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48V 2-stage System Efficiency Optimization by using STC Converter with Dynamic Converting Ratio

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2-Stage Architecture for 48-to-PoL Power Delivery – Ratio Adjustable STC Converter

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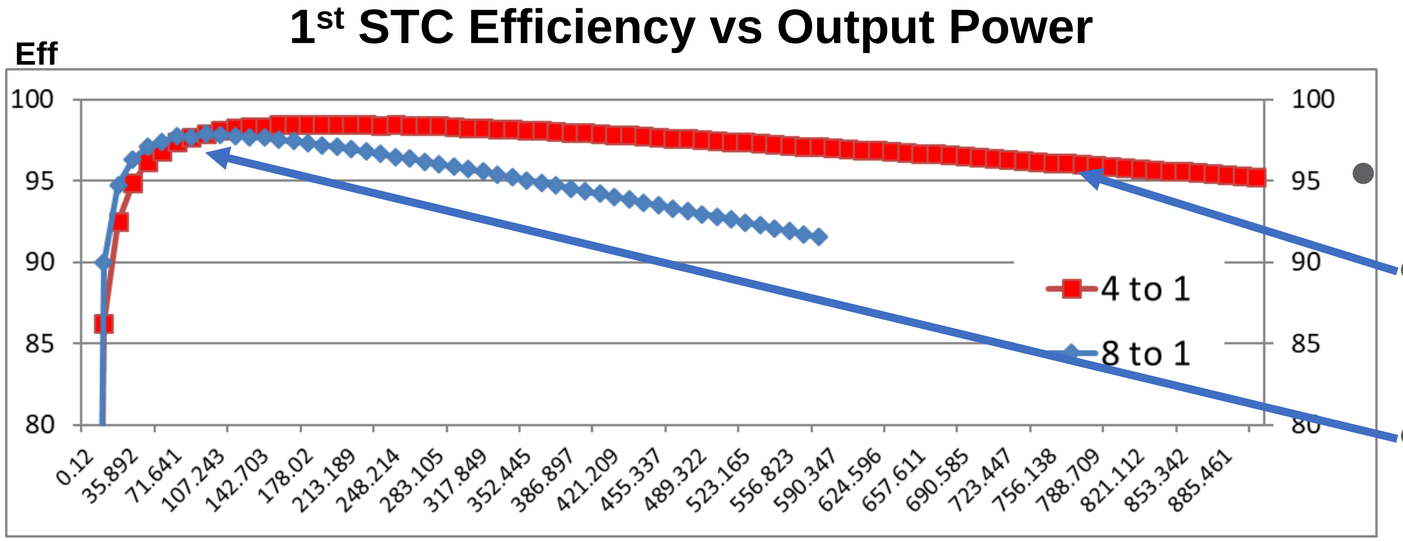
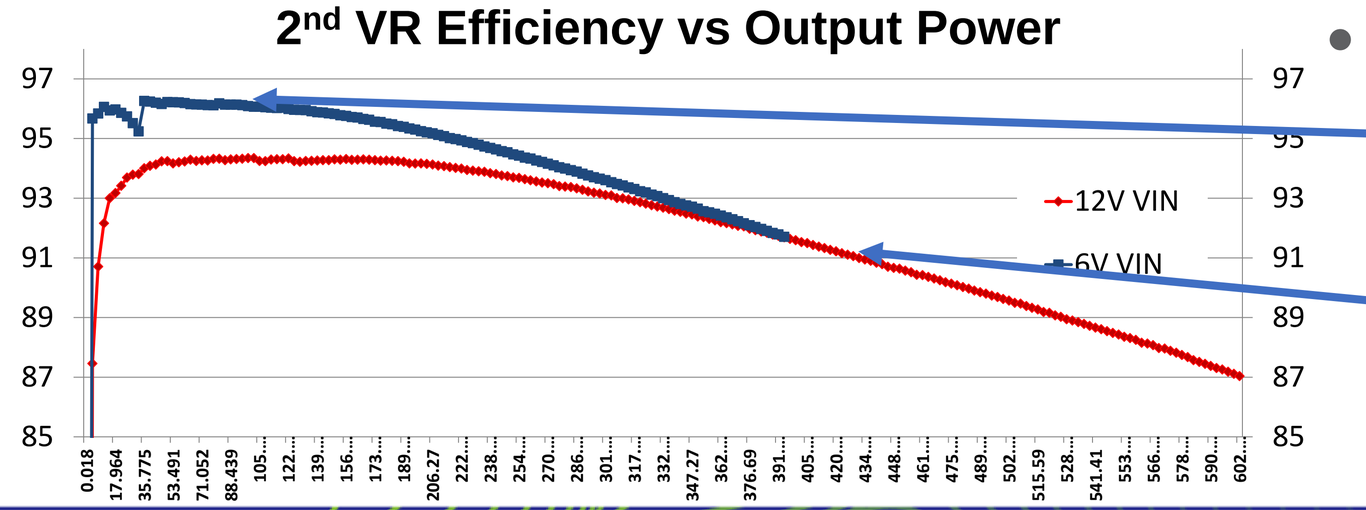
- Google’s proprietary STC 48V Bus intermediate STC(Switched Tank Converter) enables high efficiency high density 48V 1st stage conversion in 2-stage architecture.
- To further optimize system efficiency over all the load range Wiwynn propose dynamically change STC converting ratio based on output power condition:
  - High converting ratio for lower power application
  - Low converting ratio for higher power application

Case Studies

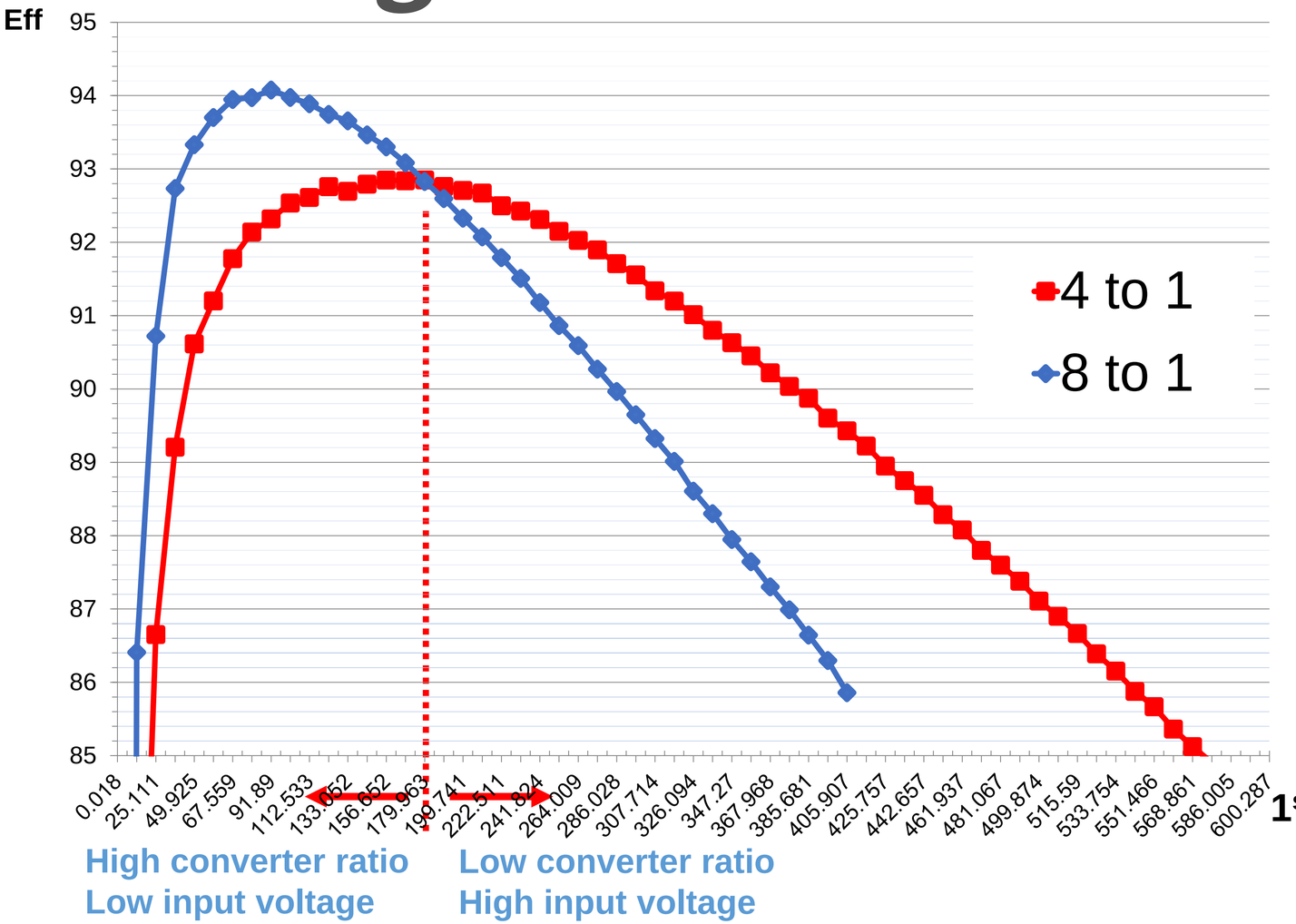
2-Stage Separate Efficiency Chart





- 1st stage STC eff:
  - Higher eff with low converting ratio at high output power
  - Moderate eff difference at lower load
- 2nd stage VR eff:
  - Higher eff with lower Vin in light load
  - Moderate eff difference at heavy load

2-stage Combined Efficiency



- Higher converting ratio gives better efficiency at lower load while reducing converting ratio can effectively gain higher efficiency at heavier load.

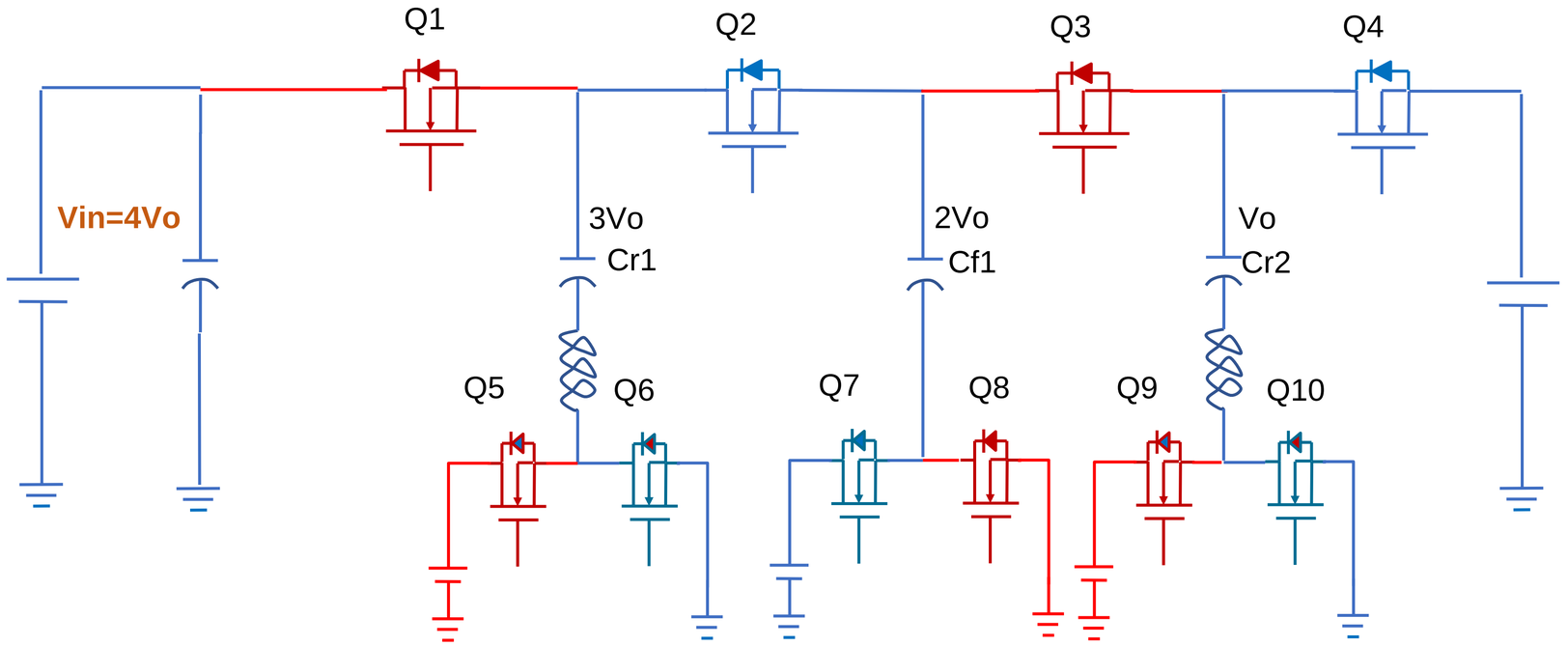
- With dynamic adjusted STC converting ratio, system efficiency can be optimized over all load range.

EV-board measurement data

		Io_50A		Io_100A		Io_200A		Io_300A		Io_350A	
		Efficiency	P_loss(W)	Efficiency	P_loss(W)	Efficiency	P_loss(W)	Efficiency	P_loss(W)	Efficiency	P_loss(W)
4:1	1st Stage	97.889%	2.058	98.453%	2.798	98.114%	6.776	97.356%	14.207	96.917%	19.49
	2nd Stage	94.309%	5.545	94.298%	10.077	92.764%	25.436	90.185%	51.476	88.608%	89.437
	overall	92.318%	7.60	92.839%	12.89	**91.014%**	**32.212**	**87.8%**	**65.683**	**85.876%**	**108.927**
8:1	1st Stage	97.86%	2.071	97.34%	4.792	94.877%	18.981				
	2nd Stage	96.14%	3.693	95.623%	7.757	93.068%	24.454				
	overall	**94.075%**	**5.764**	**93.085%**	**12.549**	88.3%	43.435				

Microsoft Excel
工作表

STC Circuit Converting Ratio 4 to 1

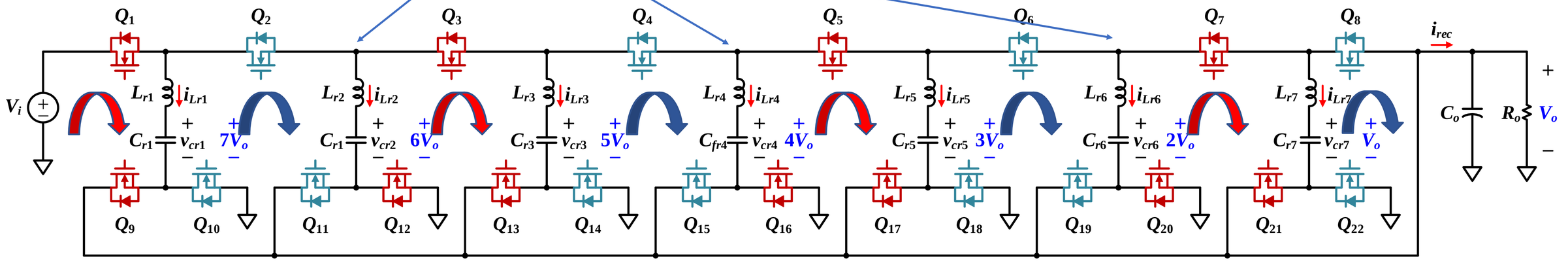


- Q1, Q3, Q5, Q8 and Q9 turn on/off at the same time with 50% duty cycle.
- Q2, Q4, Q6, Q7 and Q10 are complementary signal for the remaining 50% duty cycle
- Cr1 and Cr2 are resonant capacitors with inductance constitute resonant tank
- Cf1 is DC flying capacitor with much lower voltage ripples.

Adjustable STC Converting Ratio

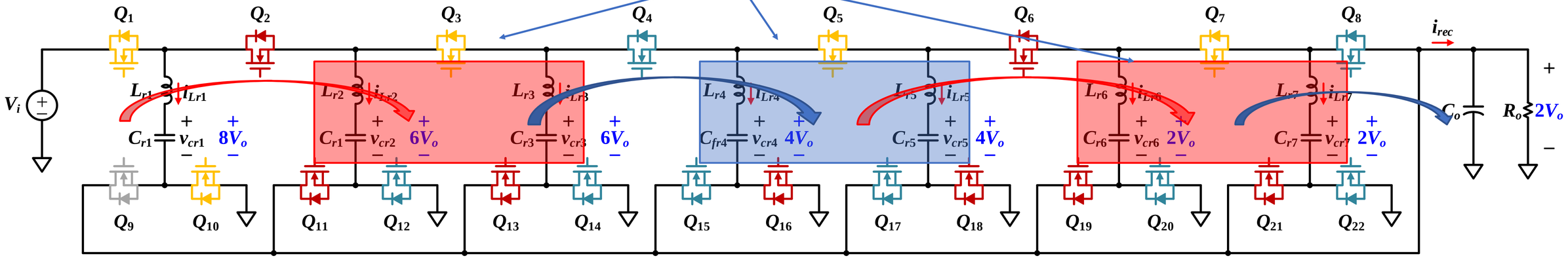
☐8-to-1 Operation

Flying cap replaced by res. cap

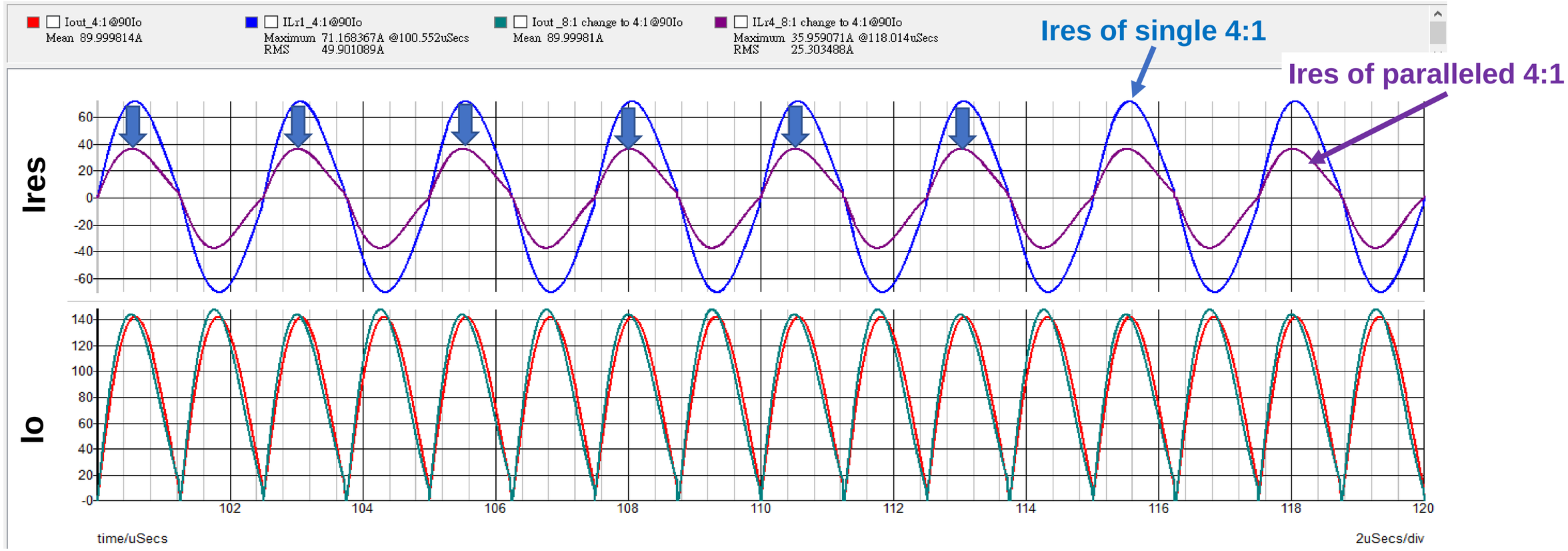


☐4-to-1 Operation

Parallel resonant to step down the converting ration

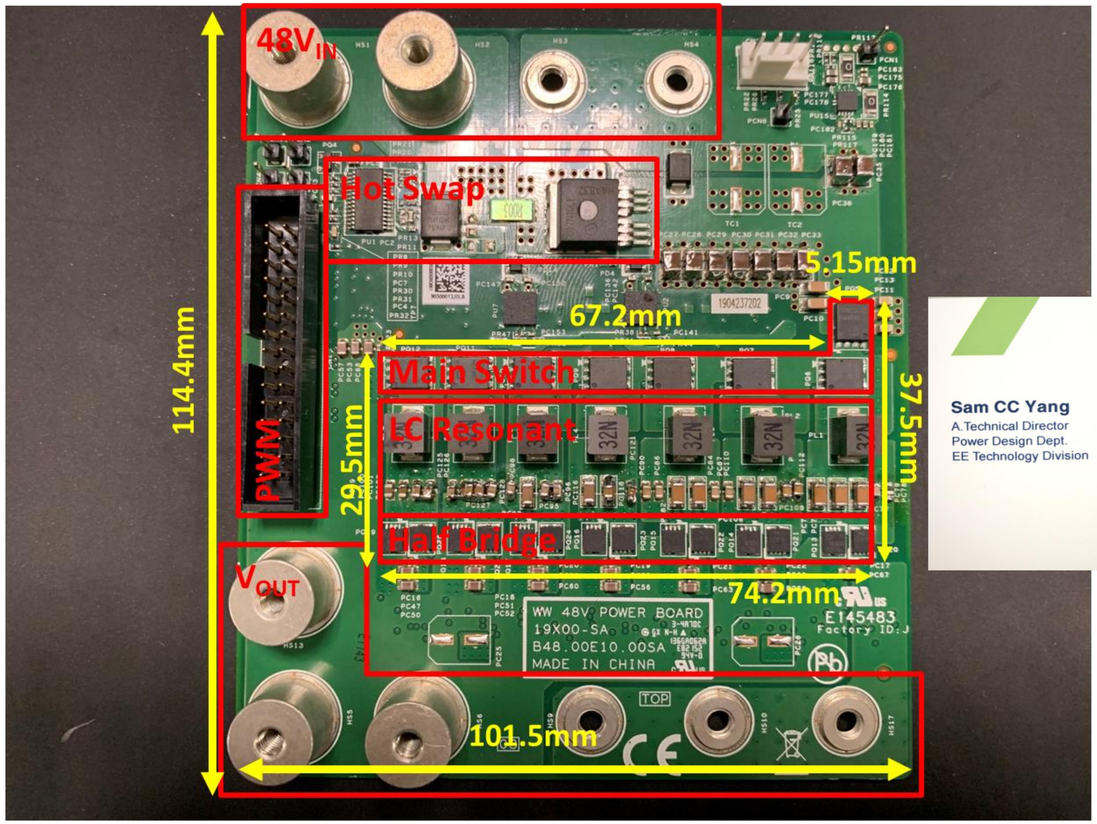


Resonant Current Comparison in 4:1 and Paralleled 4:1



- Io is distributed in each resonant leg due to parallel operation, conduction losses is cut by half.
- Resonant Freq keeps the same due to parallel operation.

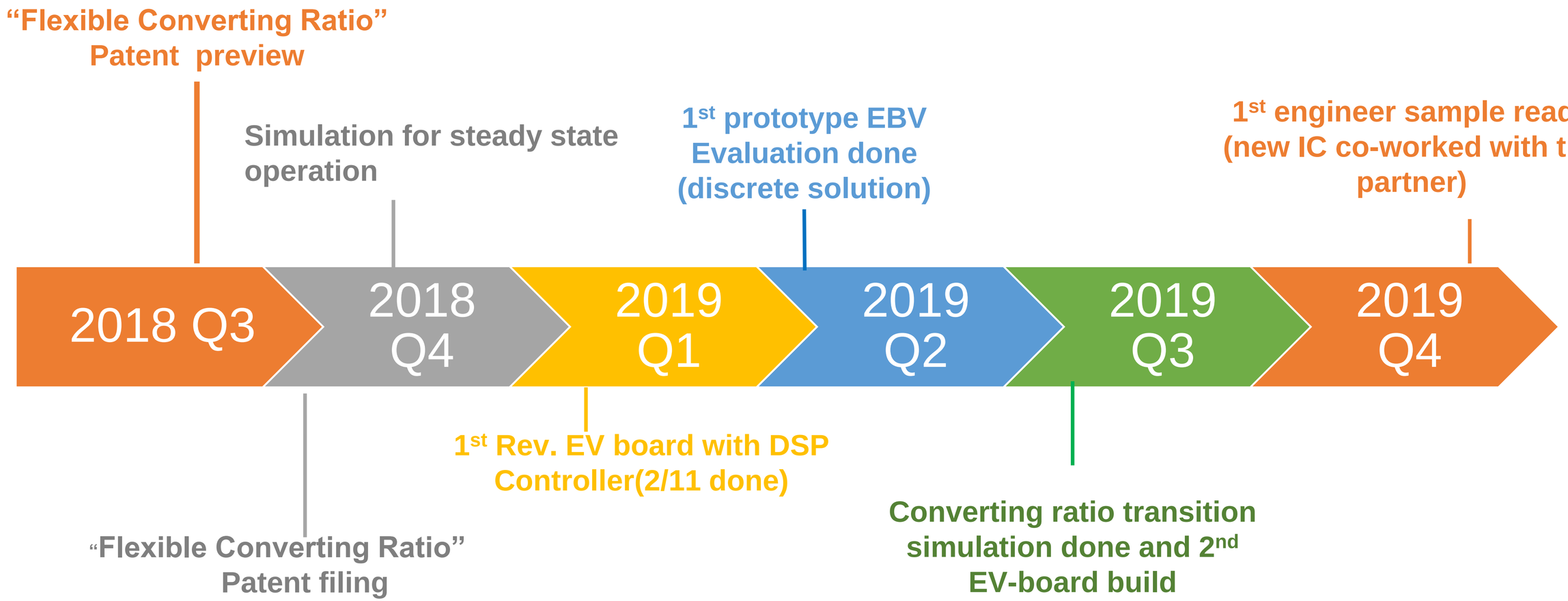
EV-Board Dimension 1.2KW Peak power



Component	PN	Company
Main switch 1	BSC015NE2LS5I	Infineon
Main switch 2	BSC022N04LS6	Infineon
Driver	2EDF7275K	Infineon
HB	BSZ011NE2LS5I	Infineon
Choke	BPMIWN06068032NK0E	Chilisin
DSP controller	F28035	TI
Resonant Cap1, 100V 2.2uF	SC2D2U100V6KX-1	Murata
Resonant Cap 2, 100V 1uF	SC1U100V5KX	Murata
Resonant Cap 3, 50V 2.2uF	SC2D2U50V6KX-4	Murata
Resonant Cap 4, 50V 1uF	CL21B105KBFNNNE	Samsung

Main Switch MOSFET: 5.15*5.95mm^2 Inductor: 5.7*5.7mm^2 Half Bridge MOSFET: 3.2*3.2mm^2

Developing Roadmap



Summarize

- STC employ LC resonant tank to realize high efficiency DCDC power conversion for 2 stage 48V system, flexible converting ratio can further improve 2-stage overall efficiency by dynamically alter converting ratio based on power requirement
  - High converting ratio reducing 2nd stage VRs voltage stress in lower load
  - Low converting ratio and parallel resonant legs to reduce 1st stage current stress in heavy load
- Future work:
  - Simplified main switches driver design and reduce choke/board size.
  - Looking for integral solution for ZCS exact switching timing.
  - Define converting ratio switching point and hysteresis

Question?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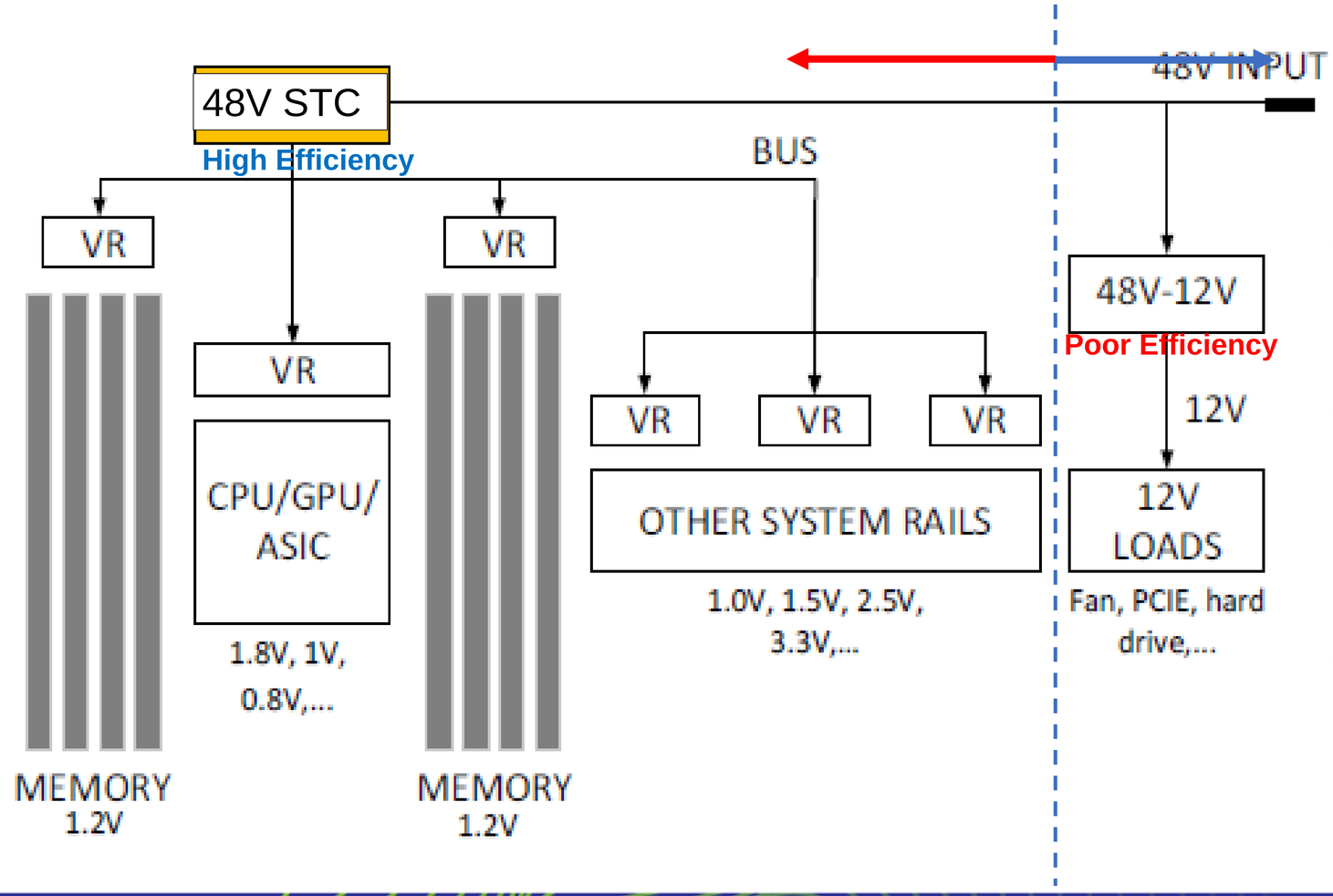
Appendix

Google’s 48V 2-Stage Conversion Approach



- STC enables high efficiency 2-stage conversion, more 2nd stage VRs supported by STC, higher board efficiency is.
- Current Design Targeting 600W for STC 48V to VR with different converting ratio
  - 4:1(Intel)
  - 8:1(google)
- With increasing CPU/DDR power, higher STC power is needed

Converting Ratio Changes