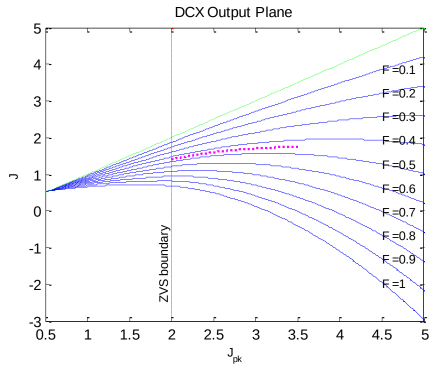
Averaging Step

Selection of Tank Inductance

$$J = \frac{n\langle i_{out}\rangle}{I_{base}} = \frac{F}{\pi}\left[2 + \frac{1}{4}\left(J_1^{\;2} - J_2^{\;2}\right) + J_p\left(\frac{\pi}{F} - \alpha - \beta - \delta\right)\right]$$



Selection of Tank Inductance

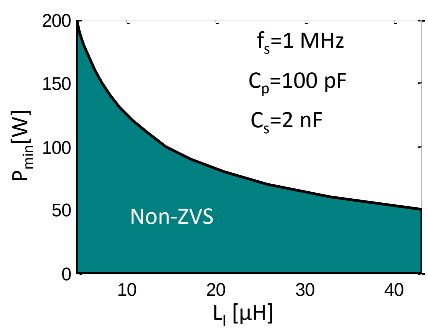
- State plane analysis gives equation of the form:

$$P_{out} = f(L_l, C_p, C_s, , f_s, J_p)$$

- If we select some minimum power P_{min} for ZVS design to place ZVS boundary ($J_p = 2$), at P_{min}

$$P_{min} = f(L_l, \text{devices}, f_s)$$

- From resulting equation, L_l determined from converter devices, application requirements, and placement of ZVS boundary
- Now select devices for minimum loss in converter



Selecting MOSFETs for DAB

150 V FETS

Device Variant	Type	r_{on} [mΩ]	C_{oss} [pF]	Q_g [nC]
EPC1012	GaN	70	80	1.9
EPC1010	GaN	18	310	7.5
FDMS2672	MOS	64	95	30
IPD320N	MOS	35	135	12.0
IRFS4020	MOS	85	91	18.0

12V FETS

Device Variant	Type	r_{on} [mΩ]	C_{oss} [pF]	Q_g [nC]
EPC1014	GaN	12.0	150	3.0
EPC1015	GaN	3.2	575	11.6
CSD16325Q5C	MOS	1.7	2190	18.0
STD60N3LH5	MOS	8.8	265	8.8
CSD16411Q3	MOS	12.0	330	2.9

- Representative sample of HV and LV devices, including Si and GaN devices
- Above P_{min}, all devices have no switching loss, so efficiency only depends on conduction losses

$$P_{cond} = P_{cond,p} + P_{cond,s} = 2r_{on,p} i_{g,rms}^2 + 2r_{on,s} i_{out,rms}^2$$

Selecting MOSFETs for DAB

150 V FETS

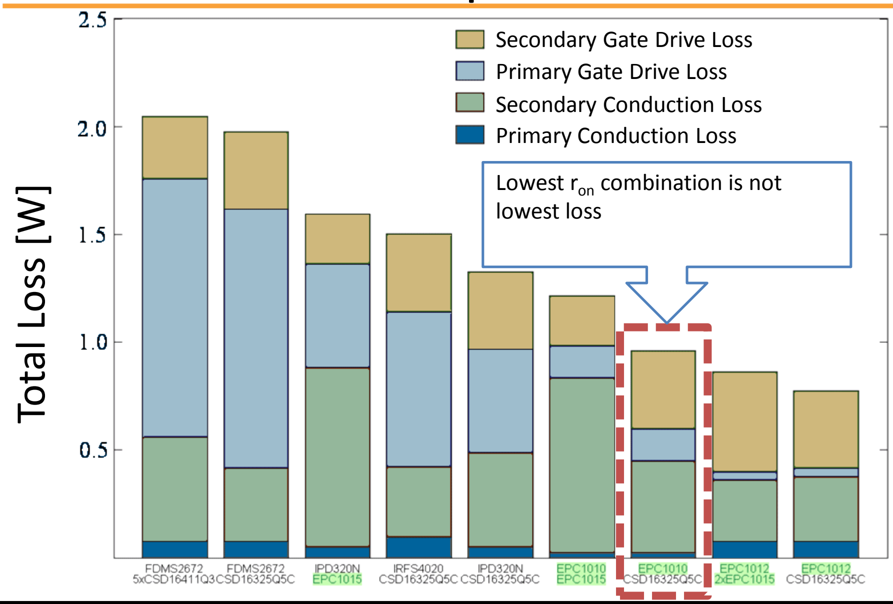
Device Variant	Type	r_{on} [mΩ]	C_p [pF]	Q_g [nC]
EPC1012	GaN	70	87	1.9
EPC1010	GaN	18	353	7.5
FDMS2672	MOS	64	177	30
IPD320N	MOS	35	379	12.0
IRFS4020	MOS	85	140	18.0

12V FETS

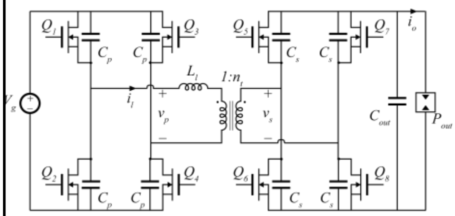
Device Variant	Type	r_{on} [mΩ]	C_s [pF]	Q_g [nC]
EPC1014	GaN	12.0	241	3.0
EPC1015	GaN	3.2	1000	11.6
CSD16325Q5C	MOS	1.7	3200	18.0
STD60N3LH5	MOS	8.8	713	8.8
CSD16411Q3	MOS	12.0	486	2.9

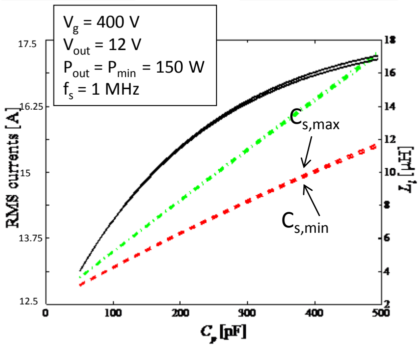
- Representative sample of HV and LV devices, including Si and GaN devices
- Above P_{min}, all devices have no switching loss, so efficiency only depends on conduction losses
- Initial conclusion is to select lowest r_{on} devices
- Can solve analytical loss model from state plane analysis

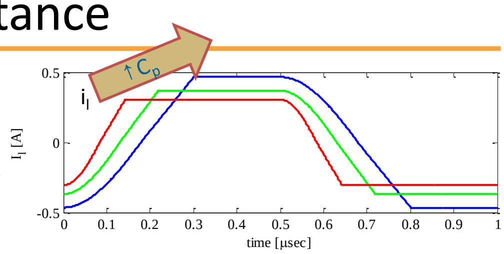
Device Loss Comparison: 150-12 V

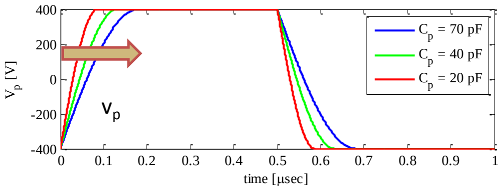


Effects of primary-side device capacitance









- Higher RMS currents lead to greater conduction losses
- RMS currents strongly dependant on C_p

Selecting MOSFETs for DAB

150 V FETS

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EPC1012	GaN	70	87	1.9
EPC1010	GaN	18	353	7.5
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12V FETS

Device Variant	Type	r_{on} [mΩ]	C_s [pF]	Q_g [nC]
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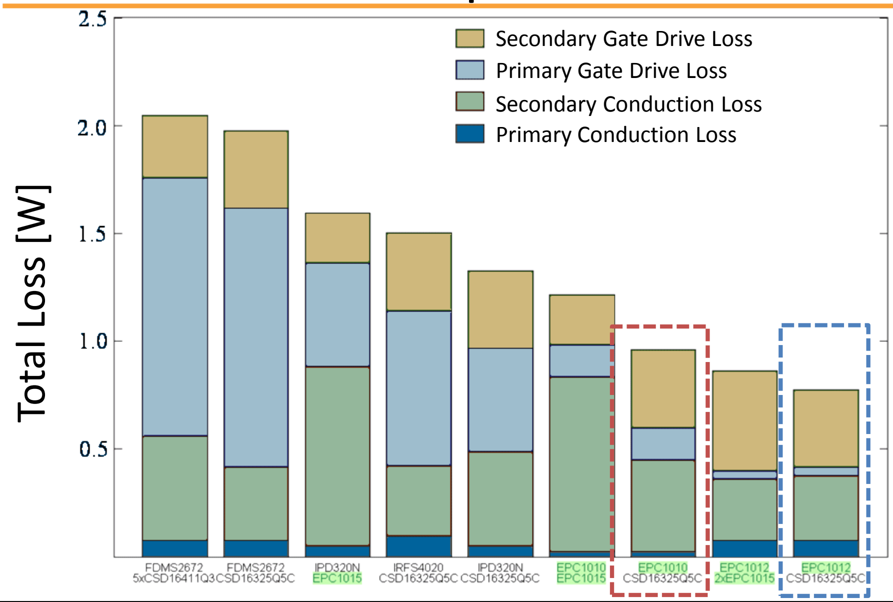
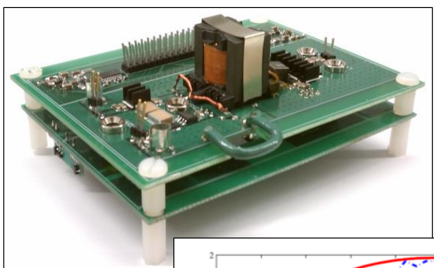
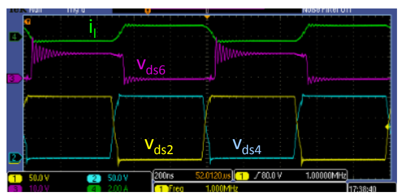
- Analysis predicts that optimal selection consists of lowest C_p primary device and lowest r_{on} secondary device

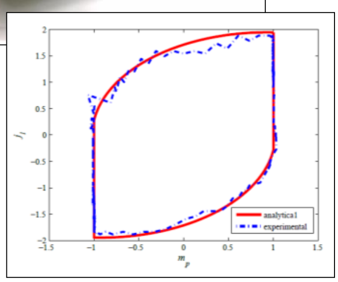
Device Loss Comparison: 150-12 V

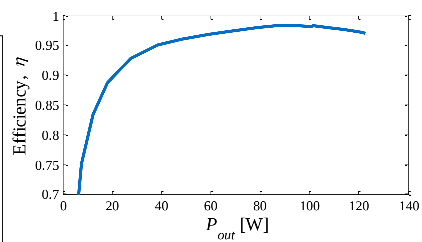


DAB: Experimental Results









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