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Working Group: PLL

Title: 100G Components

Source: Inphi Corporation

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Abstract: A Discussion of Driver Technologies

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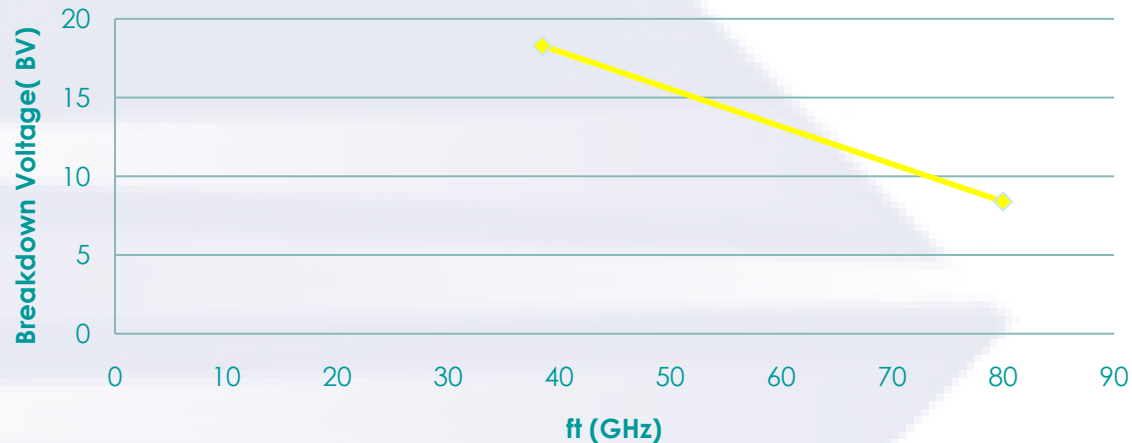
Key Considerations for 100G DP-QPSK Tx

- **Reliability, performance, and cost are key factors for 100G success**
- **Differential drivers in SMT package offer good reliability, excellent performance, and the lowest cost**
 - **Reliability: differential drivers have lower voltage drive per arm compared to single-ended drivers; single-ended drivers operate close to breakdown**
 - **Performance: differential drivers have best noise immunity**
 - **Cost: SMT packages and CPW routing provide compact, low cost solution**

Differential vs. Single Ended Drivers

	Single Ended	Differential	Comments
Reliability	Large voltage developed across transistors	$\frac{1}{2}$ voltage developed across transistors relative to single ended	Differential is farther from device breakdown
Signal Integrity	Single-ended topology has poor noise immunity	Excellent noise and common mode rejection at input, output, and on supply and ground	Differential has better AC performance
Power Dissipation	Single-ended and differential drivers have comparable power dissipation		

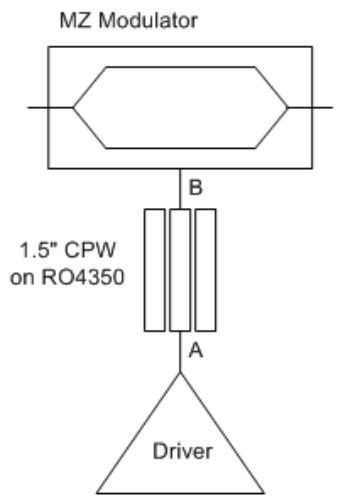
GaAs pHEMT Breakdown Voltage (DS) vs. Cutoff Frequency



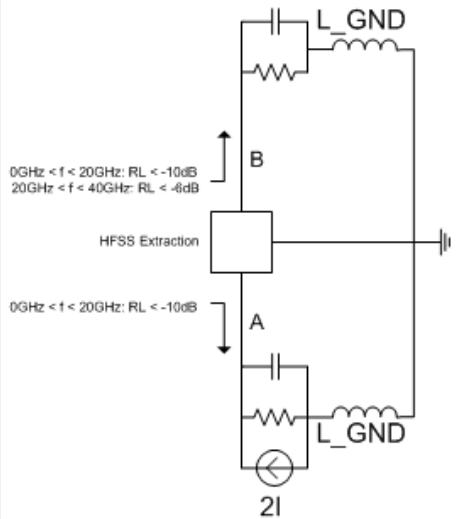
- Driver amplifiers typically use GaAs pHEMT technologies
- GaAs pHEMT technologies typically have breakdown voltage (BV) ~9V for $f_t > 75\text{GHz}$
 - Difficult to directly compare f_t and BV of different foundries since there is no single standard how to measure and report these figures of merits
 - The trend of reduced BV with shorter gatelength and higher speed, however, is universal for all GaAs PHEMT processes
- Drivers are required to provide $> 8\text{Vpp}$
- Single-ended drivers operate closer to breakdown than differential drivers, raising long term reliability concerns

Signal Integrity

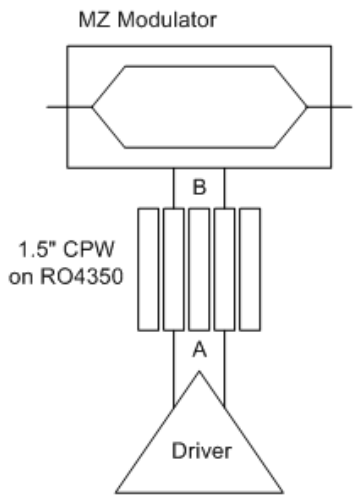
Single-Ended TX



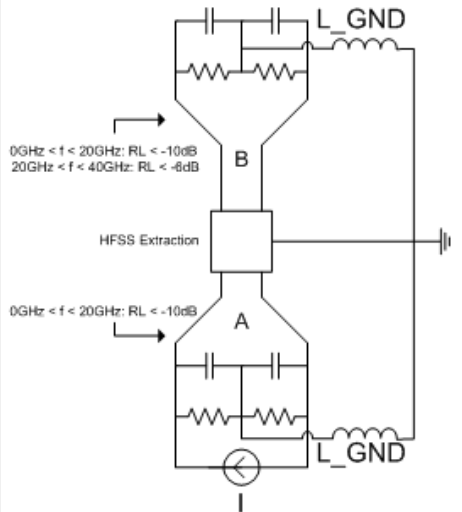
Single-Ended TX Model



Differential TX



Differential TX Model



- Simulations compare signal integrity for single-ended and differential drivers

- Assumptions:

- 28Gbps, NRZ signaling
- SMT type drivers
- Signals routed over 1.5" of CPW on RO4350

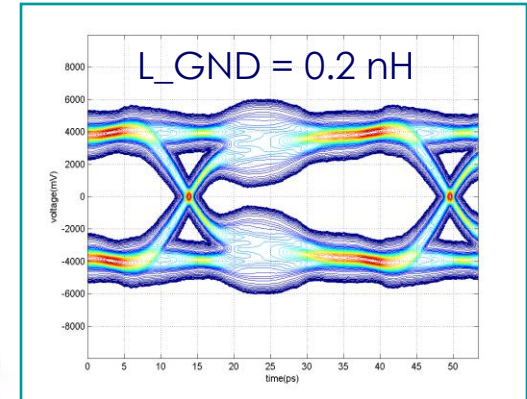
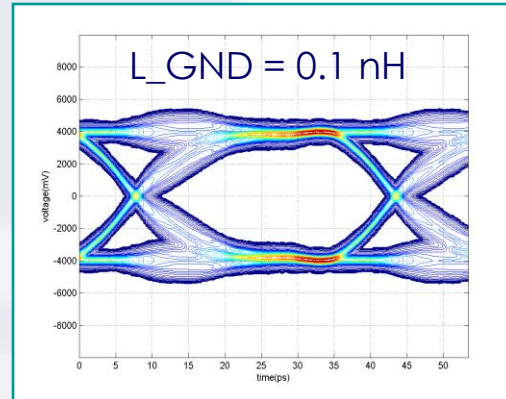
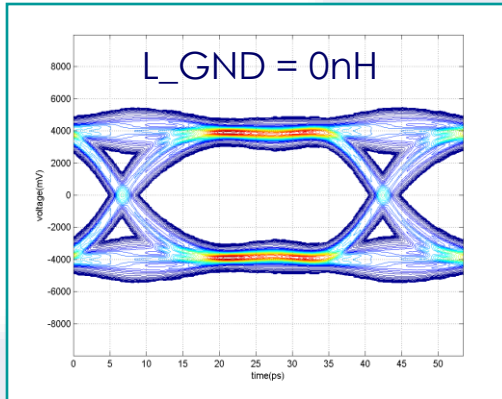
- Simulation measurements made at point B, the electrical modulator input

- Simulations compare:

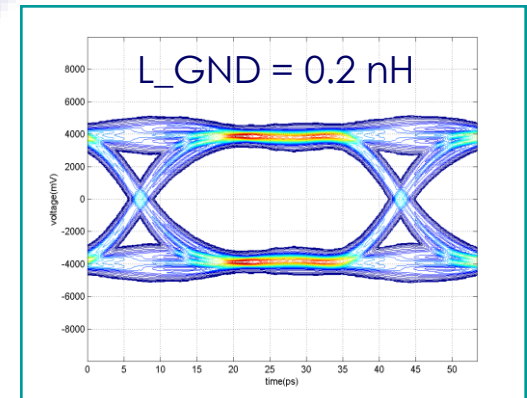
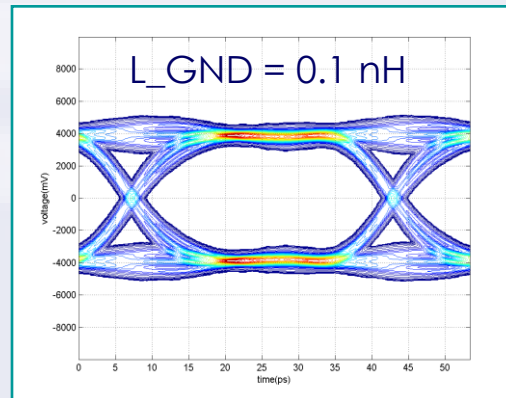
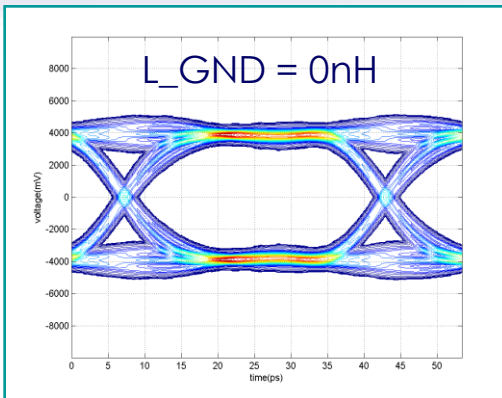
- Effects of L_GND
- Effects of asymmetric rise/fall

Signal Integrity

Single-Ended



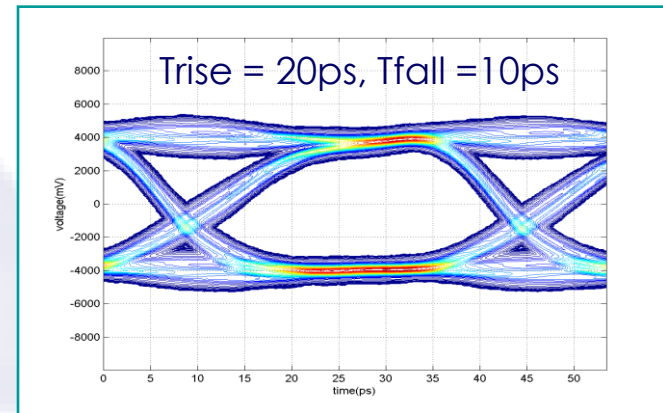
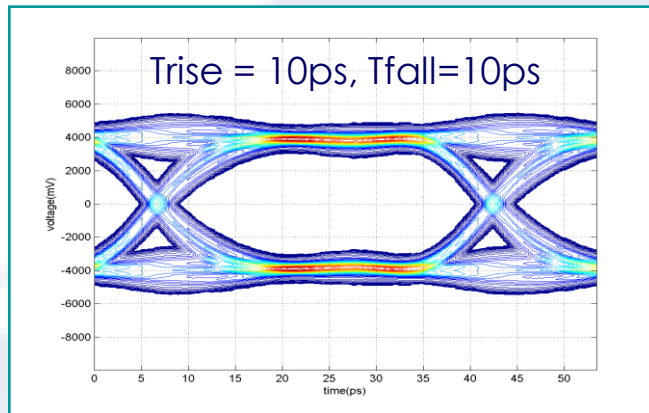
Differential



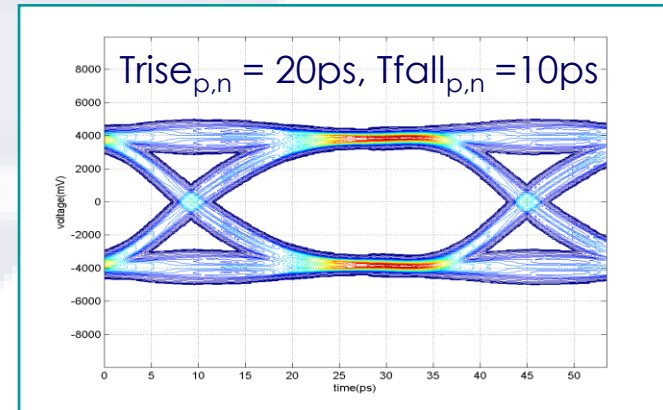
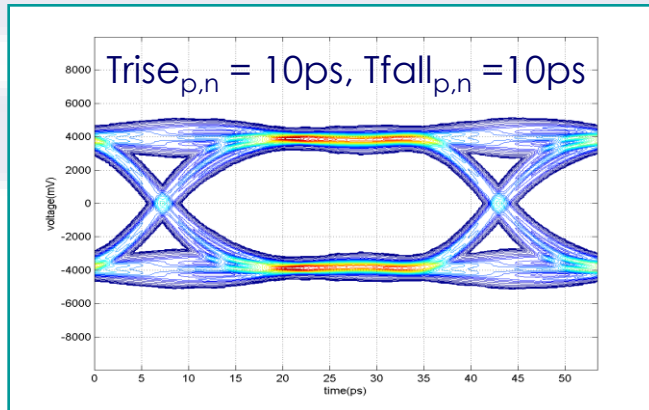
Single-ended drivers are more sensitive to return path parasitics

Signal Integrity

Single-Ended



Differential



Single-ended drivers are more sensitive to asymmetric rise/fall times

Power Dissipation

Supplier	A	B	C	D	Unit
SE or Diff?	Diff	Diff	SE	SE	-
Power Dissipation	0.9 ¹	1.3	1.3	1.1	W
Modulator Type	EA	MZ	MZ	MZ	-
Data Rate	11.3	10.7	11.3	12.5	Gbps
Output Amplitude	6	6	6	6	Vpp
SE Input Amplitude	0.4-1.2	0.1-1	0.4-1	0.5	Vpp
Rise/Fall Time	27	23	<40	25	ps
PP Jitter	11	8	-	-	ps
RMS Jitter	-	0.3	-	0.9	ps
Input Return Loss	12	15 ³	13	15	dB
Output Return Loss	-	10 ³	13	15	dB
Supply Voltage	3.3/5	-5.2	-5.2/5	5	V
Bias-T?	Yes ²	No	Yes	Yes	-
Packaging	SMT	SMT	SMT	SMT	-

1 - 0.9W w/50ohm backtermination, 0.65W w/o 50ohm backtermination

2 - Bias-T optional, power specified with Bias-T

3 - Differential S-parameters

Single-ended drivers are not necessarily lower power than differential drivers

Driver Packaging Evolution

Present:

- Metal package
- GPPO connector
- Large size

Future:

- SMT package
- CPW routing
- Small size

Time



	Single Ended	Differential	Comments
Packaging	SMT is available at 10G and is being developed for 100G DP-QPSK	Differential moving toward SMT and will be available in time for 100G DP-QPSK	SMT is lowest cost, most compact solution
CPW routing	Difficult to run single-ended high speed traces on board: higher loss, worse noise sensitivity	Best for high speed traces on PC board at >20 Gbps	30Gbps differential operation on Roger boards has been proven

Recommendation

- **For best reliability, highest performance, and lowest cost, differential drivers in SMT package are recommended**
- **Recommend that OIF Implementation Agreement select fully differential Tx architecture as primary solution**