

EDUCATIONAL LABORATORY DEMONSTRATOR FOR TEACHING DUAL ACTIVE BRIDGE CONTROL PRINCIPLES

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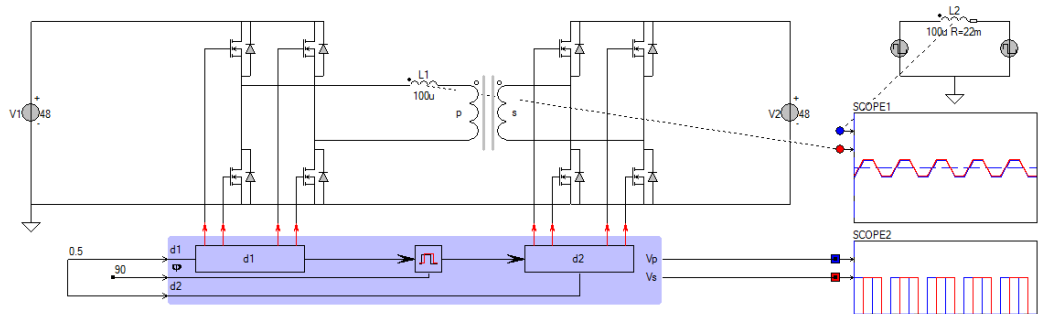
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Control of Power flow in DC grids

- Galvanic Isolation
- Bidirectional power flow
- Wide voltage range
- Short circuit protection
- Earth leakage protection

DAB Principle and Modulation



Two full bridges and duty cycle and phase shift control

Full model and simplified model

- Replace full model with two sources and only leakage inductance
- Understand the voltage across $L_{leakage}$
- Analyze the various modulation methods

Understand and Analyze

- Bidirectional power transfer via the coupled inductors
- Control the power transfer via phase and duty-cycle variation
- Importance of the leakage inductance
- Compromise between increasing switching losses in the Mosfets versus reduced losses in smaller magnetic cores for increasing switching frequency

Theory and practice

- Online design tool
- Online simulation tool for simplified model
- Simulation/Animation tool for complete model
- Experimental demonstrator

Caspo

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Dual Active Bridge

Waveforms Numerical Control

Pin=7.65[kW]	Tp2=5[μs]	Tp3=5[μs]	Tp4=10[μs]	Ts1=2.5[μs]
Ts2=2.5[μs]	Ts3=7.5[μs]	Ts4=7.5[μs]	Ts5=10[μs]	

I _m	0[μs]	0[μs]	2.5[μs]	2.501[μs]	5[μs]	5.001[μs]	7.5[μs]	7.501[μs]	10[μs]	10[μs]
V _L	340V	700V	960V	20V	-340V	-700V	-960V	-20V	340V	340V
I _m	-44.991A	-44.983A	-42.483A	-42.501A	45A	-44.983A	-42.483A	-42.501A	-45A	-44.991A
I _m	0A	-44.983A	-42.483A	-42.501A	45A	-44.983A	-42.483A	-42.501A	45A	0A

Primary and secondary gating:

Leakage winding voltage:

Input and output

Input voltage Vin [V]

Output voltage Vout [V]

Control

Switching Frequency Fs [kHz]

Duty cycle primary side dp [0..0.5]

Duty cycle secondary side ds [0..0.5]

Phase shift pN [0..360Degrees]

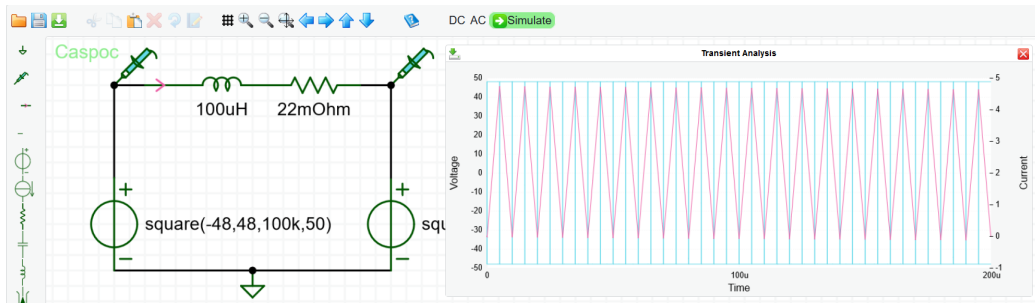
Parameter

Leakage inductor value L [μH]

Calculate

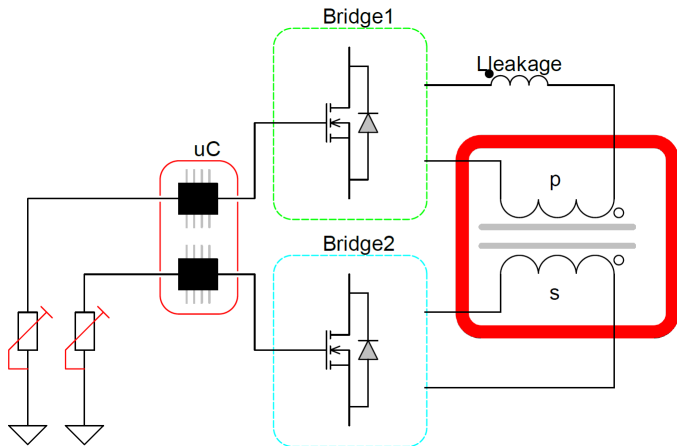
Design tool to estimate leakage inductance and waveforms

Simulation of principle



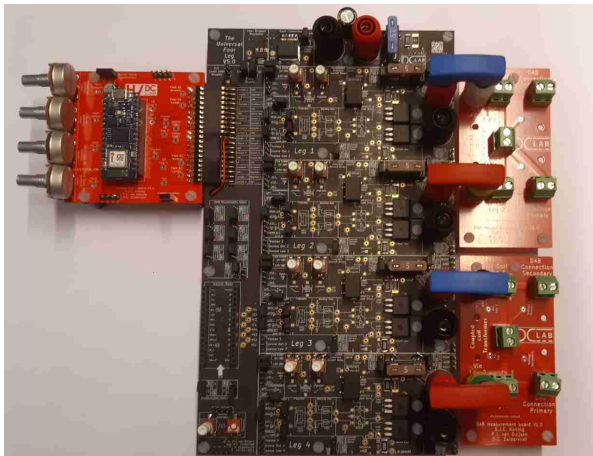
Online Simulation tool to estimate leakage inductor waveform

Principle diagram



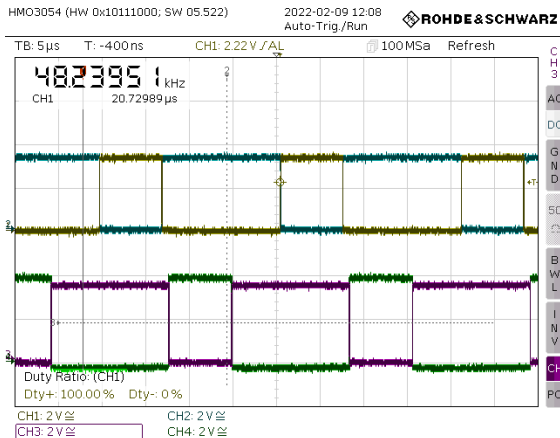
Experimental set up diagram

Experimental demonstrator

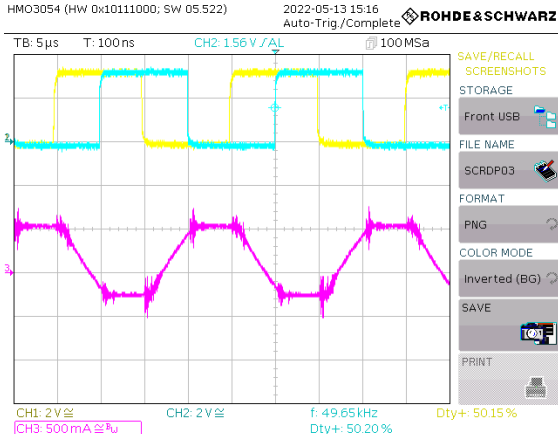


Experimental set up using Universal Four Leg

Control signals

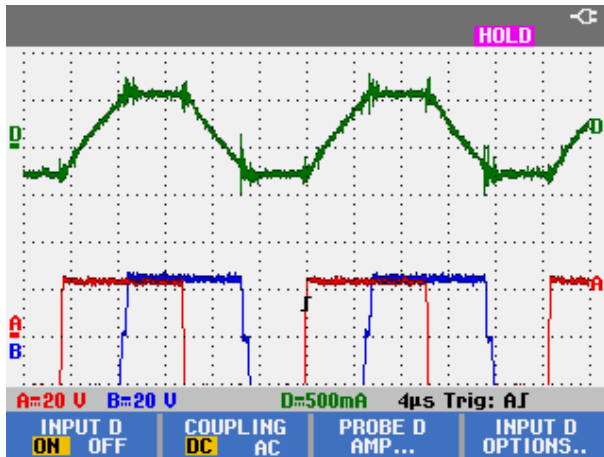


Arduino controller output signals



Upper traces are the left and right bridge gate control signals, with a phase difference of 90 degrees. The lower trace is the periodic current through the leakage inductance (Offset 300mA, Peak-Peak = 600mA).

Experimental demonstrator



Upper trace, leakage inductor current ($I_{pp}=0.9$ Ampere), and bridge output voltages ($V_{pp}=40v$), of the DAB with phase difference of 90 degrees, operating at 75kHz, $V_{dc}=20v$.

- Dual Active Bridge
- Galvanic Isolation & Protection
- Laboratory demonstrator
- Easily change frequency, duty cycle and phase shift

Thank you!
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