Pulse power supply design for 4 HORNS (300nH)

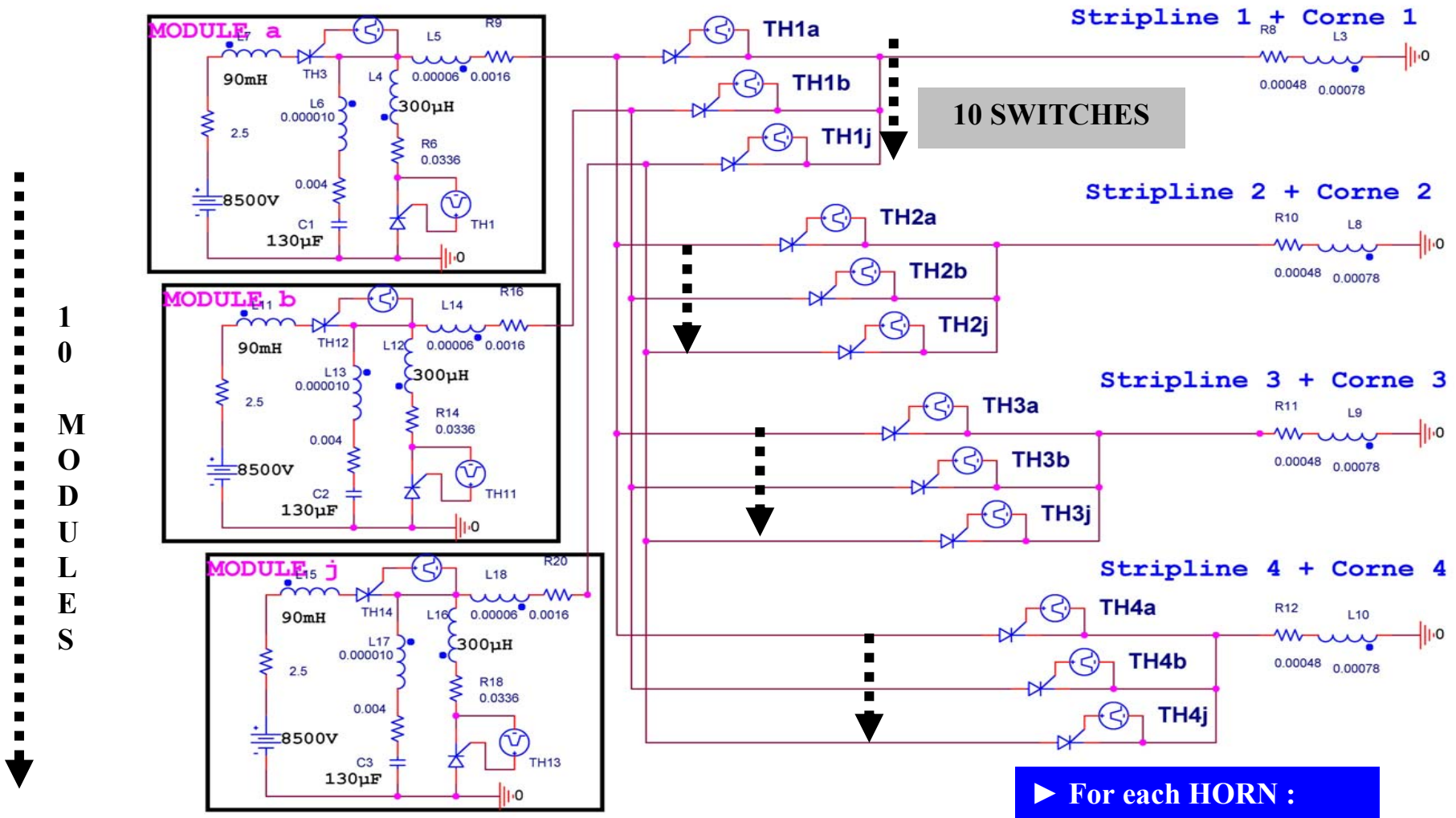
PLAN

- MODULARITY of the COMPLETE SYSTEM
  - *Method1*: Energy recovery with an inductor
  - *Method2*: Energy recovery with a freewheeling diode
- EVALUATION of the COSTS : comparison of the 2 methods. Benefits of an ideal stripline
  - Quantify numbers of thyristors vs constraints (dI/dt and dV/dt).
  - Chargers, capacitors, electric consumption.
- CONCLUSION

Pulse power supply design for 4 HORNS (300nH)

► each MODULE delivers a current of 35kA max at F=50HZ

MODULARITY of the COMPLETE SYSTEM



► For each HORN : current of 350kA max at 12.5HZ

EVALUATION of the COSTS of SWITCHES

			Recovery energy : With self recovery energy		Recovery energy : With freewheeling diode
Paramèters	Désignation		EUROnu5E-10v **Ideal Stripline** (0μΩ/m, 0μH/m)	EUROnu5C-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)	EUROnu6-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)
CONSTRAINTS on SWITCHES which SUPPLY HORN (F=12.5Hz)					
	Thyristor T 1503 NH				
VRRM	Reverse maxi voltage	**-8000 V**	**-6500V**	**-16000V**	**-3100V**
I RMS ON	RMS current	**3900 A**	**1750 A**	**1750 A**	**3000 A**
ITSM	SURGE current	**57 kA**	**35 kA**	**35 kA**	**35 kA**
dI/dt maxi		**5 kA/μs**	**13.3kA/μs**	**32kA/μs**	**40kA/μs**
dI/dt nominal		**5 kA/μs**	**1kA/μs**	**1kA/μs**	**1kA/μs**
dV/dt maxi at TOFF		**2000 V/μs**	**5700V/μs**	**8500V/μs**	**2000V/μs**
Numbers of thyristors for 10 MODULES			**(3 lines of 2 thyristors in serial)X10X4 =240**	**(7 lines of 3 thyristors in serial)X10X4 =840**	**(8 thyristors in //)X10X4 = 320**
TOTAL COSTS for 10 MODULES	**1 K€/switch**		**240 K€**	**840 K€**	**320 K€**

COSTS of CHARGERS & CAPACITORS

Pulse power supply design for 4 HORNS (300nH)

Paramèters	Recovery energy : With self recovery energy		Recovery energy : With freewheeling diode
	EUROnu5E-10v **Ideal Stripline** (0μΩ/m, 0μH/m)	EUROnu5C-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)	EUROnu6-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)
CHARGERS (F=50Hz)			
V SUPPLY	**4000V**	**8500V**	**5200V**
I MAX	**200A**	**260A**	**1250A**
I RMS	**114A**	**148A**	**780A**
Total Average Power (per s)	**456KW**	**1260KW**	**4MW**
Numbers of 25KJchargers	**20**	**50**	**160**
Total Costs CHARGERS	**456 K€**	**1260 K€**	**4000K€**
CAPACITORS (F=50Hz)			
Total VALUE	**2900μF**	**1300μF**	**1200μF**
+VMAX et VMIN	**+3700/-3500V**	**+8900/-8500V**	**+9500V/-1500V** (*) minus voltage is lower
Total ENERGY	**20KJ*50=1MJ**	**47KJ*50=2.34MJ**	**54,15KJ*50=2,7MJ**
Total VOLUME (M3) Total WEIGHT (T)	**2.7** **3.2**	**6.3** **7,6**	**7.3M3-35% (*) =4.75** **5.7**
Total COSTS (50K€/T)	**160 K€**	**380 K€**	**285 K€**
TOTAL chargers+capacitors	**616 K€**	**1640 K€**	**4285 K€**

COSTS of CONSUMPTION in ERNERGY :

		Recovery energy : With self recovery energy		Recovery energy : With freewheeling diode
Parameters		EUROnu5E-10v **Ideal Stripline** (0μΩ/m, 0μH/m)	EUROnu5C-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)	EUROnu6-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)
CHARGERS (F=50Hz)				
Total Average Power (per second)		**456KJ**	**1260KJ**	**4MJ**
COSTS in ENERGY CONSUMPTION				
Consumption per hour		**1641 MJ**	**4534 MJ**	**14394 MJ**
STROM COSTS per year (200J) @ 41.82€ per MWh		**91.5 K€**	**253 K€**	**803 K€**

COSTS SUMMARY

	Recovery energy : With self recovery energy		Recovery energy : With freewheeling diode
	EUROnu5E-10v **Ideal Stripline** (0μΩ/m, 0μH/m)	EUROnu5C-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)	EUROnu6-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)
SWITCHS HORNS	**240 K€**	**840 K€**	**320 K€**
CHARGERS	**456 K€**	**1260 K€**	**4000K€**
CAPACITORS	**160 K€**	**380 K€**	**285 K€**
TOTAL	**856 K€**	**2480 K€**	**4605 K€**
STROM COSTS per year (200J) @ 41.82€ per MWh	**91.5 K€**	**253 K€**	**803 K€**

CONCLUSION

	Recovery energy : With self recovery energy		Recovery energy : With freewheeling diode
	EUROnu5E-10v **Ideal Stripline** (0μΩ/m, 0μH/m)	EUROnu5C-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)	EUROnu6-10v **Normal Stripline 30M** (10μΩ/m, 15nH/m)
COST	+	++++	++
ENERGY CONSUMPTION	+	+++	++++++
FIABILITE	-	----	--
RESULTS	+	+++	++++++

BEST SOLUTION in TERMS of COSTS & FIABILITY

COMPROMISE

GOOD SOLUTION in TERMS of FIABILITY

WORK PLANNING for the NEXT TIME

- **SIMULATION with a 900nH HORN**
  - **With self recovery vs type of stripline**
  - **Effect of SNUBBER (in // horn switches) to reduce dV/dt and to limits the numbers of total thyristors**
- **REQUEST PRICES from VENDORS**
  - **Wait stable DEFINE PROJECT**
  - **<u>Define characteristics of the others components</u> (charger inductor, recovery switch and inductor, measure of precision current and voltage, stripline grounding, electronic system management,…)**
  - **Many potential vendors in account (see list at slide 9)**

List of VENDORS

Chargers :
- Pulse MC2 (25KJ HVP GH2525-M1)
- TECHNIX (20KJ 10kV-4A)
- FUG ELECTRONIK
- LAMBDA EMI
- OCEM

Capacitors :
- AVX France
- Pulse MC2 (General Atomics)
- VISHAY
- NORFOLK CAPACITORS LTD
- Athesys

Selfs (charger and recovery) :
- TRANSRAIL
- N'ERGY
- TRASFOR SA/CH
- CEFEM

Mesure of current and high voltage :
(35kA@ 100µs)
- *PEMUK (+-1%)*
- *LEM (+-1%)*
- *PEARSON (<0.1%)*
- *STANGENESS*

Stripline grounding (human safety vs high voltage return)
- *CEFEM*
- *SOCOMEC*