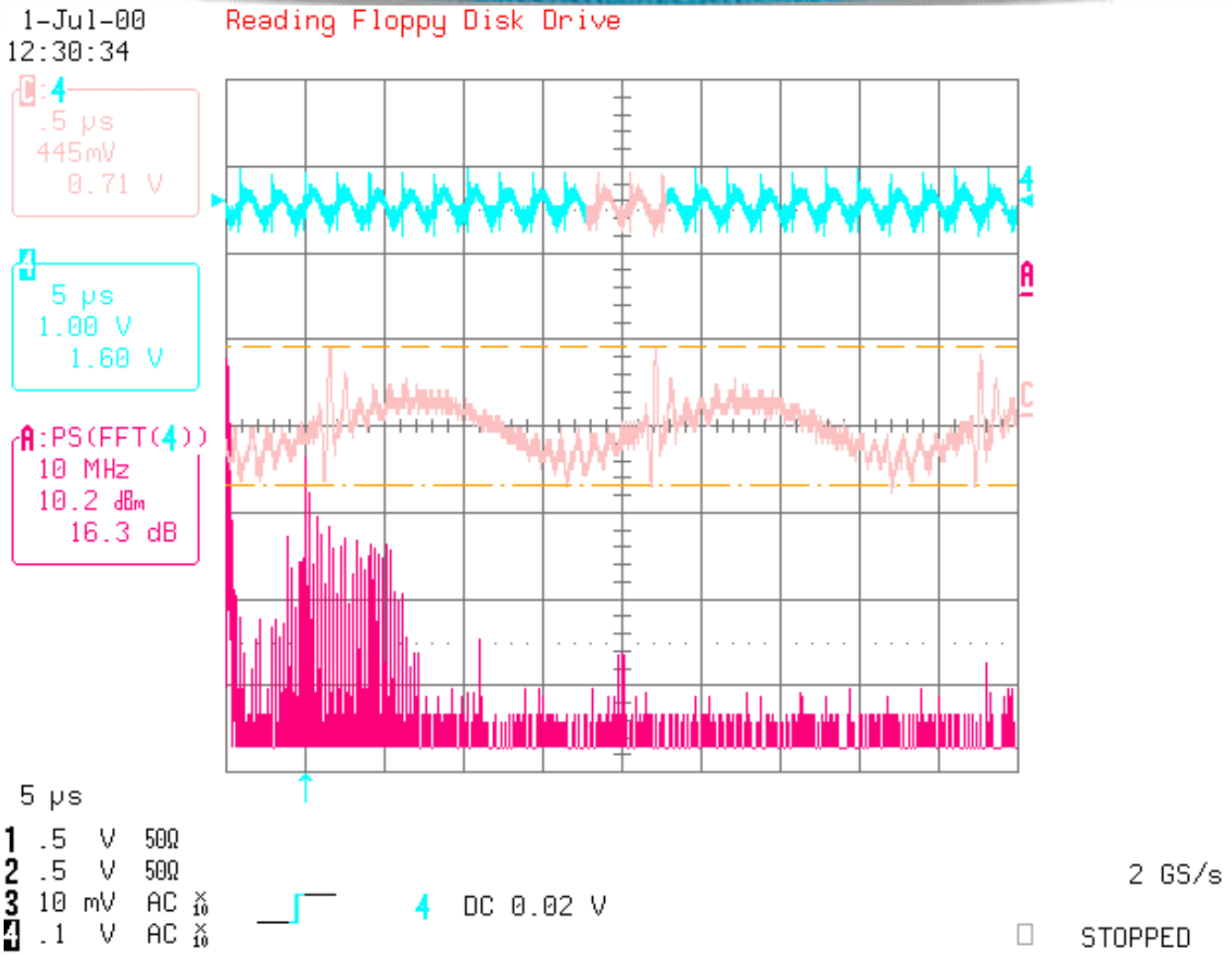

**50 Watt Switching Noise (Unfiltered) at Tx Center Tap**

# Signal Quality Measurements BER and Switching Noise



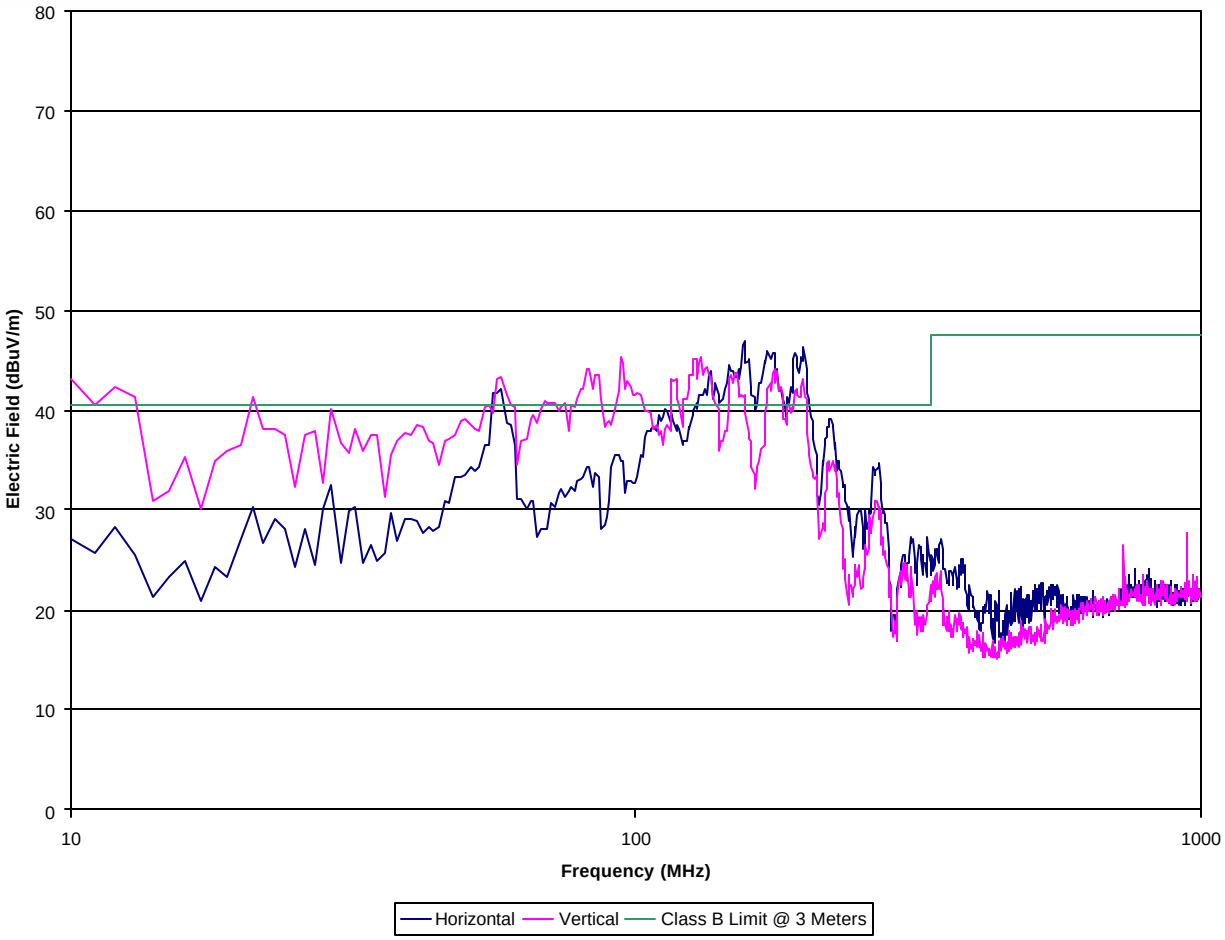

**50 Watt Switching Noise FCC Scan, Fails Class B, with No Input Filter, Affects BER, Reduces Cable Length**

# Signal Quality Measurements
# BER and Switching Noise




**50 Watt Switching Noise (Filtered) at Tx Center Tap**

# Signal Quality Measurements
# BER and Switching Noise

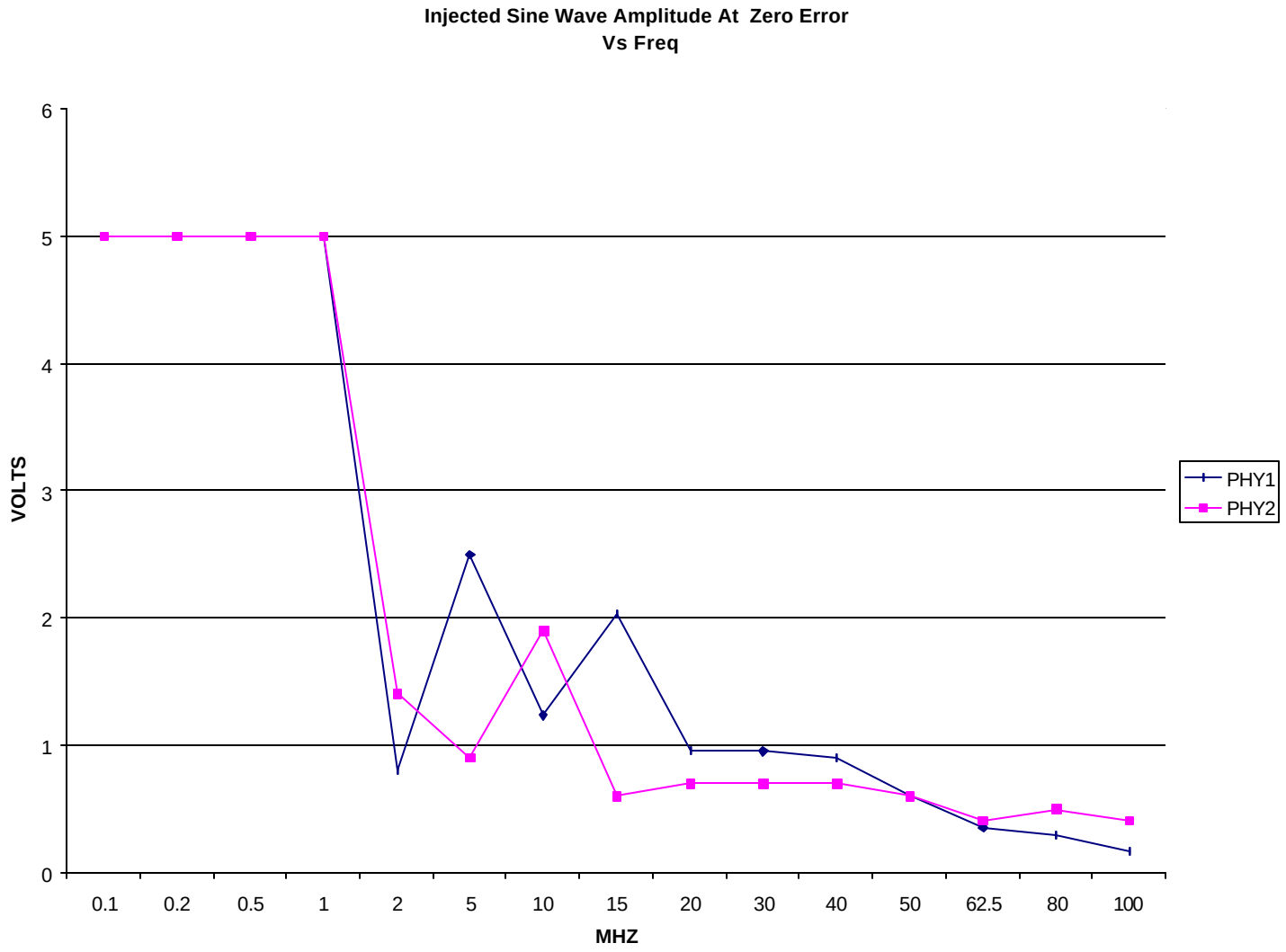



**50 Watt Switching Noise FCC Scan, Fails Class B, with Input Filter, Restore BER Performance at Maximum Cable Length**

# Signal Quality Measurements BER and Switching Noise

- Controlled Noise Injection Study
- Characterize the Frequency Envelope For Common Mode Noise Immunity

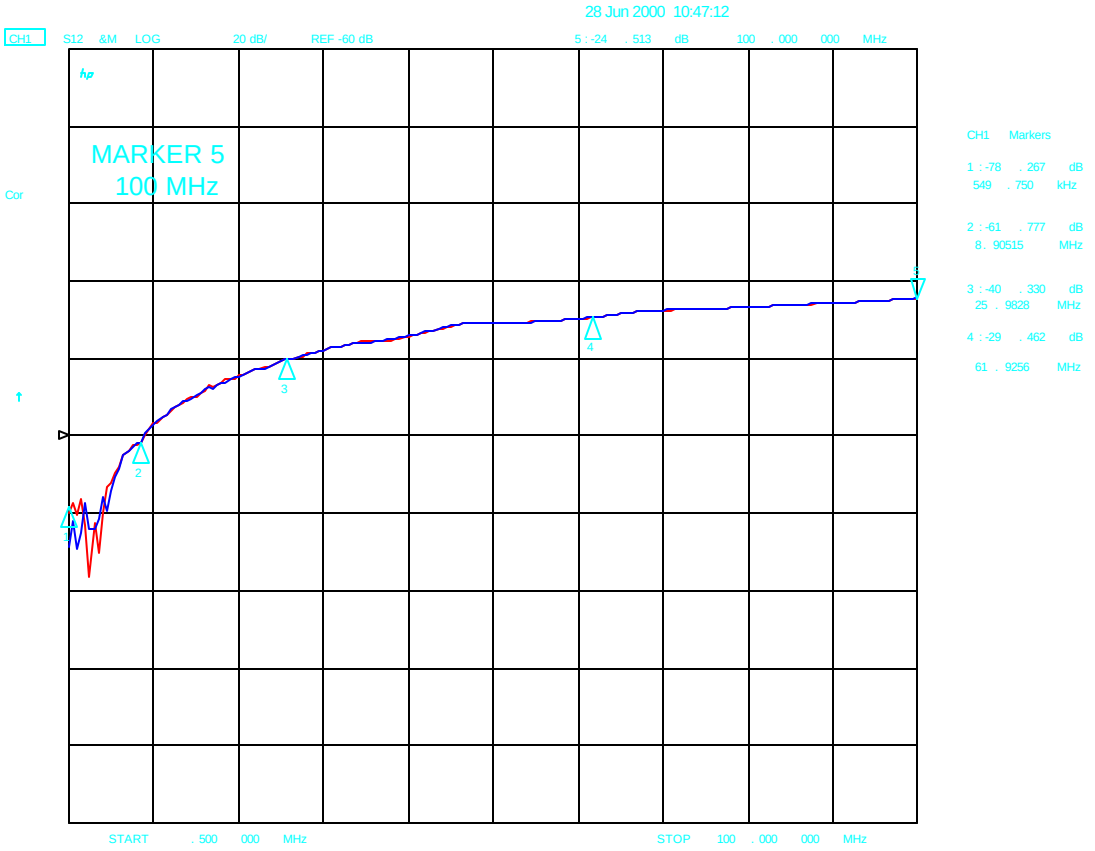
# Signal Quality Measurements
# BER and Switching Noise



# Signal Quality Measurements BER and Switching Noise

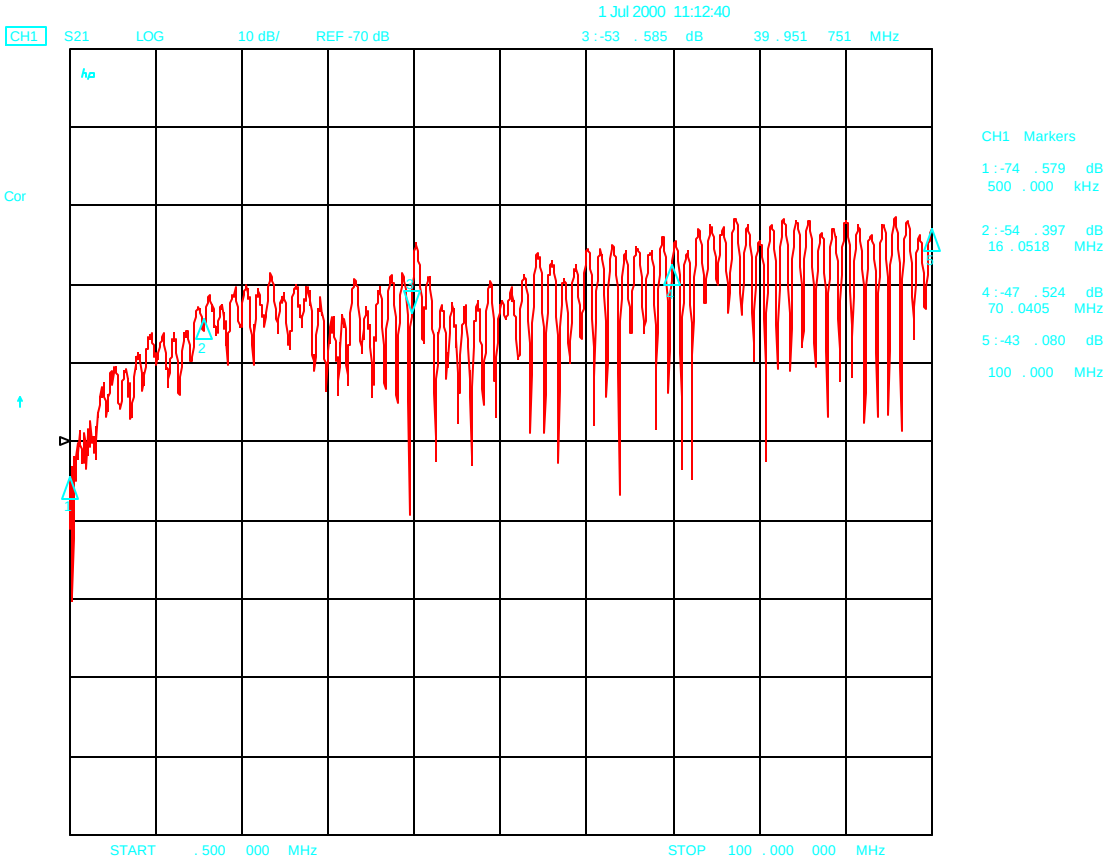
- **Conclusion: With Switching Power Supply Noise on the center tap of the used pairs, the system is EMI limited, not BER or cable reach limited.**
- **Same EMI limitations with power over unused pairs (next slide)**

# Signal Quality Measurements Magnetics



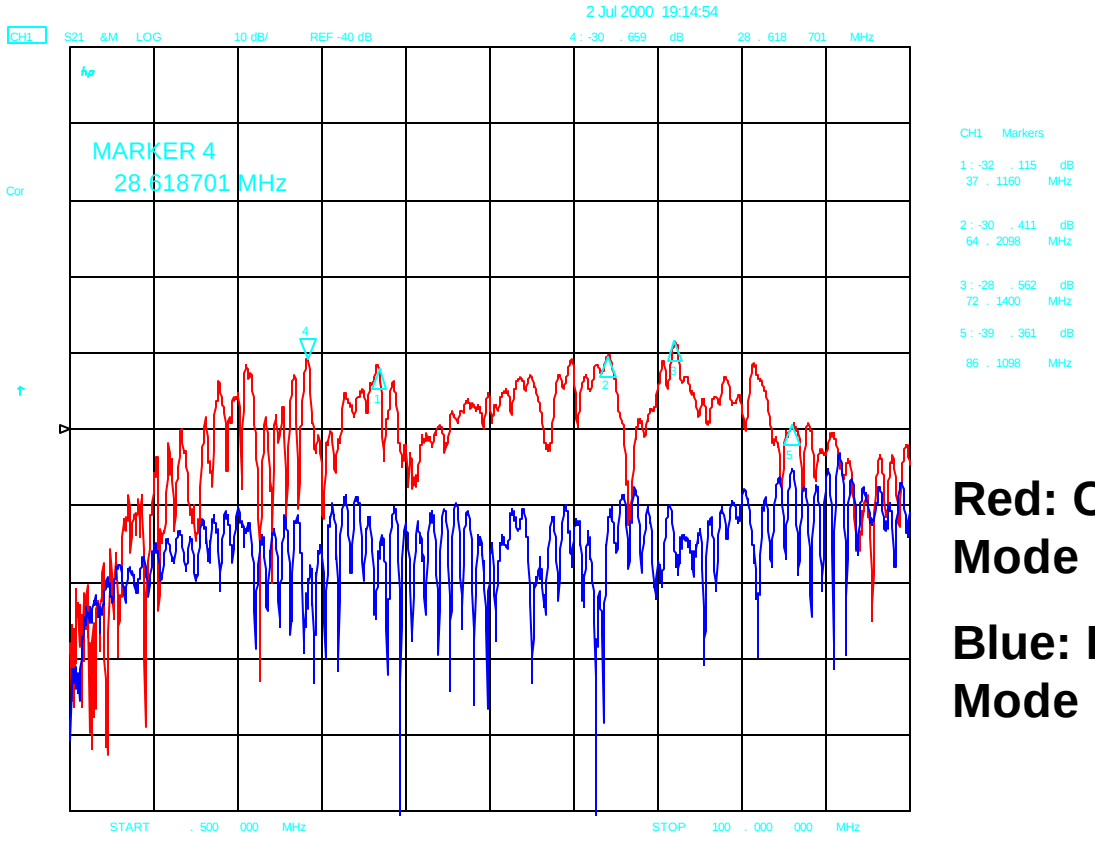

**Common Mode to Differential Conversion, Drove Supply Side, Measure at PHY on the RL Side, I = 0, I = 300 mA**

# BER and Switching Noise Effects on the "Unused" Pairs




Isolation of Differential Pairs

# BER and Switching Noise Effects on the "Unused" Pairs




**Red: Common Mode**

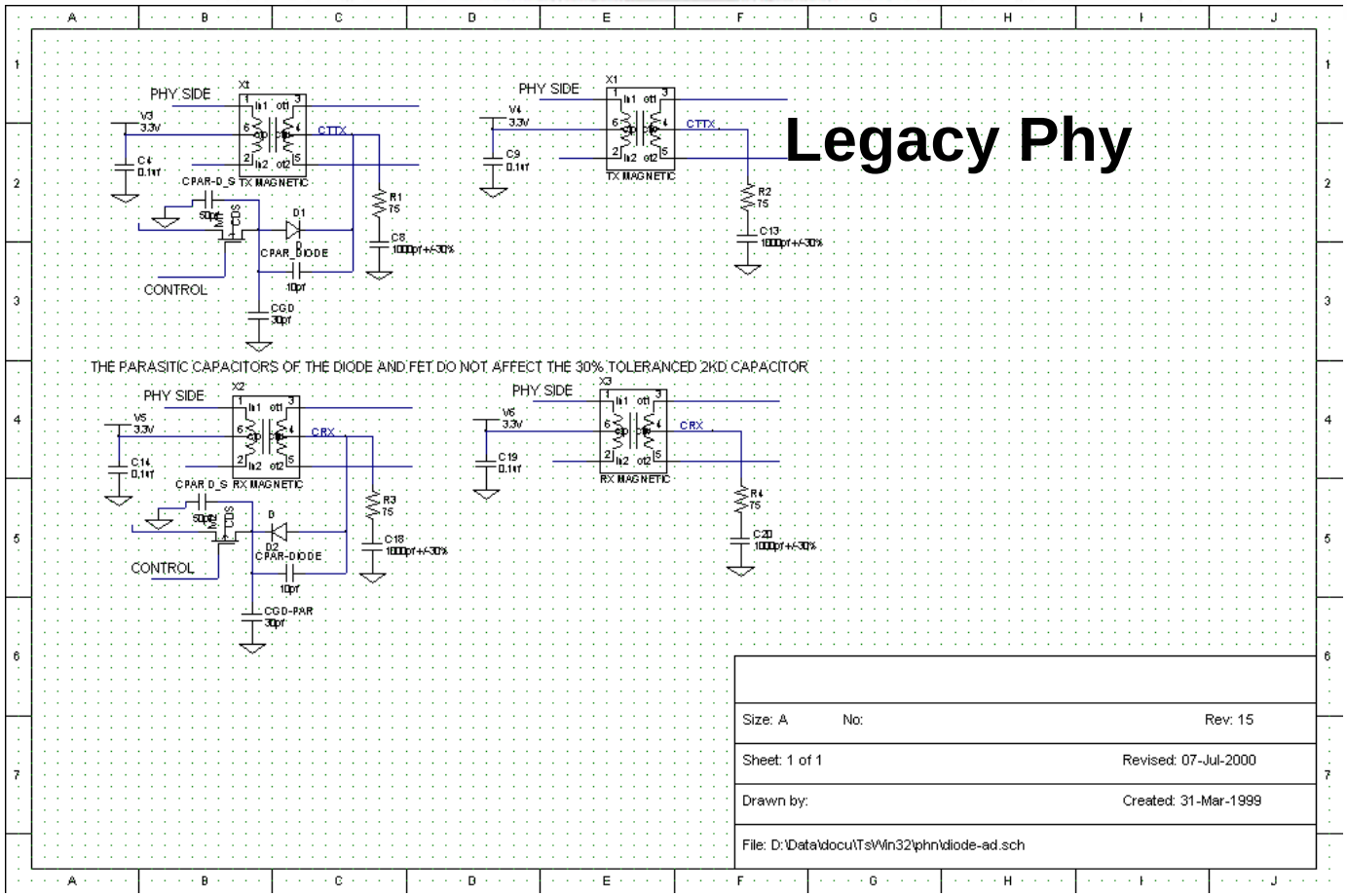
**Blue: Differential Mode**

**Isolation of Differential vs Common Mode Signals on the "Unused Pair"**

# BER and Switching Noise Effects on the "Unused" Pairs

| Condition<br>Phy Two/Magnetic Two, 50 W DC/DC | Cable Length | Errors, Source | Errors, Load |
|---|---|---|---|
| No Power to DC/DC on the Unused Pairs on This Slide. | 148M | 0 | 0 |
| Power Off, 50 Watt Switcher Load Connected(Test 1/Test 2) | 148M | 0 / 0 | 0 / 0 |
| 50 Watt Switcher(With No Input Filter) with 300 mA Load (Test 1/Test 2) Stuck to 300mA- NOT Wcast noise that was at 200ma… | 148M | 12861/ 13920 | 136/29/40 |
| 50 Watt Switcher(With No Input Filter) with 300 mA Load (Test 1/Test 2/Test 3) | 124M | 3/19/7 | 0/0/0 |
| 50 Watt Switcher(With No Input Filter) with 300 mA Load (Test 1/Test 2/Test 3) | 100M | 5/0/0 | 0/0/0 |
| Go Back to 200ma and 148M All Hell Broke Loose, So much for the "Unused Pairs" | 148M | 0/0 | 842186/ 852436 |

# Operation of Legacy PHYs: Analysis(No Power Applied)




**Conclusion: Power over Signal Pairs does not impact link operation and hence legacy PHYs.**

# Power over the Signal Pair

- **Technically Feasible**