



Your world in real time.

RTDS
Technologies

RTDS.COM



Modelling of DC Breakers



RTDS Technologies Inc.
User's Groups Meeting
2019 China

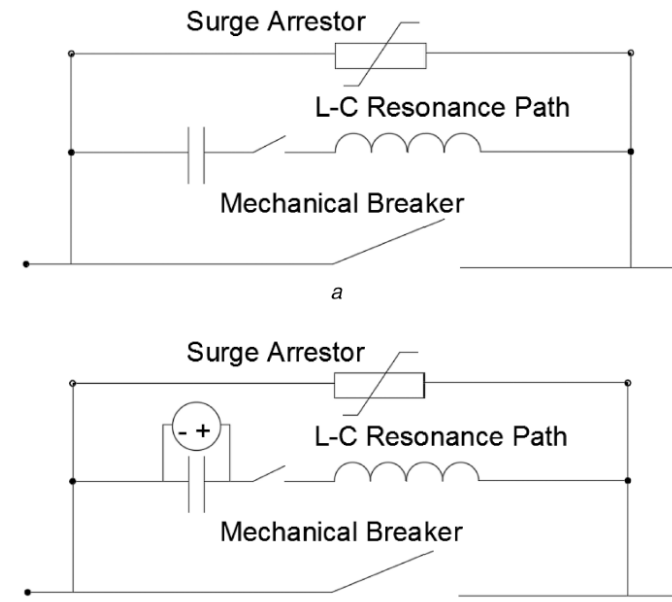
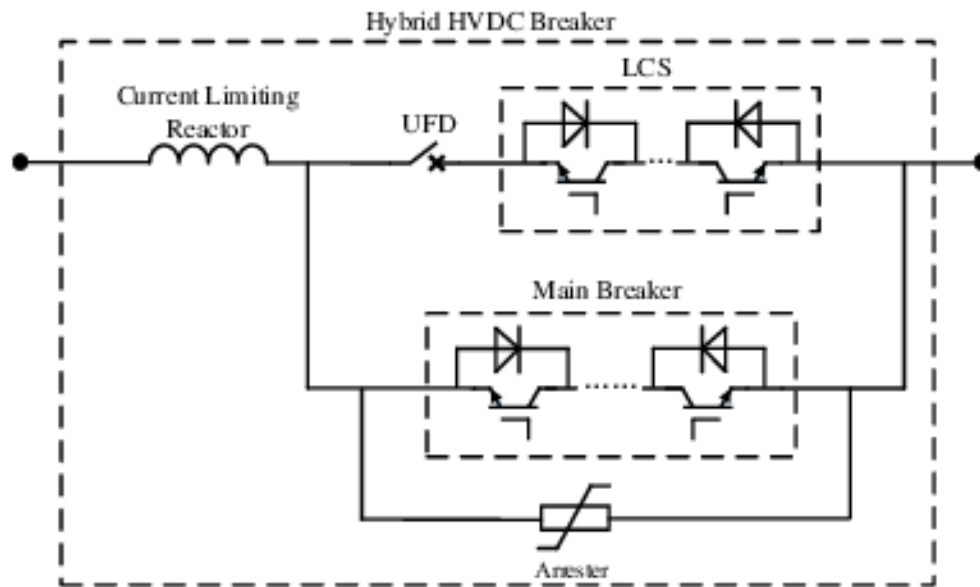
Outline

Types and Operating
Modelling and Simulation
Conclusion



DC Breaker Types

- ❖ Hybrid Breaker
- ❖ Mechanical Resonant Breaker



Breaker operating

1. Close the auxiliary branch IGBT
2. Open the main branch switch

Hybrid breaker: *Open IGBT then Breaker*

Mechanical breaker: *using LC oscillation branch*

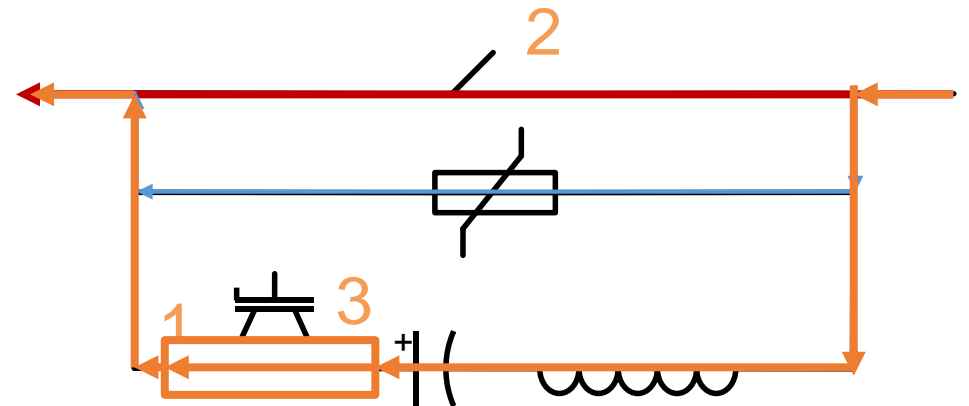
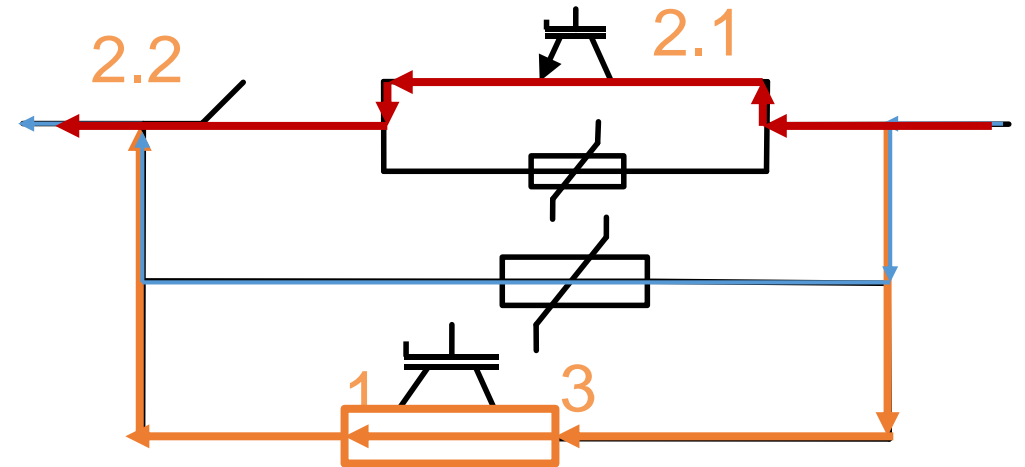
Open Breaker at zero-crossing

3. Open the auxiliary IGBT

IGBT current commutates to the surge arrester

Circuit response determined by the arrester

4. Possible secondary breaker action

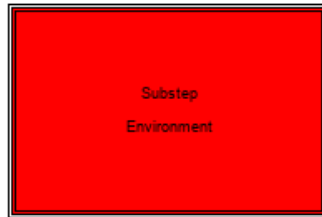


Breaker characteristics

- ❖ Requires very high accuracy as a secondary breaker action may be required due to a re-closing failure
- ❖ The transient response happens in millisecond level, even in microsecond level
- ❖ High frequency oscillation is usually excited (several kHz)

Modelling Environment in RTDS

- Substep (Novacor only)



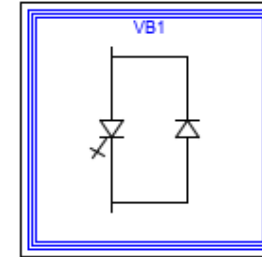
HIERARCHY

Box Parameters | Substep Options

Name	Description	Value	Unit	Min	Max
Name	Box Name	Box1			
FCOL	COLOR	BLACK			
BCOL	COLOR	RED			
LW	LINE WIDTH	1.0		0.0	
DESC1	Description : Line #1	Substep			
DESC2	Description : Line #2	Environment			
IMAGE	Image file path (.gif or .jpeg)				
IMAGE_RESIZE	Resize image to fill box?	NO			
EXCLUDE	Exclude contents from circuit	NO			
Type	Choose type of hierarchy box	SUBSTEP			

Update Cancel Cancel All

- SmallDt (PB5, Novacor)



rtds_vsc_BRIDGE_BOX

ENABLE DIGITAL INPUT | ENABLE GTAO OUTPUT CARDS | Icon Image Options

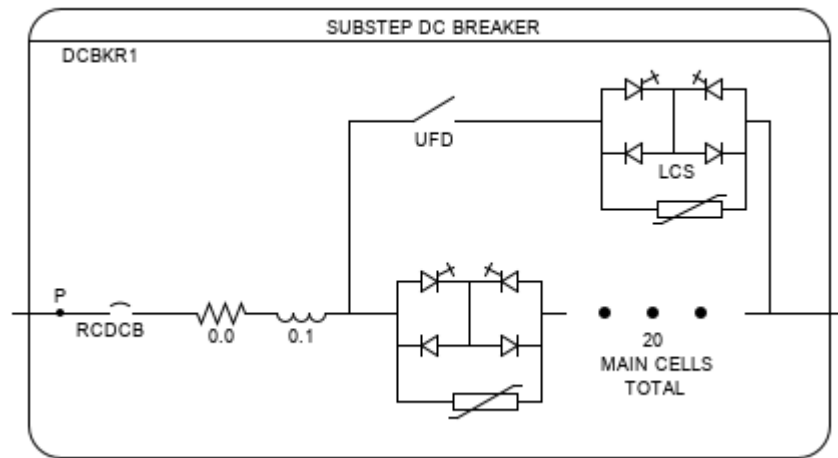
BRIDGE PARAMETERS | BRIDGE PROCESSOR PARAMETERS

Name	Description	Value	Unit	Min	Max
Name	Bridge Name	VB1			
Desc	Description				
dt_size	Request a small time-step size of:	1400	nanoSec	1400	3750
rqnmp	Requested Number of Processors:	One		0	1
supprs	Suppress WARNINGS, not ERRORS, about step size:	NO			

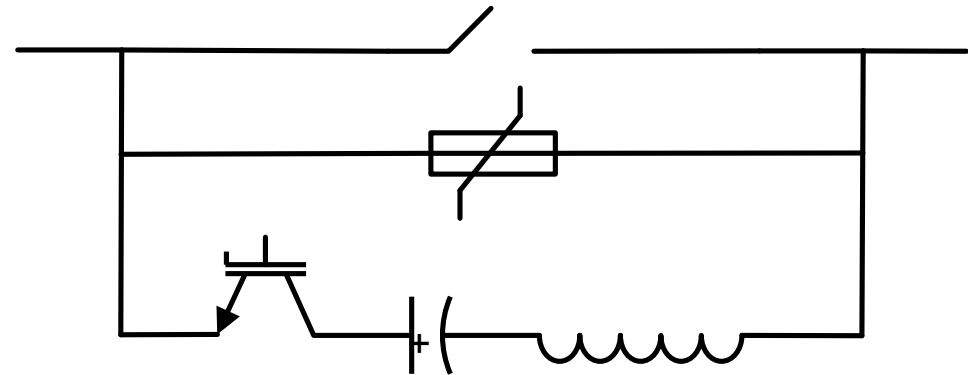
Update Cancel Cancel All

Modelling in RTDS Simulator

- Customized DC Breaker Model
- Built with Individual Component



Hybrid DC Breaker

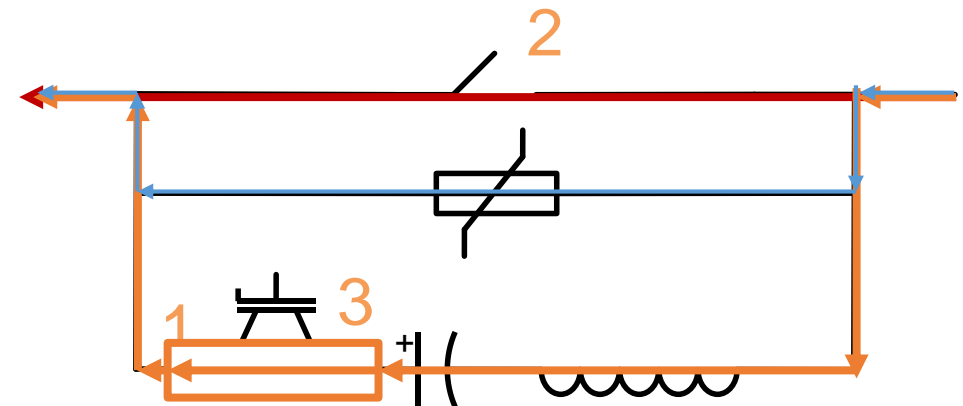
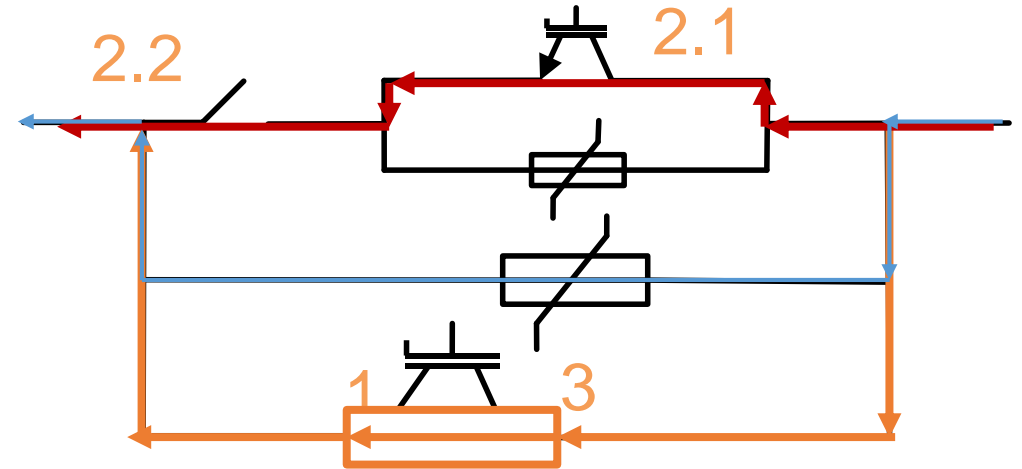


Individual Combination

IGBT Switch model

- Fast current conducting
- Block current immediately after turning-off

PSCAD	Resistive representation
SUBSTEP	Resistive representation LC representation
SMALLDT	LC representation

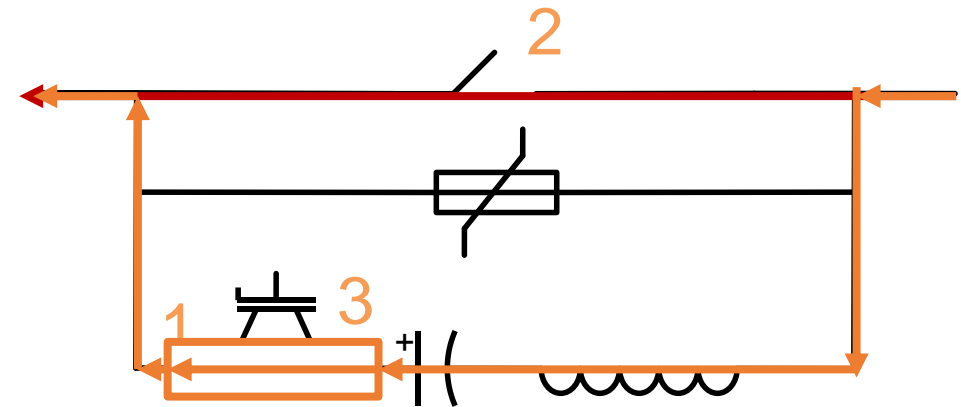
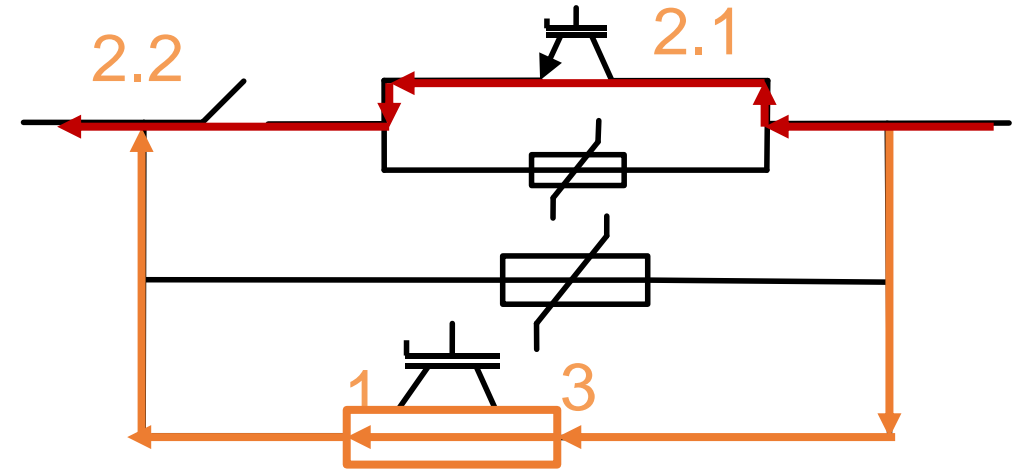


Mechanical Switch

(Breaker model)

- Block current immediately after turning-off

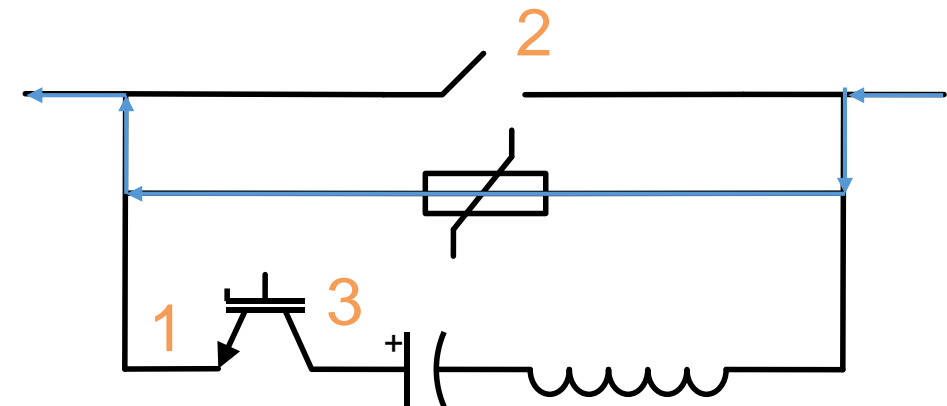
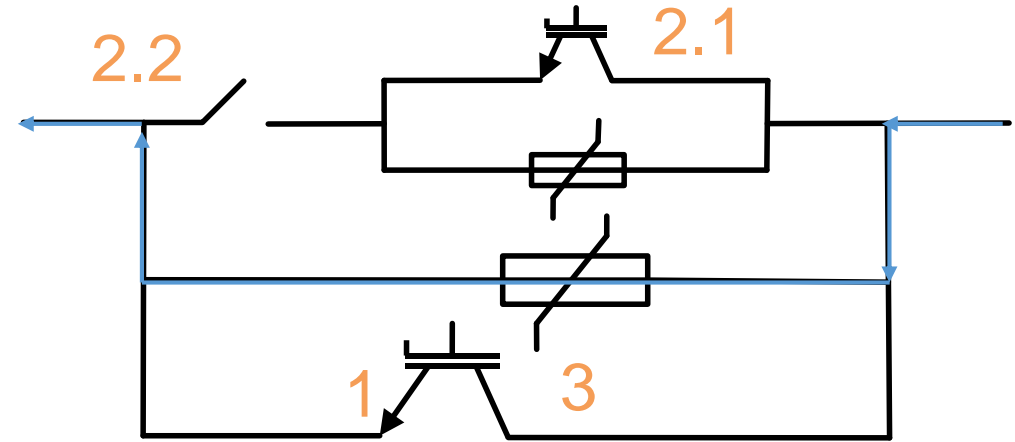
PSCAD	Resistive representation
SUBSTEP	Resistive representation LC representation
SMALLDT	Resistive representation (number limited) LC representation



Surge Arrestor

- Determines the V-I characteristic after the IGBT open action
- Decides the response of the secondary breaker action

PSCAD	Piecewise V-I model
SUBSTEP	Piecewise V-I model Exponential V-I model
SMALLDT	Piecewise V-I model Exponential V-I model (both with Interface Line)

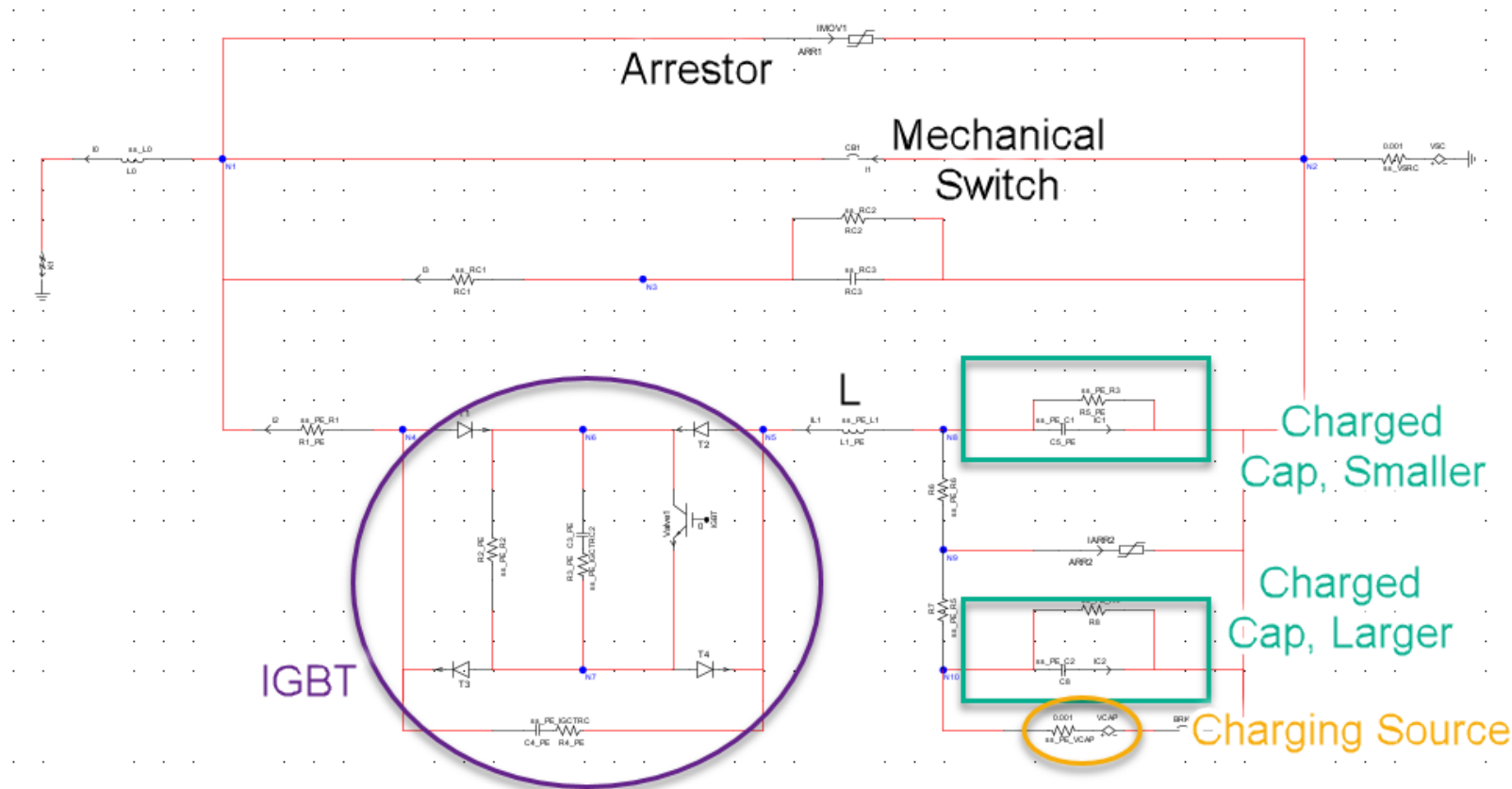


Modeling Experiences

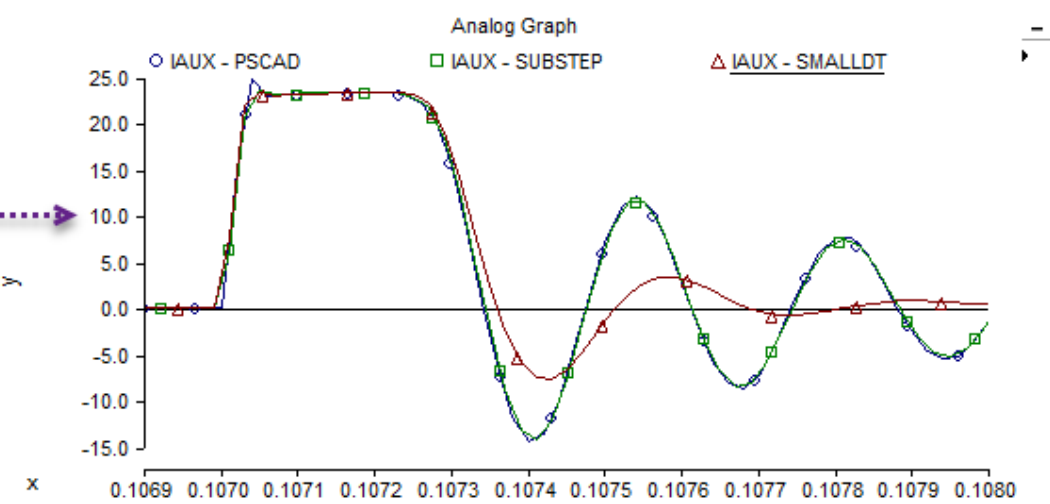
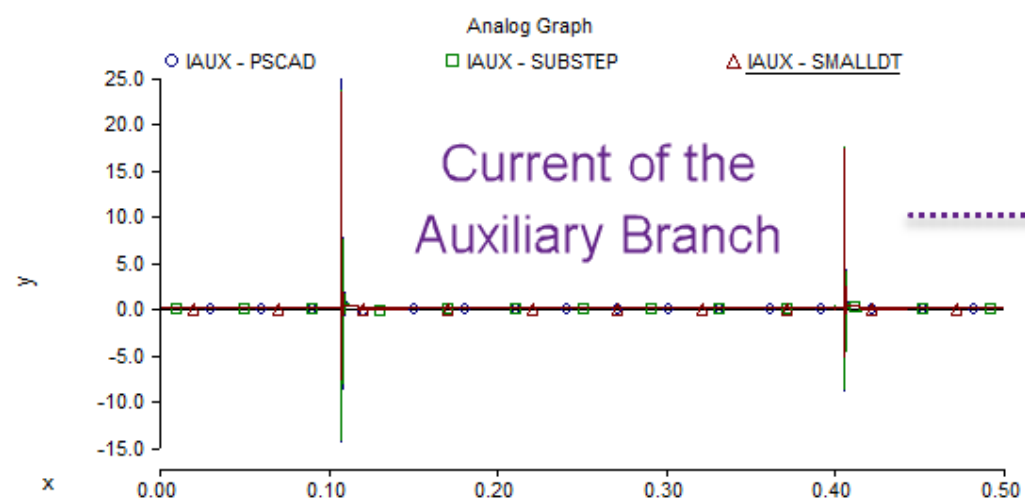
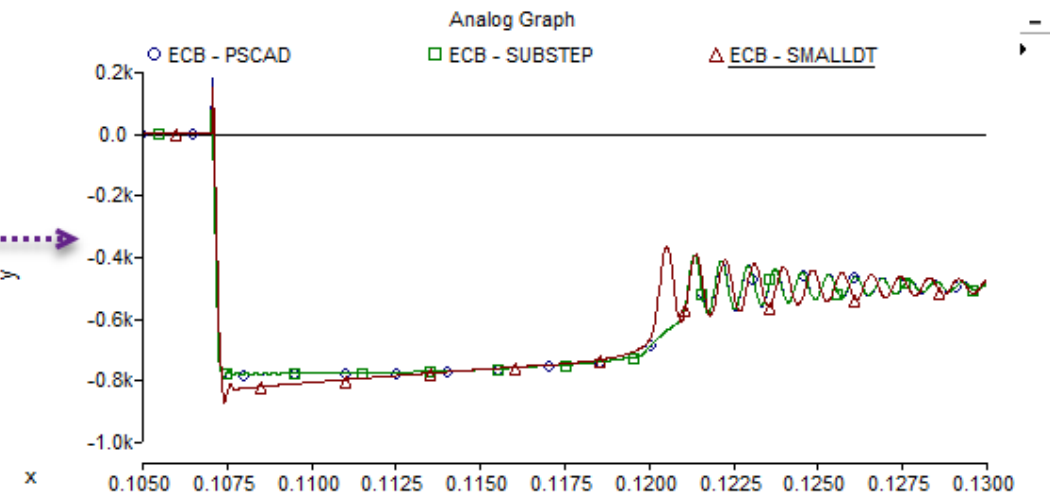
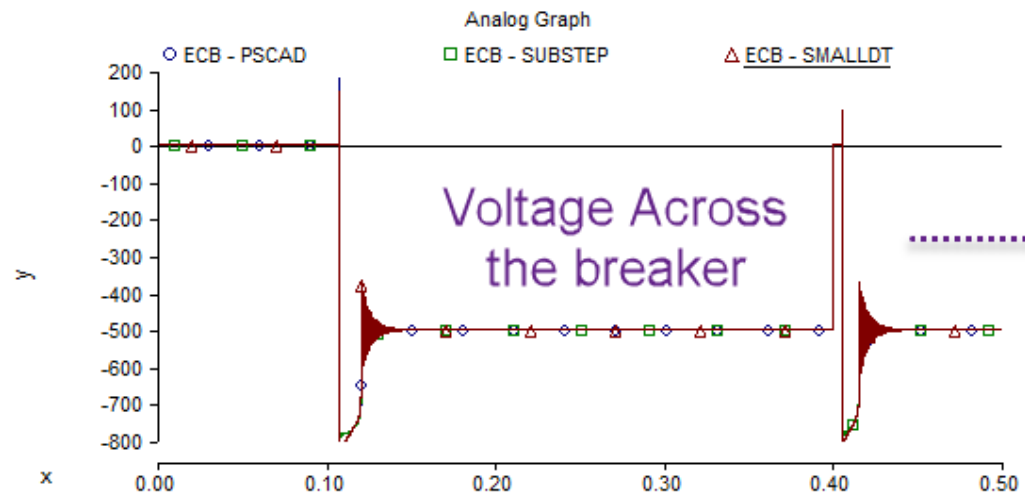
- Using LC switch representation on the power electronic switches (IGBT, Thyristor) has high possibility of giving wrong result (e.g., the failure of disconnection)
- Interface transmission line (Bergeron model) introduces additional voltage drop and current flowing path (virtual grounding capacitor), and possible high frequency oscillation
- An accurate arrester characteristic is necessary as it directly determines the V-I characteristic (energy) and consequently, the accurate action of the secondary breaking

Resonant Breaker I

- Two charged capacitor (large and small)

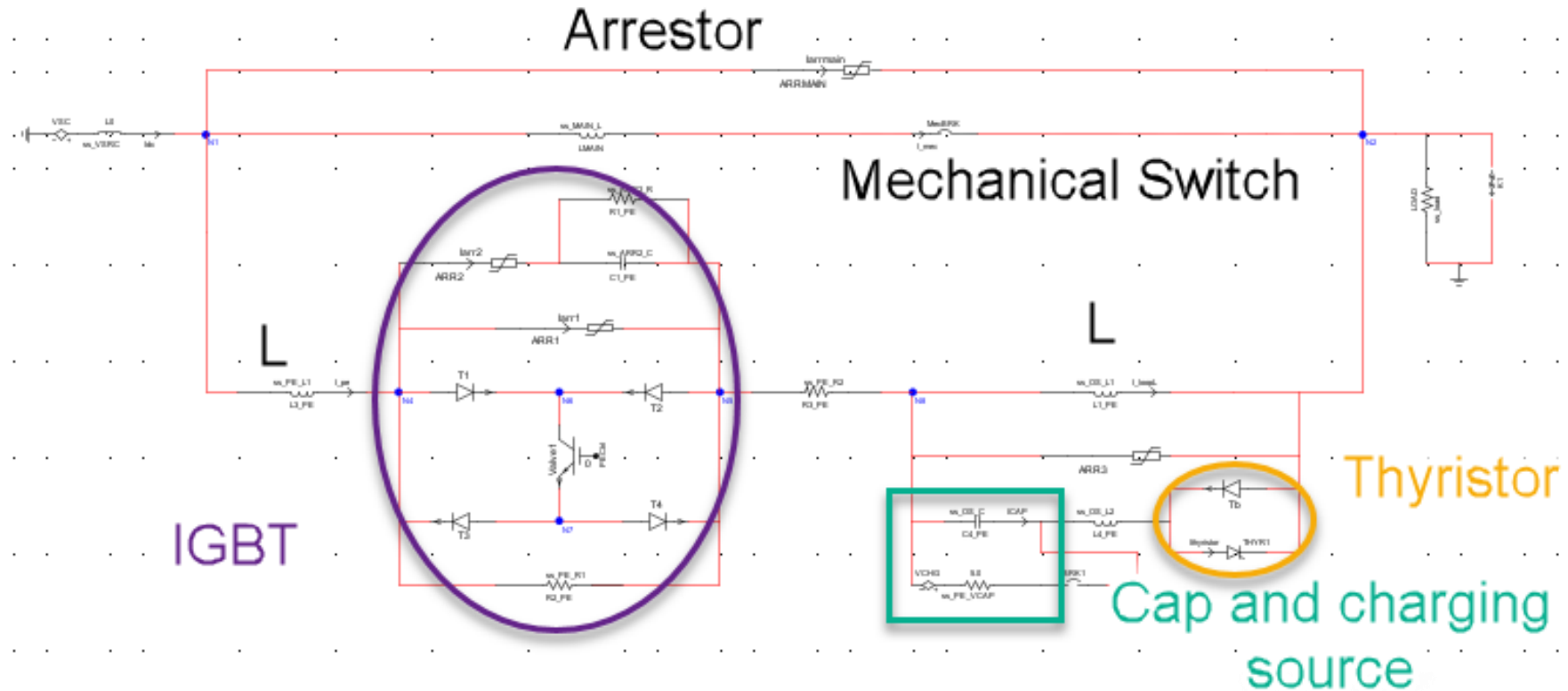


Resonant Type I - Result

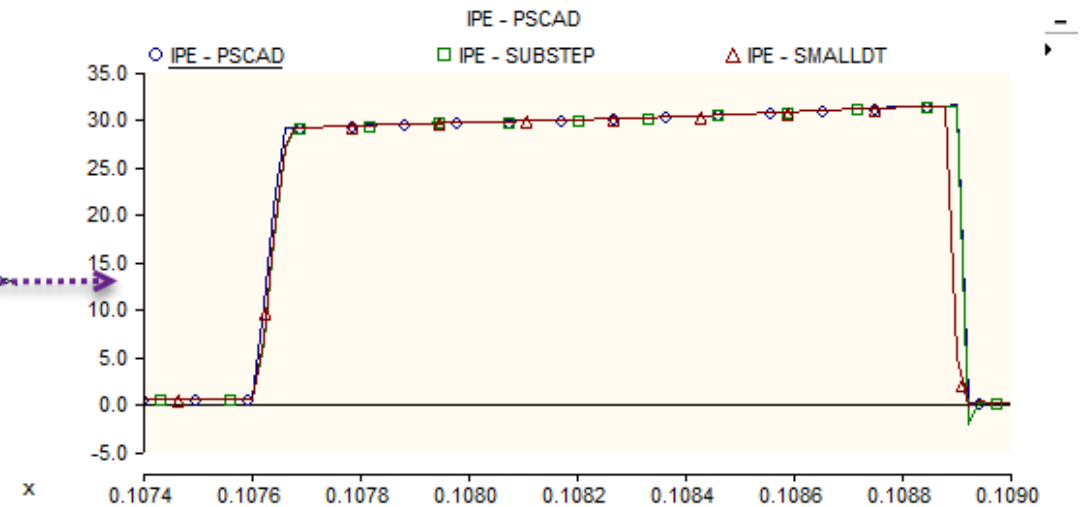
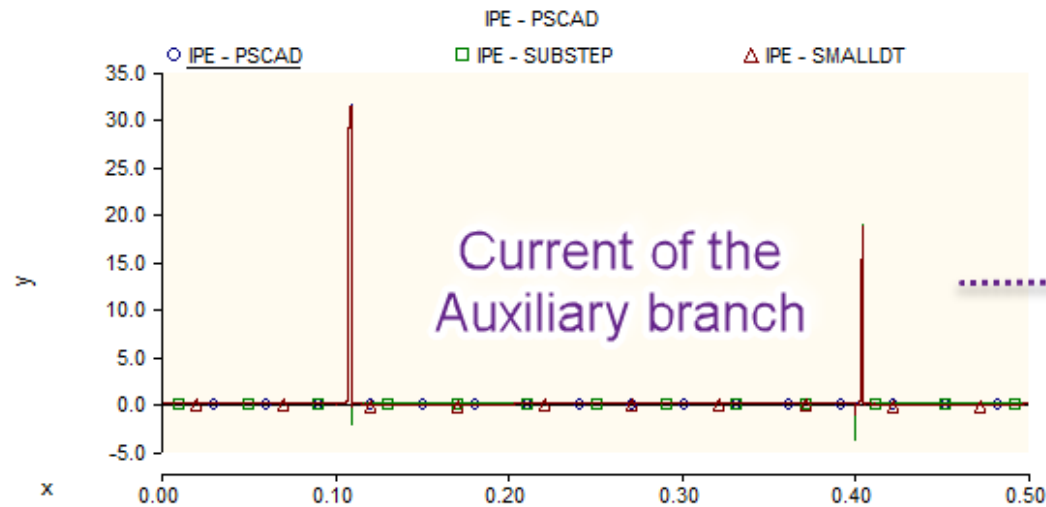
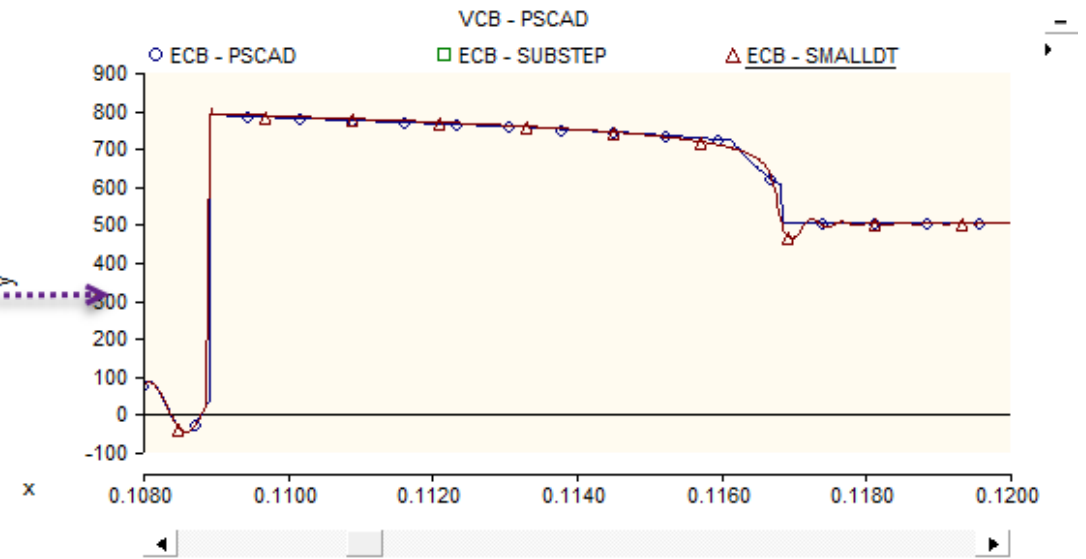
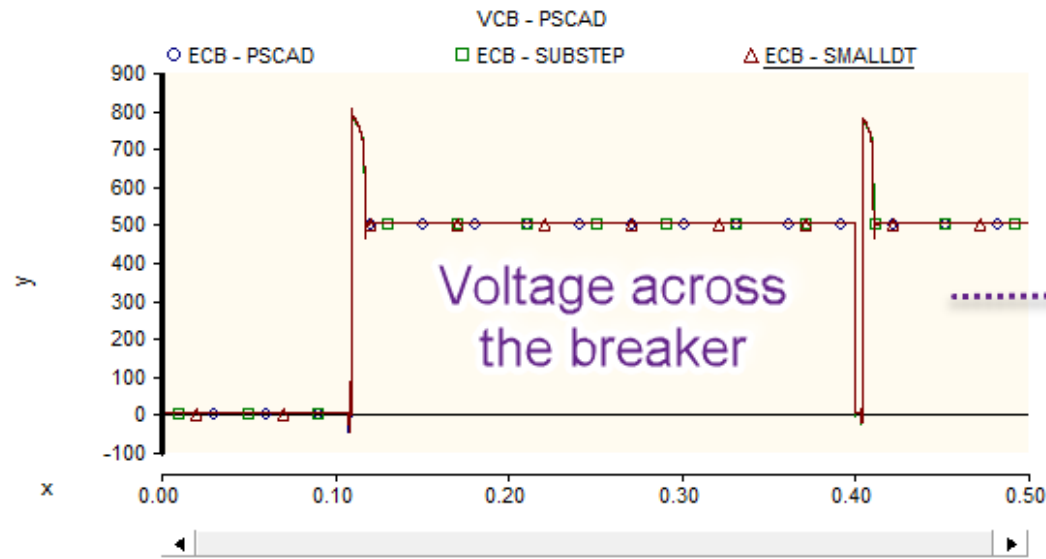


Resonant Breaker II

- One charged capacitor and use thyristor to restore capacitor energy

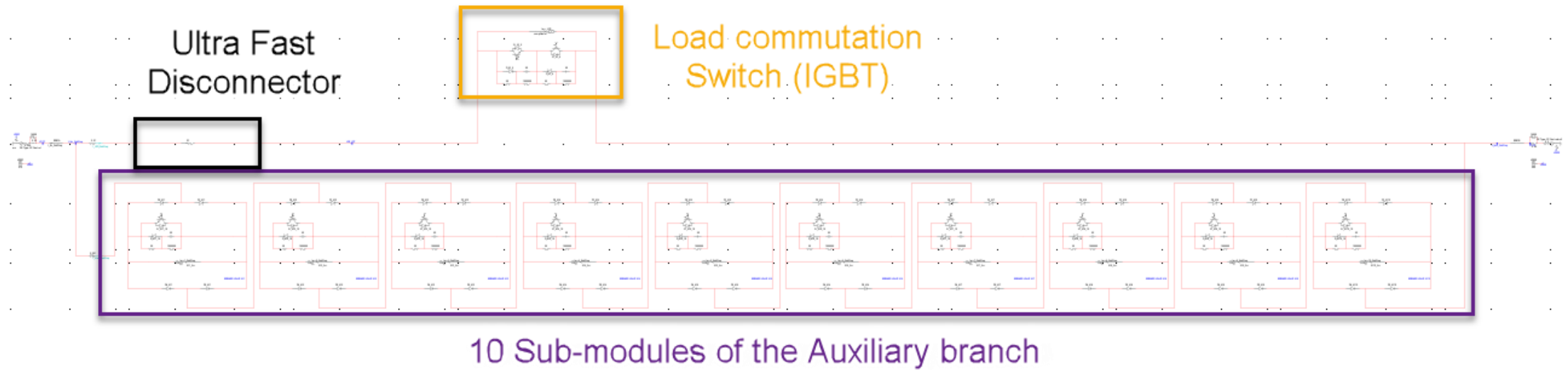


Resonant Type II - Result



Hybrid Breaker

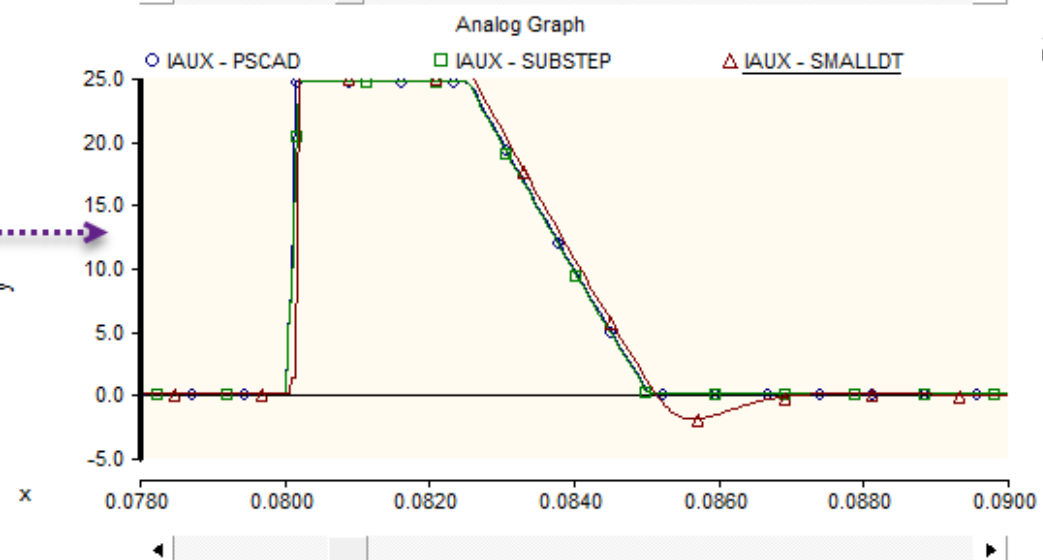
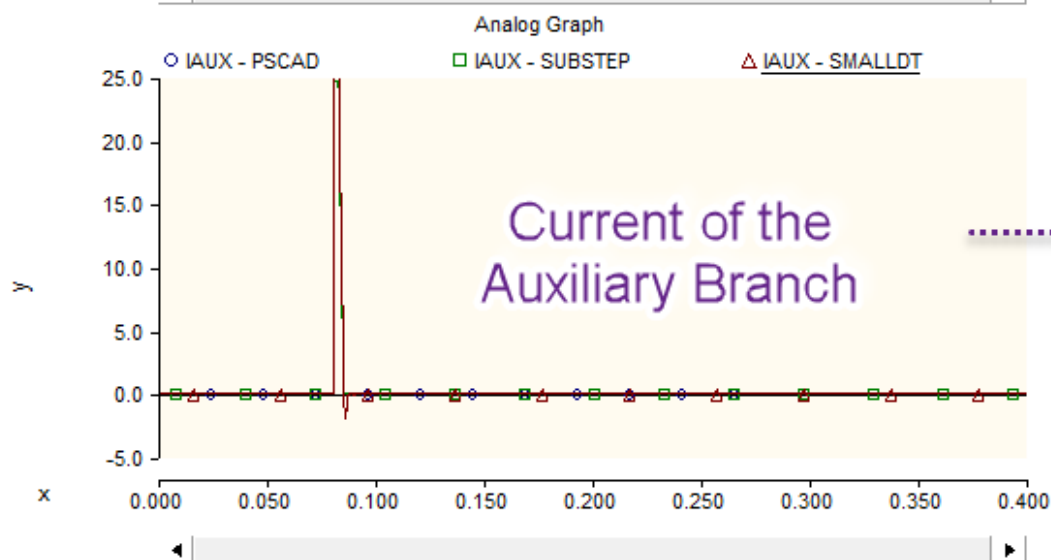
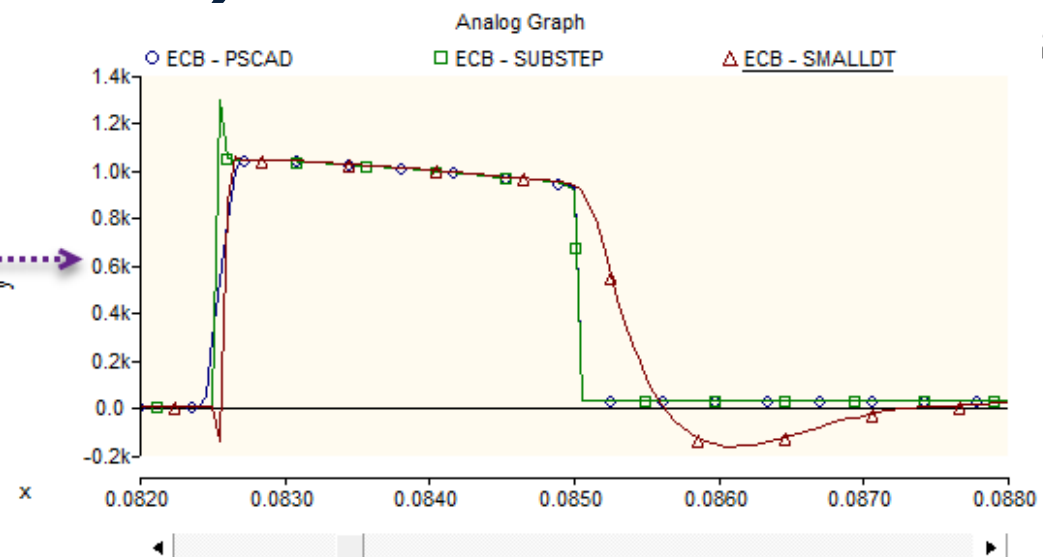
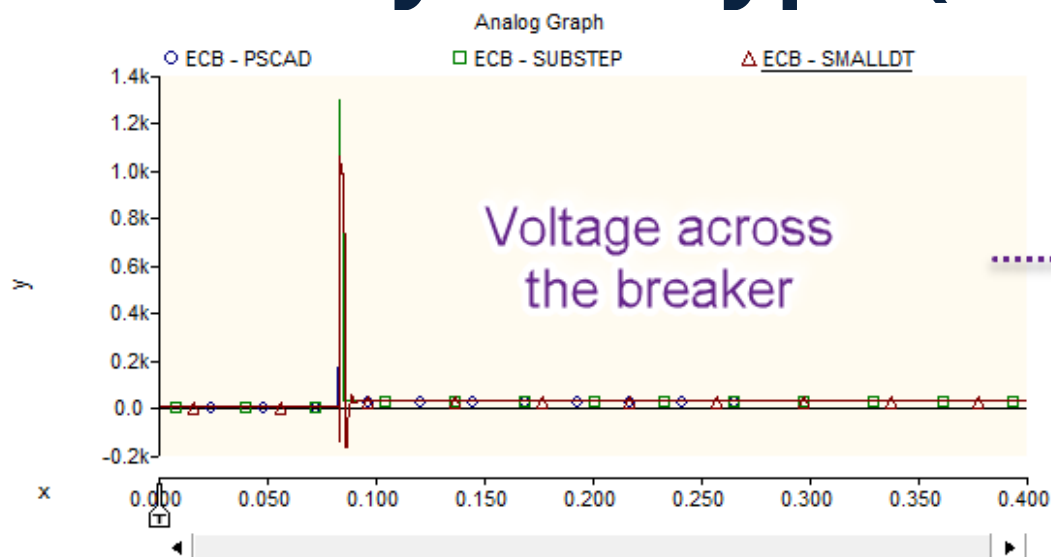
- Modelling of the sub-modules in the Auxiliary branch



52 Nodes; 64 IGBTs / Diodes; 11 Arrestors

Can be simulated in SUBSTEP with a time step of 4.167us

Hybrid Type (in detail) - Result



Conclusion

- Substep environment can provide **exactly the same** model representation as in PSCAD/EMTDC, and consequently identical result waveforms
- Substep environment enables the DC breaker modelled in detail, e.g., into sub-modules for manufacture test
- Avoid of using the switches of LC representation is necessary in the dc breaker modeling, as there are components with current zero-crossing logic (e.g., a breaker)

Thank you !

Questions?