Quadra Solutions Limited

People. Knowledge. Innovation.

Why Should I Care About Power Integrity?

D&E 2015

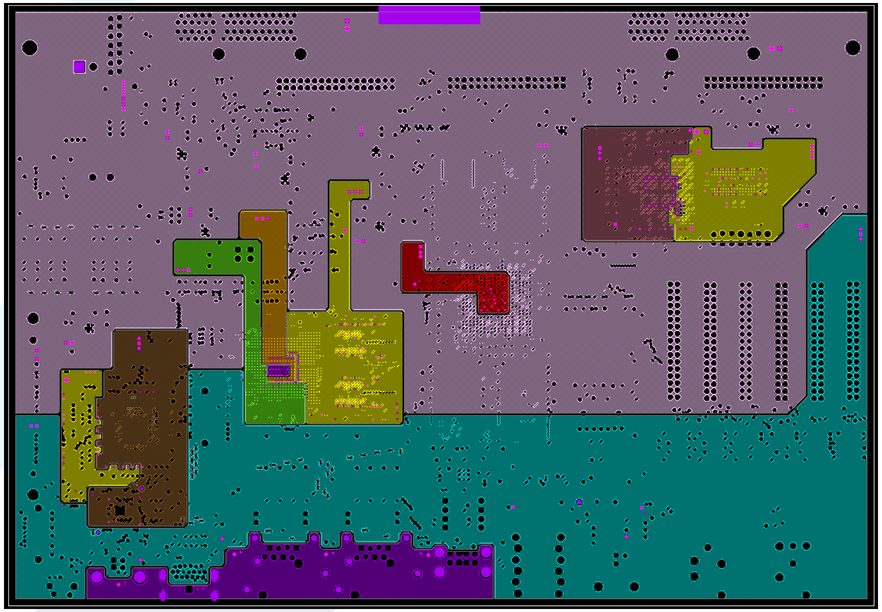
Presenter: Bob Sadowski

Applications Consultant

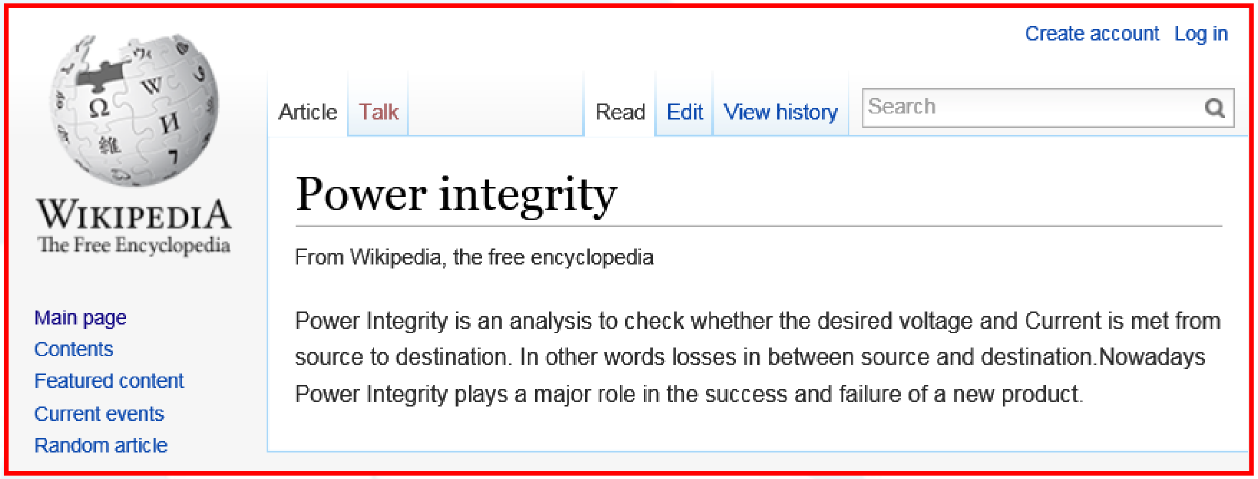
quadra solutions

Power Integrity

> What Is Power Integrity?
> Why Should I Care?
> When Should I Be Concerned?
> What Can I Do About It?



What Is Power Integrity?



- Power Integrity provides a measure of the **quality** of the power distribution network
  - Minimise the DC voltage drop across power planes
  - Minimise the propagation of IC switching currents by optimising decoupling capacitance
  - .. and thereby reduce EMC emissions

Image courtesy of Wikipedia

Why Should I Care?

> Technology trends

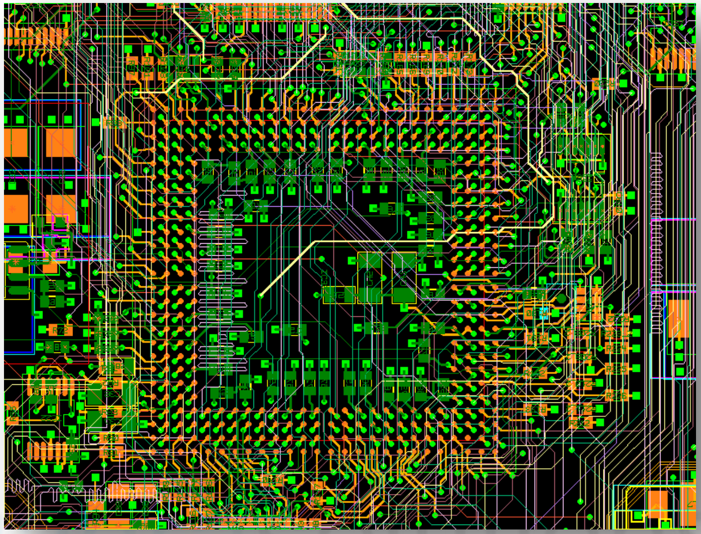
THE DIFFERENCES BETWEEN SIGNAL INTEGRITY AND POWER INTEGRITY		
	Signal integrity	Power integrity
Became mainstream	~20 years ago	~5 years ago
Analysis based on	Transmission lines	Transmission planes
Typical impedance targets	~50 Ω	~mΩ
Subsets of analysis	Signal quality Timing Crosstalk	dc drop Decoupling Noise
Models needed	IBIS, Spice	Capacitors with parasitics
PCB design changes driven	Trace width Trace length Trace spacing	Amount of metal to carry current Number, value, mounting of caps Power/ground plane pairs, stackup

Image courtesy of ElectronicsDesign.com / MGC

A Real-World Example

A Xilinx FPGA with 456 pins:

- Controls a video grabber card
- 64 bits can switch in parallel
  - worst case, rise time of 750ps
- Output pin drives into a load of 15pf



The maximum switching current can be determined by:

$$\Delta I = n * C * \frac{Vcc}{t} = 64 * 15pf \frac{2.5V}{0.75ns} = 3.2A$$

Based on this maximum current, the impedance limit to guarantee a ripple of less than 125 mV (5% of 2.5 V) :

$$Z = \frac{U}{I} = \frac{125mV}{3.2A} = 0.039\Omega$$

Should I be Concerned?

- If you need high performance or reliability
  - High utilisation
  - Thermal stability
- If you are using leading edge controllers …
  - CPU, FPGA, DSP
    - Low voltage
    - High power
    - Fast edge rates
    - Low noise margins
    - **Requiring multiple power distribution networks**
- Yes!

quadrasolutions

quadra solutions

ZUKEN CADSTAR Distributor

An Example .....

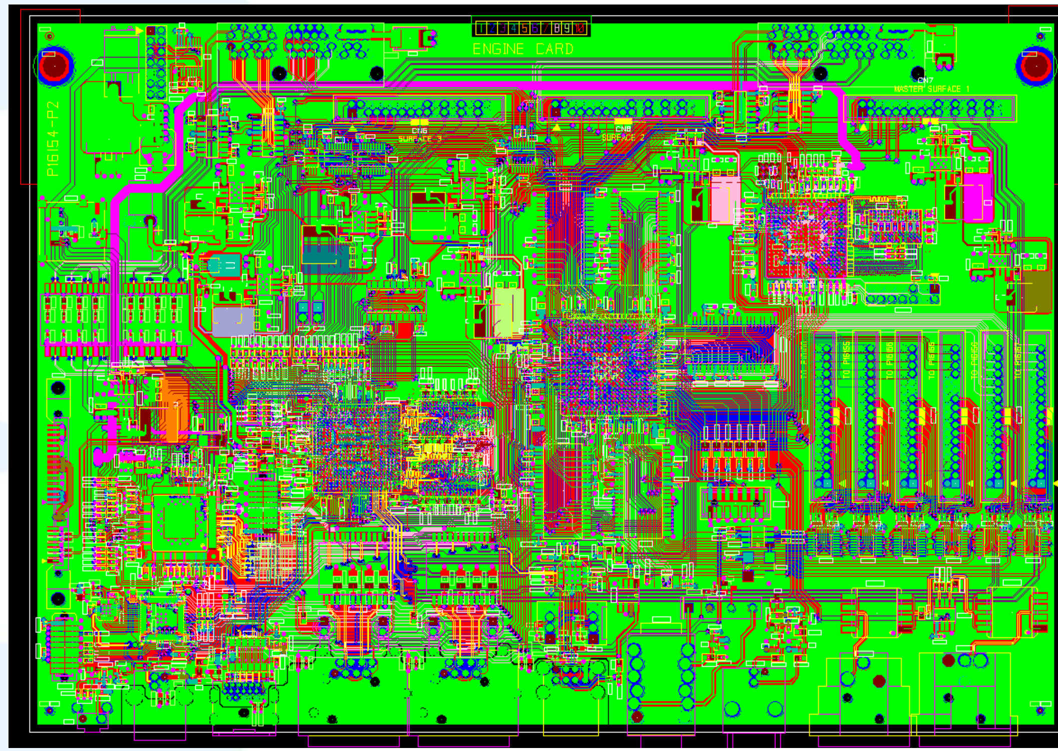
- 1 or 2 failures (hang-ups, black screen) per month
- Shutdown and reboot required

What are Typical PI Symptoms?

- Physical
  - CPU/FPGA/memory device failure
  - PCB Vias or Tracks go open circuit (fuses!)
  - Blistering, delamination or discolouration of PCB
  - …
- Electronic
  - CPU reset on high utilisation
  - Memory fails or data corruption
  - Analog circuits go out of spec.
  - …

What Can I Do About It?

- Simulate your PCB Design!
  - Run Power Integrity Analysis on the virtual layout before manufacture and assembly of an expensive prototype



quadra solutions

ZUKEN
CADSTAR Distributor

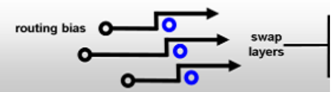
What Data is Required?

- Fully Defined Layer Stack
  - Electrical
  - Construction
  - Materials
- Classified Power nets
  - Reference voltages
  - Series interconnects
    - Resistor
    - Inductor
    - FET
- Part data
  - Values
  - IBIS models (useful)
  - Pin types
  - Power requirements
- Net data
  - Type
    - Bus, Data, Analog, etc
  - Target frequency

Layer Stack & Power Nets

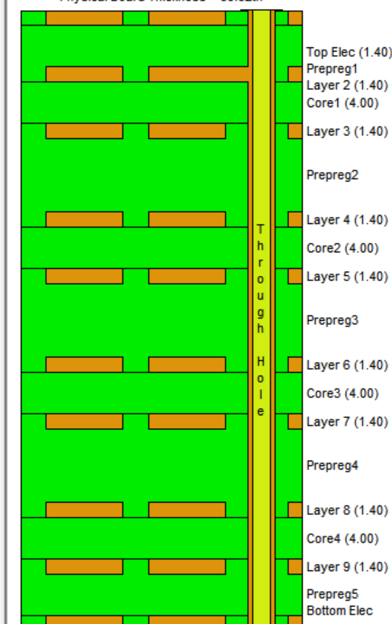
Layers

Layers



	Name	Type	Physical Layer	Thickness (Thou)	Material	Embedding	Reference Plane	Sub Type
	Top Resist Construction	Construction		0.01	Resist	None	☐	(None)
	Top Elec	Electrical	1	1.40	Copper Foil	Above	☐	(None)
	Prepreg1	Construction		4.00	Prepreg	None	☐	(None)
	Layer 2	Electrical	2	1.40	Copper Foil	Above	☑	(None)
	Core1	Construction		4.00	FR4	None	☐	(None)
	Layer 3	Electrical	3	1.40	Copper Foil	Below	☐	(None)
	Prepreg2	Construction		7.10	Prepreg	None	☐	(None)
	Layer 4	Electrical	4	1.40	Copper Foil	Above	☐	(None)
	Core2	Construction		4.00	FR4	None	☐	(None)
	Layer 5	Electrical	5	1.40	Copper Foil	Below	☑	(None)
	Prepreg3	Construction		7.10	Prepreg	None	☐	(None)
	Layer 6	Electrical	6	1.40	Copper Foil	Above	☑	(None)
	Core3	Construction		4.00	FR4	None	☐	(None)
	Layer 7	Electrical	7	1.40	Copper Foil	Below	☐	(None)
	Prepreg4	Construction		7.10	Prepreg	None	☐	(None)
	Layer 8	Electrical	8	1.40	Copper Foil	Above	☐	(None)
	Core4	Construction		4.00	FR4	None	☐	(None)
	Layer 9	Electrical	9	1.40	Copper Foil	Below	☑	(None)
	Prepreg5	Construction		4.00	Prepreg	None	☐	(None)
	Bottom Elec	Electrical	10	1.40	Copper Foil	Below	☐	(None)
	Bottom Resist Constructio	Construction		0.01	Resist	None	☐	(None)

Physical Board Thickness = 59.32th



Blind Via: Unavailable

Buried Via: Unavailable — Copy

☑ All Layer Pairs ☑ Fit to Window

Power Nets
- +1.2V
- +1.35V
- +1.8V
- +1.8V_1
- +1.8VA
- +1V0
- +1V05
- +2.5V
- +3.3V
- +3.3V_SUPPLY
- +5V
- +12V
- CHASSIS
- DDR3_VCC
- DDR3_VREF
- GND
- RAW_1V0
- RAW_1V2
- RAW_1V05
- RAW_1V8
- RAW_1V35
- RAW_2V5
- RAW_3V3
- RAW_5V
- RAW_DDR3_1V5
- USB_5V
- VDDARM_CAP
- VDDHIGH_CAP
- VDDPU_CAP
- VDDSOC_CAP
- VDDUSB_CAP

quadra solutions

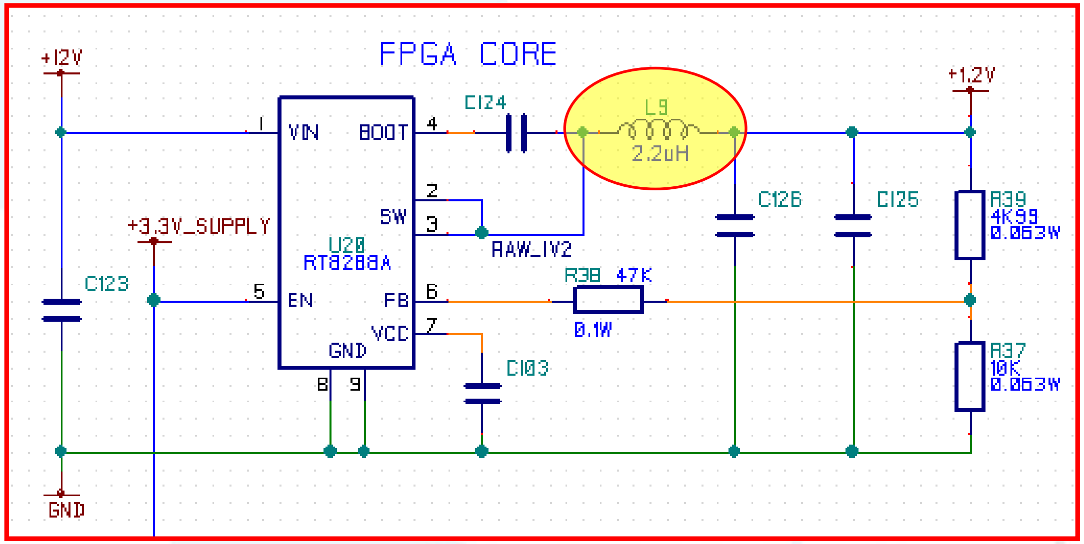
ZUKEN CADSTAR Distributor

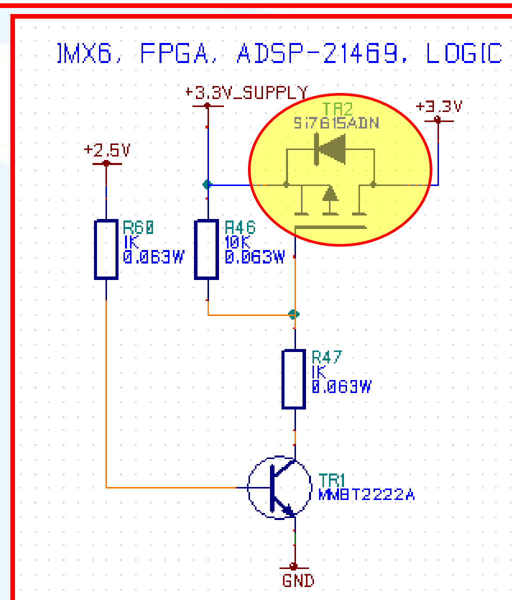
Power Interconnects

> Direct

> Filtered

> Switched



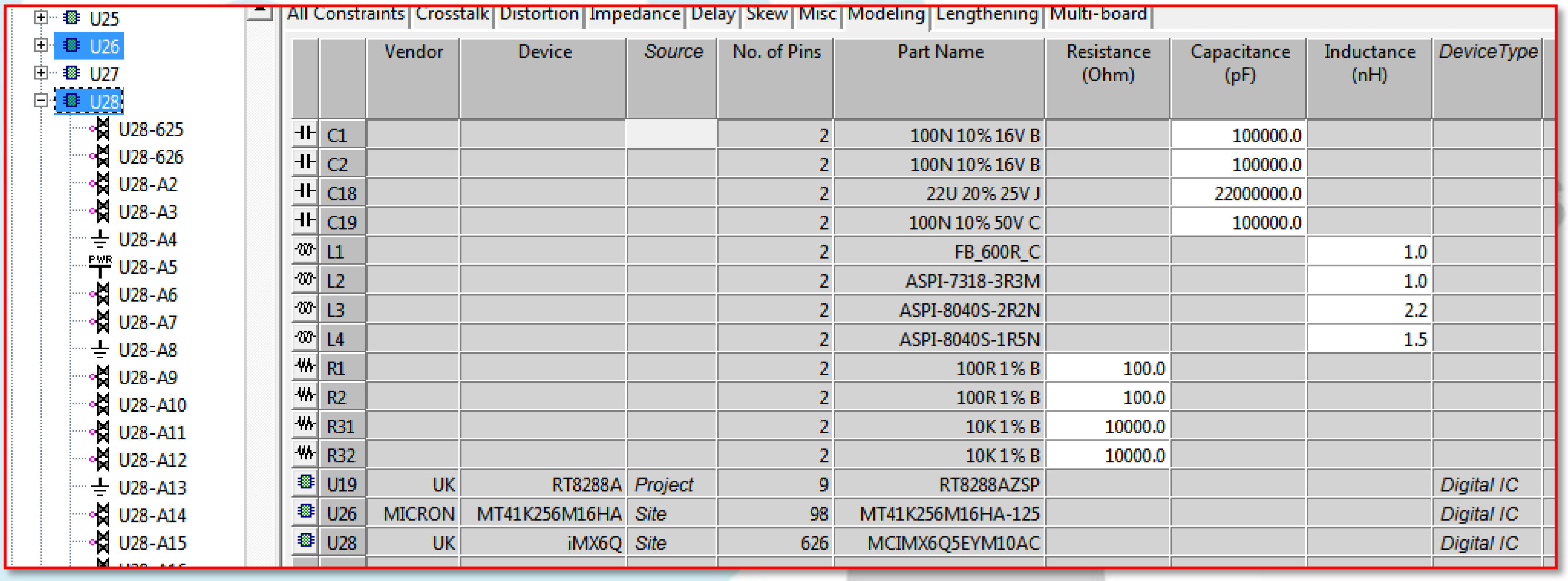


quadra solutions

ZUKEN CADSTAR Distributor

Part Data

- > Active
  - > Models
    - > Device
    - > Pin types
- > Discrete
  - > Value



	Vendor	Device	*Source*	No. of Pins	Part Name	Resistance (Ohm)	Capacitance (pF)	Inductance (nH)	*DeviceType*
C1				2	100N 10% 16V B		100000.0		
C2				2	100N 10% 16V B		100000.0		
C18				2	22U 20% 25V J		22000000.0		
C19				2	100N 10% 50V C		100000.0		
L1				2	FB_600R_C			1.0	
L2				2	ASPI-7318-3R3M			1.0	
L3				2	ASPI-8040S-2R2N			2.2	
L4				2	ASPI-8040S-1R5N			1.5	
R1				2	100R 1% B	100.0			
R2				2	100R 1% B	100.0			
R31				2	10K 1% B	10000.0			
R32				2	10K 1% B	10000.0			
U19	UK	RT8288A	*Project*	9	RT8288AZSP				*Digital IC*
U26	MICRON	MT41K256M16HA	*Site*	98	MT41K256M16HA-125				*Digital IC*
U28	UK	iMX6Q	*Site*	626	MCIMX6Q5EYM10AC				*Digital IC*

Part Classification

> Identify power sources

> Nominal power consumption per supply rail per device

Classification

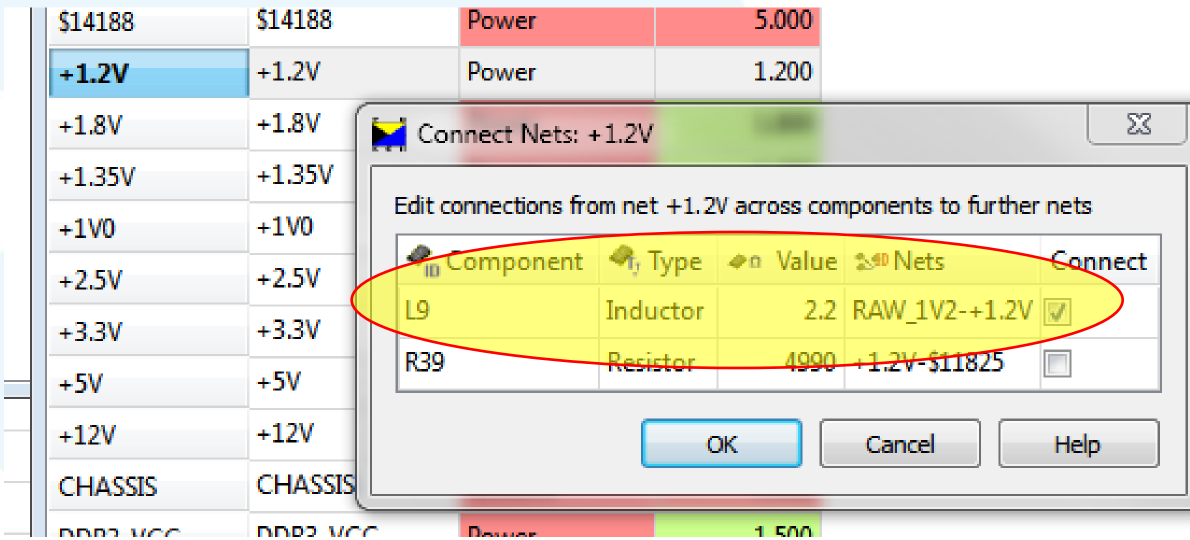
Component | Net | Supply | Via Type | DC Via | Power Bus

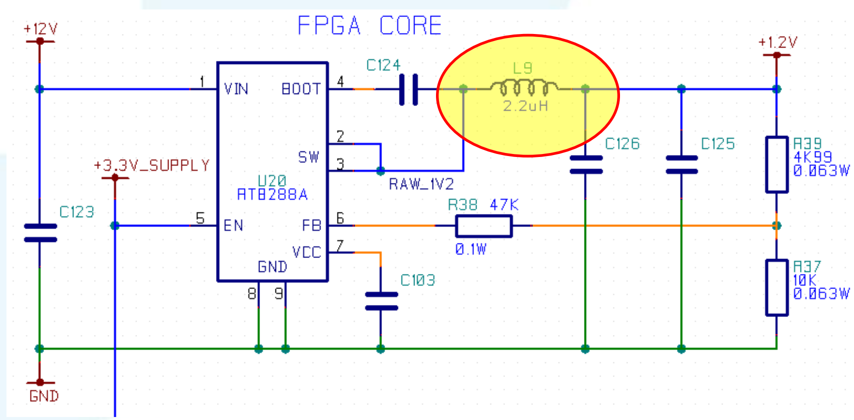
	Name	Part Name	Type	Value (Ω|pF|nH)	Active	# Pins	Heatsink
U12	U12	RT8288AZSP / RT8288A	IC			9	no
U13	U13	RT8288AZSP / RT8288A	IC			9	no
U14	U14	RT8288AZSP / RT8288A	IC			9	no
U15	U15	MT48LC16M16A2P-7E / MT48LC16M16A2TG	IC			54	no
U16	U16	MT48LC16M16A2P-7E / MT48LC16M16A2TG	IC			54	no
U17	U17	ADSP-21469 / ADSP-2146x	IC			326	no
U18	U18	MT47H64M16HR-25 / MT47H64M16HR	IC			86	no
U19	U19	RT8288AZSP / RT8288A	IC			9	no
U20	U20	RT8288AZSP / RT8288A	IC			9	no
U21	U21	RT8288AZSP / RT8288A	IC			9	no
U22	U22	DS90C385AMT	IC			56	no
U23	U23	XC6SLX100-2FGG484C / SPARTAN-6	IC			486	no
U24	U24	MT48LC16M16A2P-7E / MT48LC16M16A2TG	IC			54	no
U25	U25	RT8288AZSP / RT8288A	IC			9	no
U26	U26	MT41K256M16HA-125 / MT41K256M16HA	IC			98	no

Pin | Power Bus | DC

	Name	Power Bus	Source	Power Consumption (W)	Package Resistance (Ω)	Min IC Voltage (V)
U11	U11	+12V_GND	no	5.000	0.001	12.000
U11	U11	+1.8V_GND	yes		0.001	1.800
U12	U12	+12V_GND	no	8.000	0.001	12.000
U12	U12	+3.3V_GND	yes		0.001	3.300
U14	U14	$14188_GND	no	5.000	0.001	5.000
U14	U14	+1.35V_GND	yes		0.001	1.350
U15	U15	+3.3V_GND	no	1.000	0.001	3.300
U18	U18	+1.8V_GND	no	1.000	0.001	1.800
U23	U23	+3.3V_GND	no	5.000	0.001	3.300
U23	U23	+1.2V_GND	no	1.000	0.001	1.200
U25	U25	+12V_GND	no	2.000	0.001	12.000
U25	U25	+1V0_GND	yes		0.001	1.000

Power Interconnects





Net Classification

- > Signal Type
  - > Bus
  - > Data
  - > Clock
  - > Control
  - > Etc.
- > Target clock frequency

Classification

Component | Net | Supply | Via Type | DC Via | Power Bus

	Name	Signal Type	I/O	Clock (MHz)
DRAM3_A13	DRAM3_A13	Bus	no	100.000
DRAM3_A14	DRAM3_A14	Bus	no	100.000
DRAM3_CAS_B	DRAM3_CAS_B	Control	no	100.000
DRAM3_CS0_B	DRAM3_CS0_B	Control	no	100.000
DRAM3_D0	DRAM3_D0	Data	no	233.000
DRAM3_D1	DRAM3_D1	Data	no	233.000
DRAM3_D2	DRAM3_D2	Data	no	233.000
DRAM3_D3	DRAM3_D3	Data	no	233.000
DRAM3_D4	DRAM3_D4	Data	no	233.000
DRAM3_D5	DRAM3_D5	Data	no	233.000

A short overview of PIA ..

Key Benefits

- Power Integrity Advance enables analysis and exploration of the power distribution network at the ‘virtual prototype’ design stage, **before** you commit to a costly physical prototype

- Helps you reduce project timescale and cost to bring your product to market faster and improve quality and reliability

Quadra Solutions Limited

People. Knowledge. Innovation.