HIGH PRESSURE GRINDING ROLL (HPGR) MACHINE CONTROL METHODS

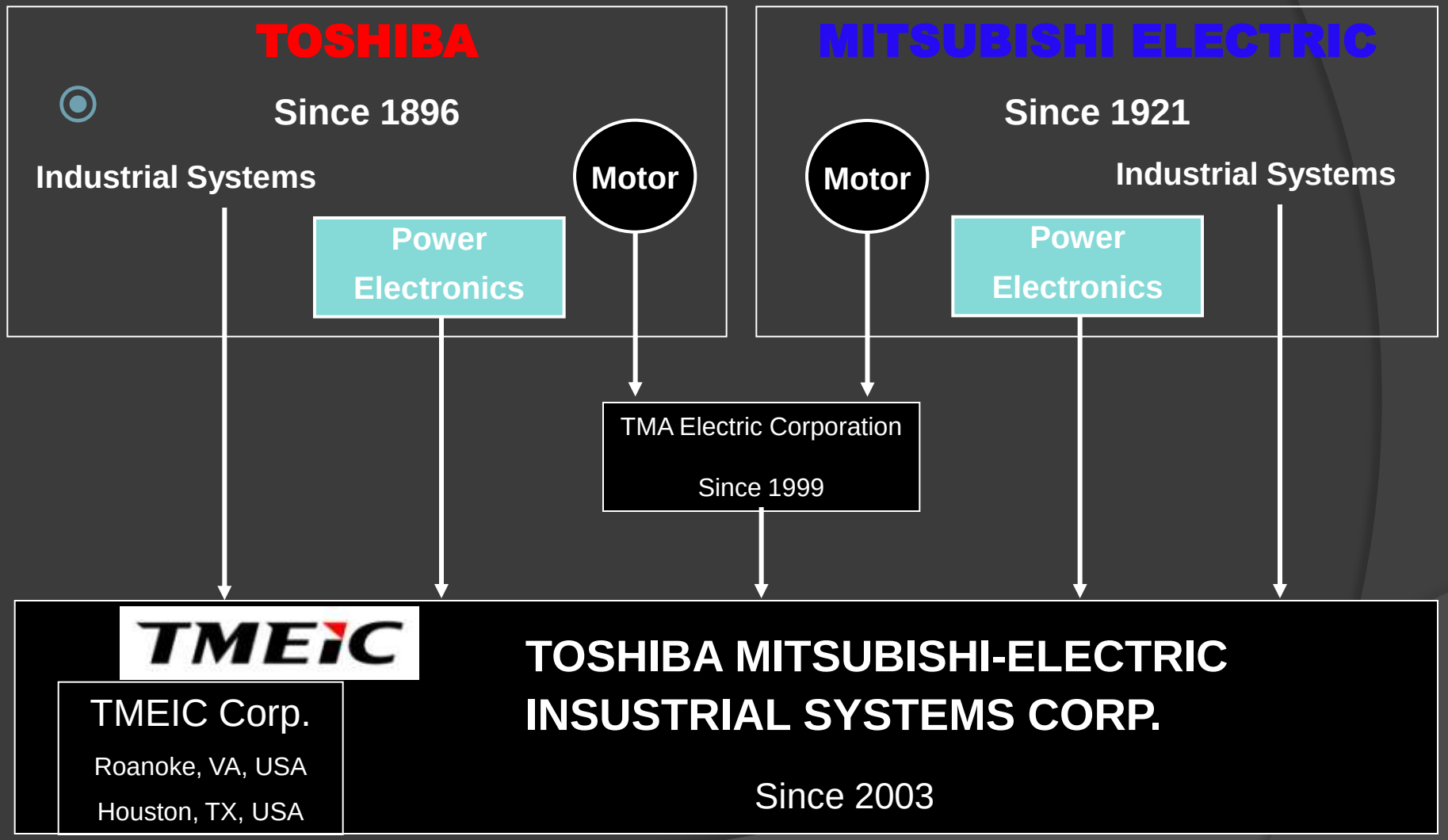
Michael Uliana
Technical Sales Manager

TMEIC
We drive industry

2012 – WMEA San Antonio Meeting and Technical Symposium
San Antonio, TX, November 16, 2012

MEMSA
Mining Electrical Maintenance & Safety Association

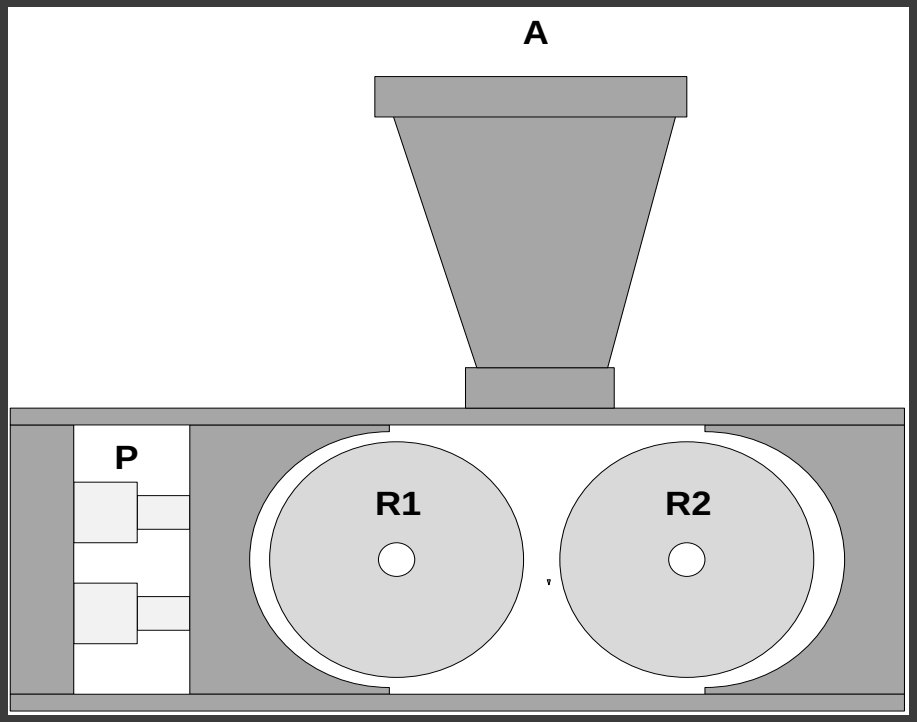
Who is TMEIC?


TOSHIBA
Since 1896
Industrial Systems
Motor
Power Electronics
MITSUBISHI ELECTRIC
Since 1921
Motor
Industrial Systems
Power Electronics
TMA Electric Corporation
Since 1999
TMEIC
TMEIC Corp.
Roanoke, VA, USA
Houston, TX, USA
TOSHIBA MITSUBISHI-ELECTRIC INSUSTRIAL SYSTEMS CORP.
Since 2003

Presentation/Paper outline

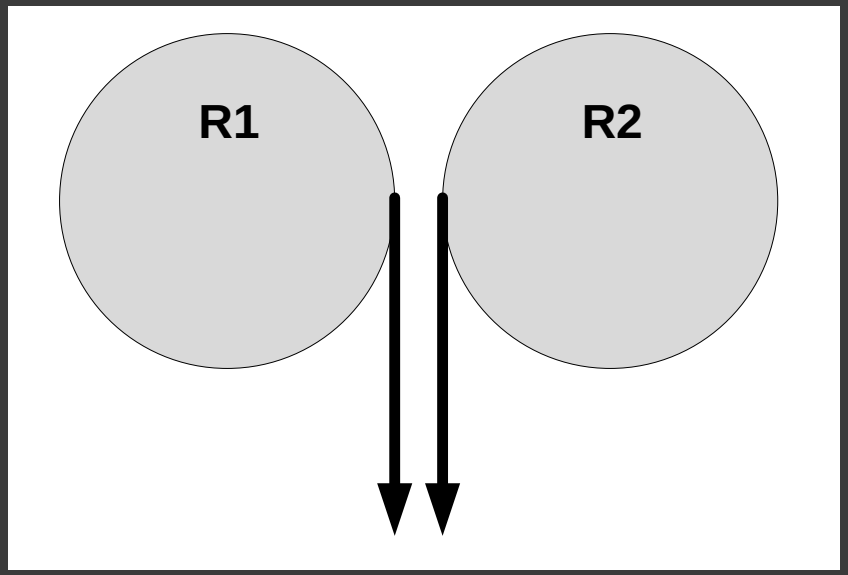
- HPGR Machine Design
- Control Methods
- Conclusion

What is an HPGR Machine?



- Material is crushed between two independently driven rolls
- Hydraulic pressure is applied to maintain a specified gap
- An autogenous layer forms on the rolls to protect the roll surface

HPGR Machine Design



Maintaining the same roll tangential velocity is important:

- **Helps maintain the autogenous layer**
- **Minimizes roll wear**
- **Increases uptime**

HPGR Machine Design (cont.)

Industries using this technology:

- **Cement (very common, mostly fixed speed)**
- **Mining (becoming more common, variable speed)**

- **Why?**
  - **Potential energy savings v/s other grinding methods**
  - **Roll life becoming longer**

HPGR Machine Design (cont.)

Control Concerns:

- **When starting the mill, no connection between the rolls**

  How do you maintain speed?

- **While running, rolls are essentially connected by ore being crushed**

  How do you share load?

- **Rolls are not absolutely identical and can wear at different rates.**

  How do you keep the tangential velocity the same?

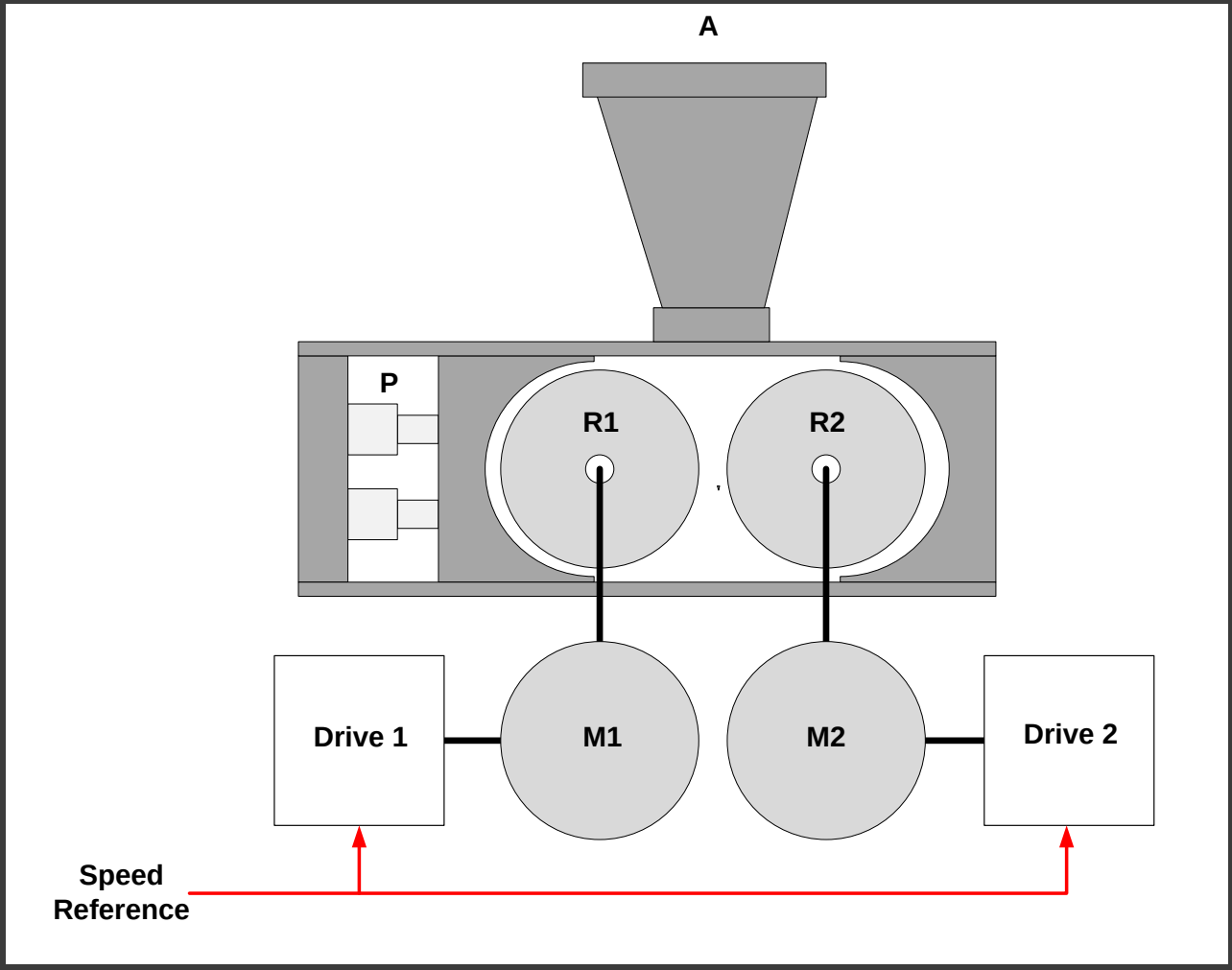
Potential Control Solutions

1. Independent Speed Regulators

2. Torque Regulation

3. Master-Follower Arrangement

Independent Speed Regulation



Independent Speed Regulation

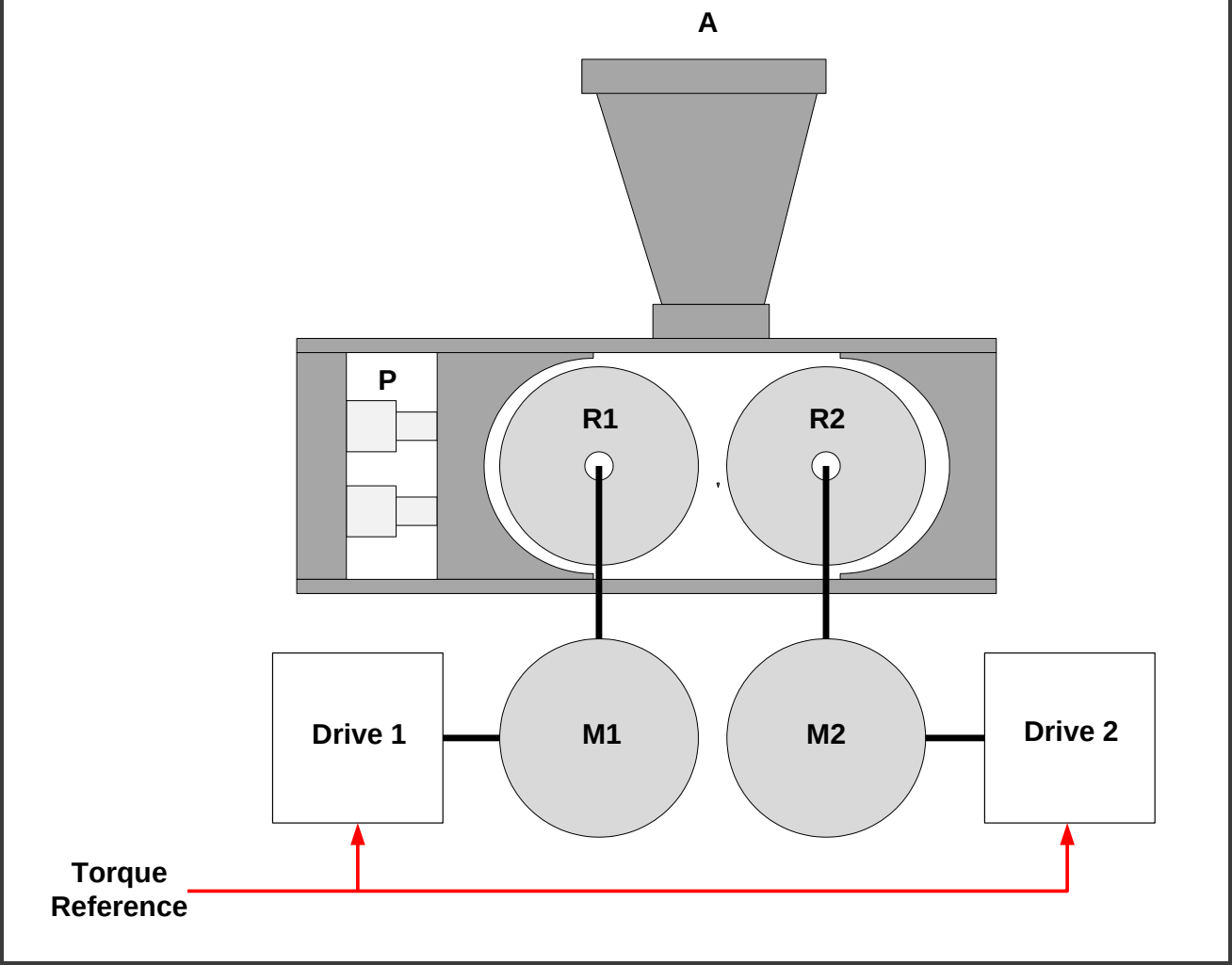
Benefits:

- **Speed control during startup**

Concerns:

- **Load sharing**
- **Tangential Velocity**

Torque Regulation



Torque Regulation

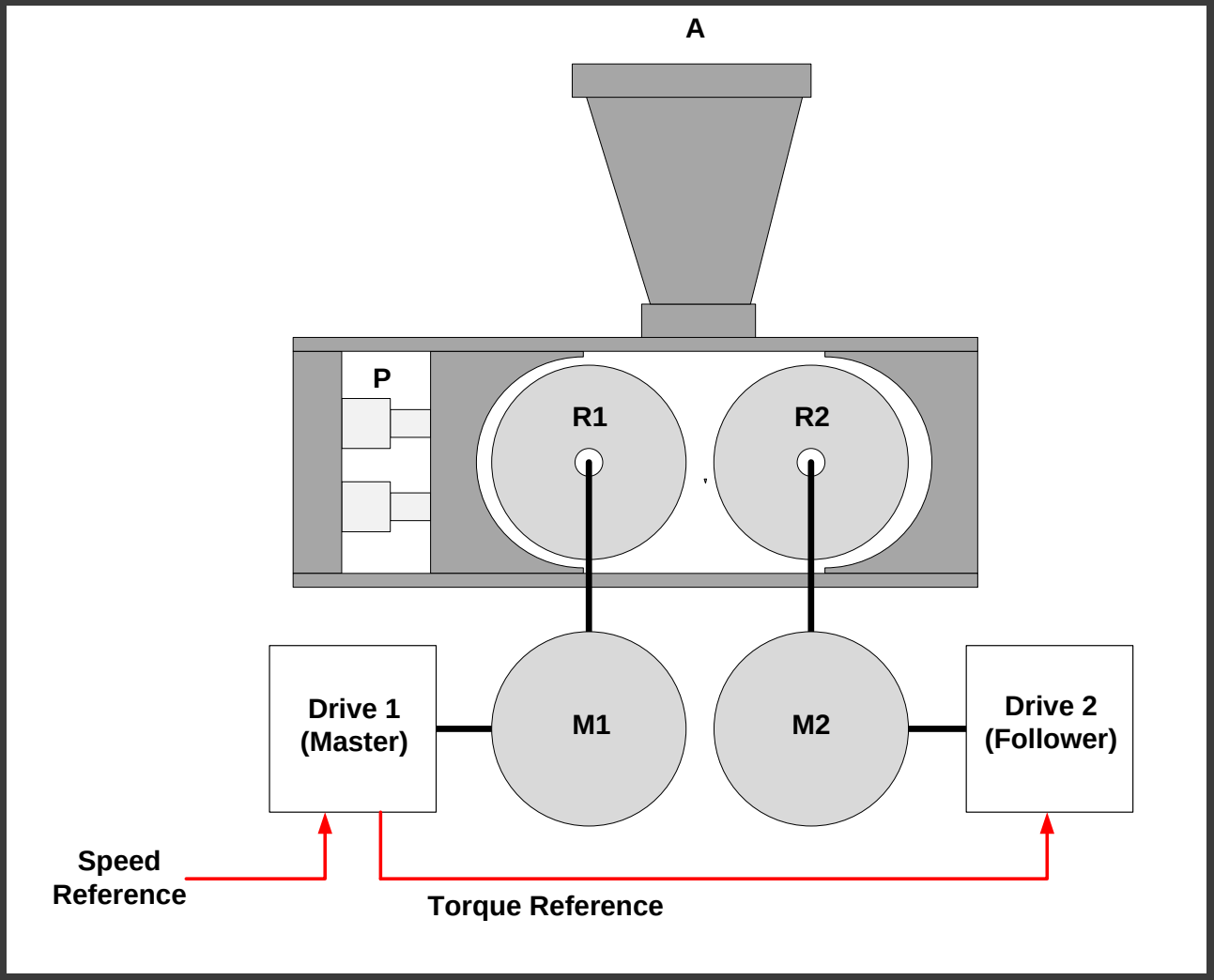
Benefits:

- **Even Load sharing**

Concerns:

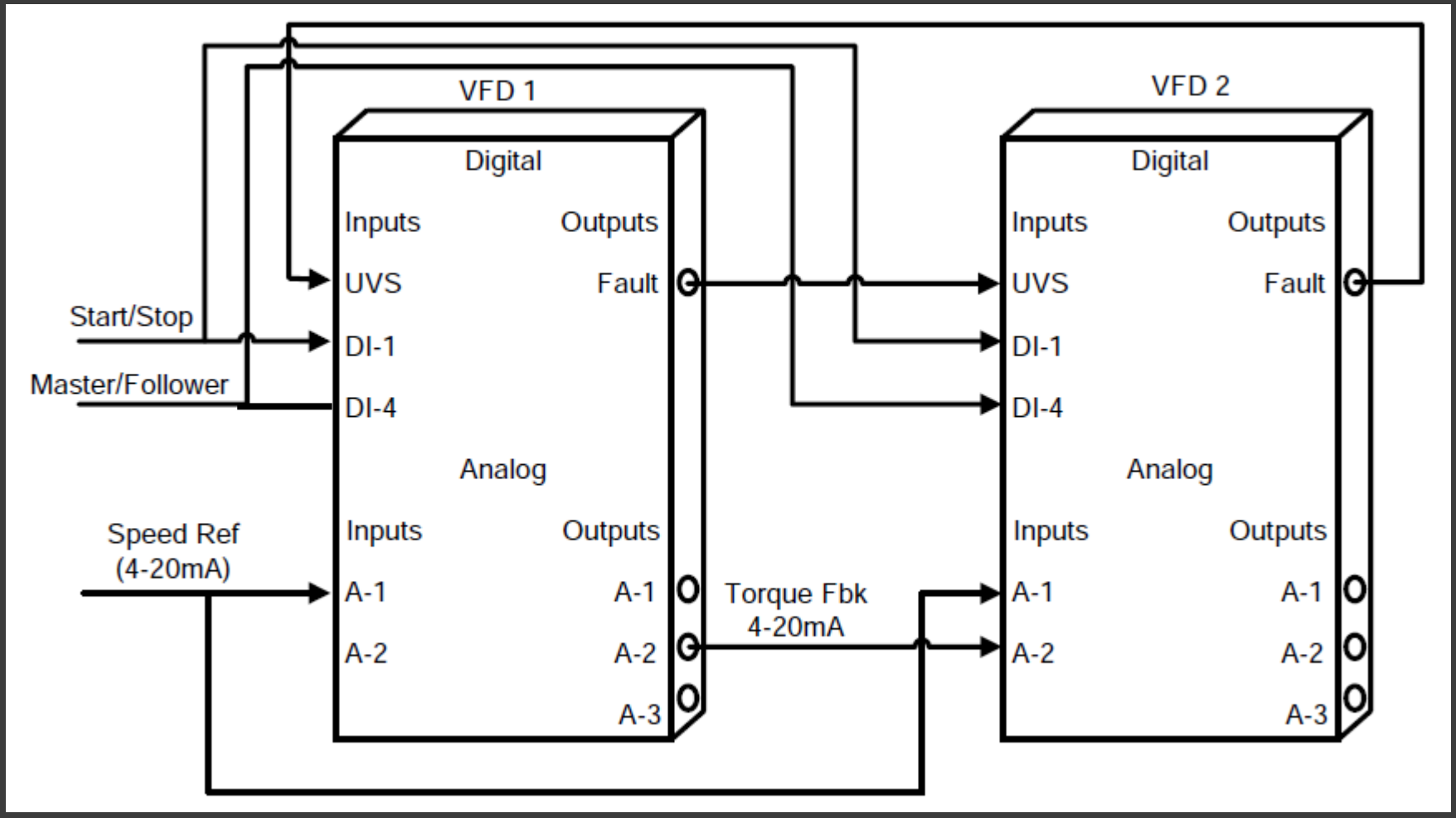
- **Speed control**
- **How is the torque reference generated?**

Master – Follower Arrangement



Master – Follower Arrangement

- The “master” drive operates as a speed regulator
- The “follower” drive operates as a torque follower



Master – Follower Arrangement

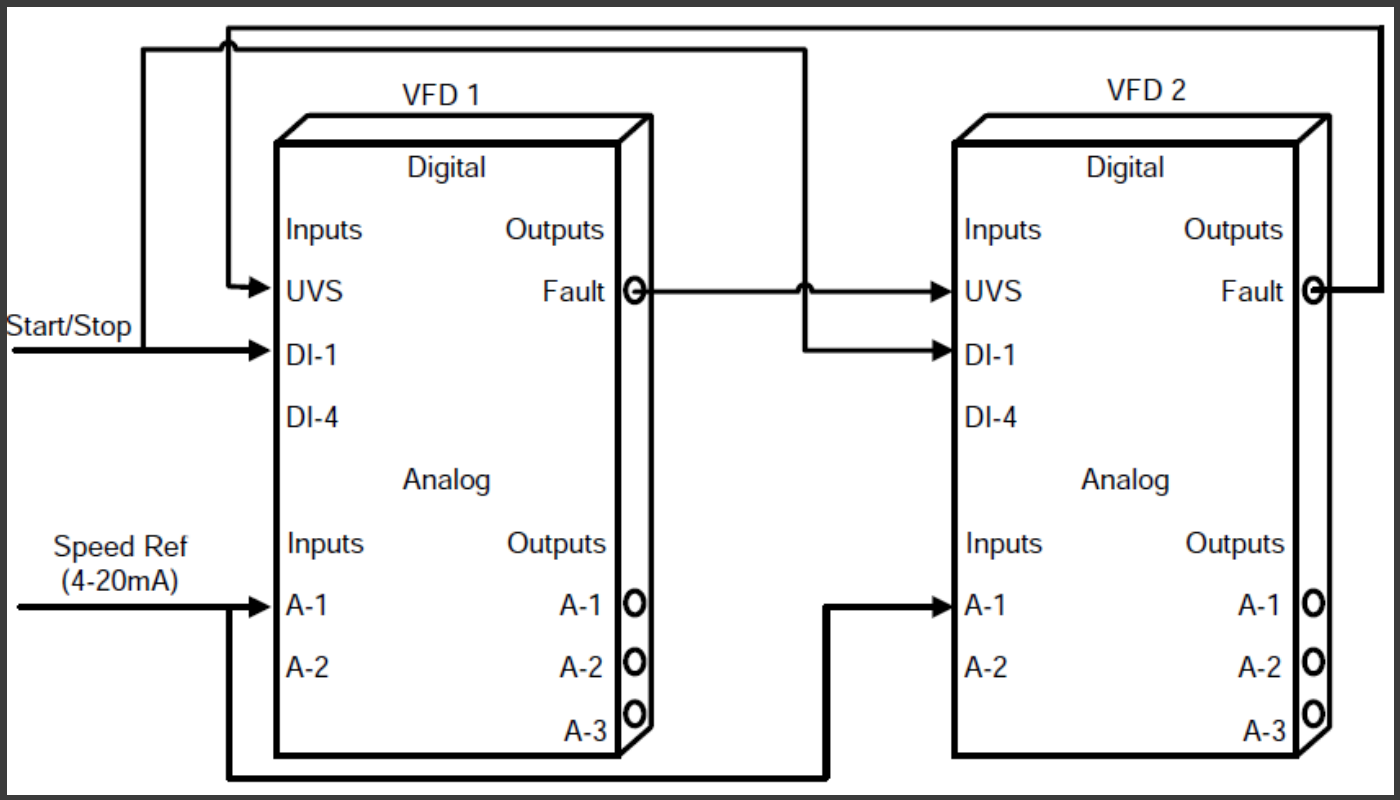
Benefits:

- **Even Load sharing**
- **Good at maintaining tangential velocity**
- **Utilizes a speed reference**

Master – Follower Arrangement

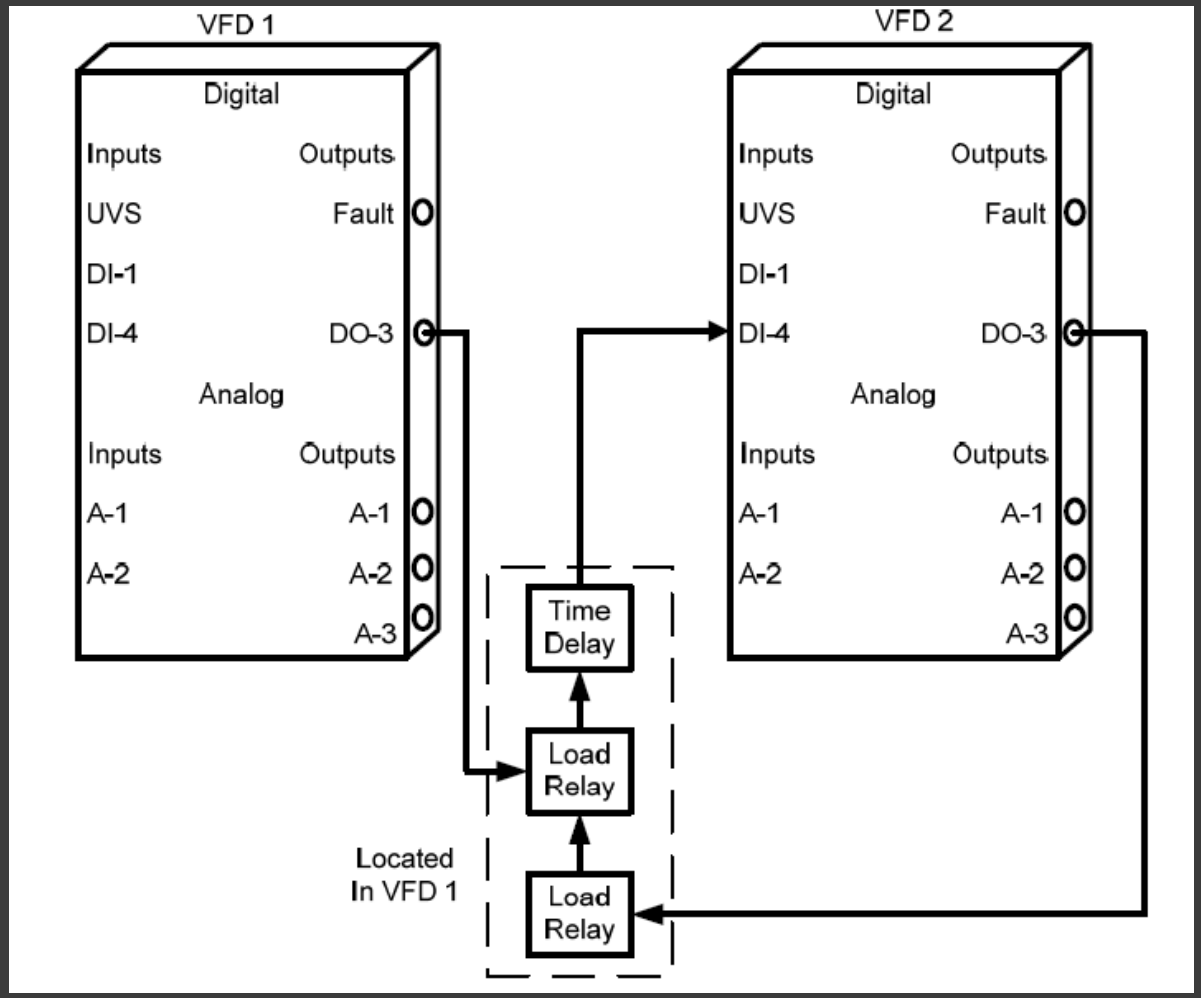
Sequencing: Uses different control schemes for startup and operation.

1. Mill starts up with both drives in speed regulation



Master – Follower Arrangement

2. Drives monitors torque and shifts to master-follower mode when the load threshold is met



Master – Follower Arrangement

Additional Functionality: OR Regulator

- **Monitors actual drive speed v/s the speed reference.**

- **If measured speed diverges from reference speed the follower drive will shift back to speed regulate**

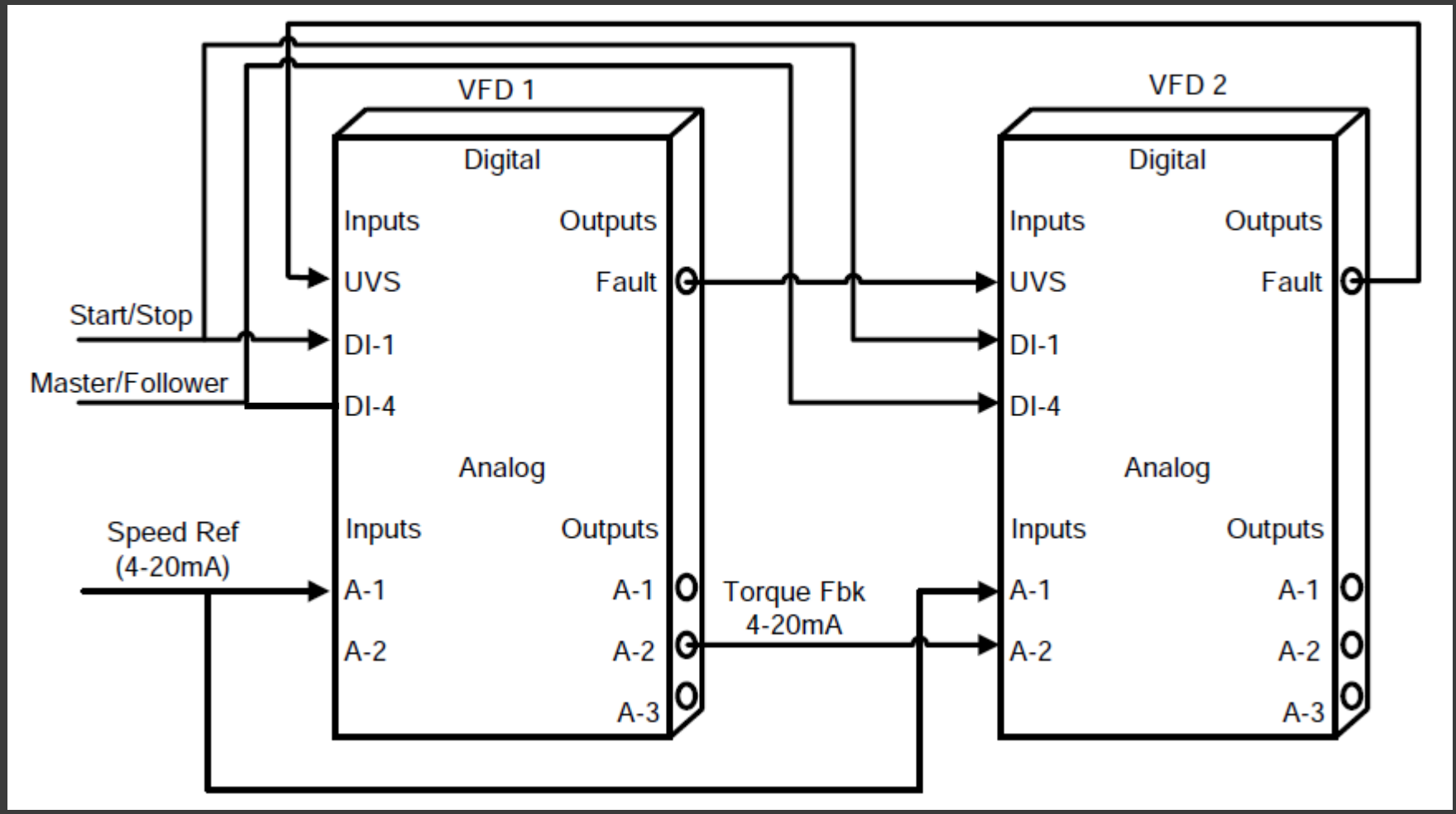
Master – Follower Arrangement

Additional Functionality: Master Drive Selection

- **Either drive can be designated as the master**
- **Selector switch on Drive #1 cabinet used in this example**

Master – Follower Arrangement

Master Drive Designation

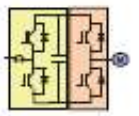
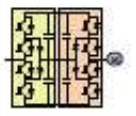
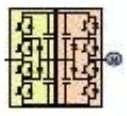
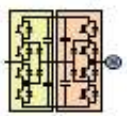
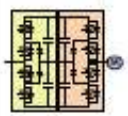
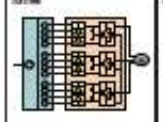
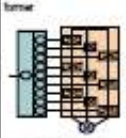
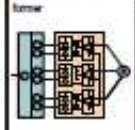
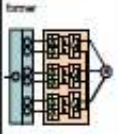
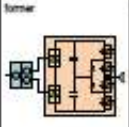
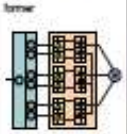
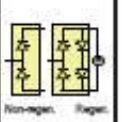


Conclusions

After analyzing various control methods for HPGR machines we determined an effective way to control the system is via a Master-Follower arrangement

TMEIC Drive Line

TMEIC Drive Specifications

Product	LV AC Drive	MV AC Drive										DC Drive
	TMdrive-10/10A (inverter) TMdrive-P10/T10 (converter)*	TMdrive-30 TMdrive-P30/T30	TMdrive-50 TMdrive-P50/60	TMdrive-70 TMdrive-P70/70	TMdrive-80 TMdrive-P80/80	Dura-Bilt5 for North America	TMdrive-MVG	TMdrive-XL55	TMdrive-XL75	TMdrive-XL80	TMdrive-XL85	TMdrive-DC (LEGEND MEDIUM)
Typical View												
Line-side converter	Common converter with IGBT(P), diode(D) or thyristor (T)*	Common converter with IGBT (P), diode (D) or thyristor (T)	Common converter with IGBT (P), diode (D)	Common converter with IEGT (P), or diode (D)	Common converter with GCT (P) or diode (D)	24 pulse diode converter	Diode converter 18 pulse (3.3 kV) 18 or 36 pulse (6.6 kV) 54 pulse (10 kV) 30 pulse (11 kV)	36 pulse diode converter	36 pulse diode converter	12 or 24 pulse diode converter	36 pulse diode converter	Thyristor
Inverter	2 level PWM*1	3 level PWM-NPC*1	3 level PWM-NPC	3 level PWM-NPC	3 level PWM-NPC	3 level PWM-NPC (2.3 kV) 5 level PWM (4.16 kV)	Multilevel PWM	5 level PWM	5 level PWM	3 level PWM-NPC	5 level PWM	—
Device in inverter	IGBTs	IGBTs	IGBTs	IEGTs	GCTs	IGBTs	IGBTs	IGBTs	IEGTs	GCTs	GCTs	—
Cooling system	Heatpipe air cooled	Heatpipe air cooled	Water cooled	Water cooled	Water cooled	Forced air cooled	Forced air cooled	Water cooled	Water cooled	Water cooled	Water cooled	Forced air cooled
Output voltage	460/575/690 V	1.25 kV	3.3 kV	3.3 kV	3.3 kV	2.3/4.6 kV	3.3/6.6/10/11 kV	6.6 kV	6 kV	3.8 kV	7.2 kV	440/750/900/1200 V
Maximum capacity	1460kVA/460 V 1720kVA/690 V	4,000 kVA	6,000kVA (2x3000 kVA)	40 MVA (4x10MVA)	25 MVA (2x12MVA)	2500 kVA/2.3 kV 5000 kVA/4.16 kV	3000 kVA/3.3 kV 6000 kVA/6.6 kV 10000 kVA/11 kV	16 MVA (2x8 MVA)	80 MVA (4x20 MVA)	30 MVA (2x15 MVA)	120 MVA (4x30 MVA)	850 kW/440 V 9100 kW/1200 V
Overload	150% - 60 sec.	150% - 60 sec.	150% - 60 sec.	150% - 60 sec.	150% - 60 sec.	115% - 60 sec.	125% - 60 sec.	100% - Cont.	110% - 60 sec.	110% - 60 sec.	110% - 60 sec.	150% - 60 sec.
Max output freq.	120 Hz	120 Hz	60/90 Hz	60/90 Hz	60/90 Hz	60/120 Hz	60/120 Hz (3.3/6.6 kV) 60/72 Hz (10/11 kV)	60/250 Hz	60/200 Hz	60/100 Hz	60/200 Hz	DC
Speed control	Resolver, Encoder, V/F*1 control, Sensorless	Encoder, Resolver, V/F control, Sensorless	Resolver, Encoder	Resolver, Encoder	Resolver, Encoder	Sensorless vector, V/F control	Sensorless vector, V/F control	V/F control, Sensorless vector	V/F control, Sensorless vector	V/F control, Sensorless vector	V/F control, Sensorless vector	Resolver, Encoder
Motor Type	Induction Motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Induction motor Synchronous motor	Synchronous motor	DC motor
Major applications	Process industries, Material handling, Dynamo meter	Metal processing, Marine, Mining	Metal processing, Marine, Mining	Metal rolling mills, Compressors, Utilities	Metal rolling mills, Compressors	Pumps, Fans, Blowers, Extruders, Mixers	Pumps, Fans, Blowers, Extruders, Mixers	Compressors, Pumps, Fans, Blowers, Extruders, Mixers	Compressors, Pumps, Fans, Blowers	Compressors, Pumps, Fans, Blowers, Extruders, Mixers	Compressors	Various applications
Features	-10: max. 8 stages -10A: max. 12 stages	Compact with heatpipe technology, Regen with IGBT/Thyristor	High efficiency, Clean AC power, Compact	High efficiency, Clean AC power, Compact	High efficiency, Clean AC power, Compact	Clean AC power, No sensor required for most applications	Clean AC power, No sensor required for most applications	Clean AC power, No sensor required for most applications	Clean AC power, No sensor required for most applications	Clean AC power, No sensor required for most applications	Higher efficiency and PF compared to LCI or Cycloconverter	Upgrade is possible by replacement
Circuit Diagram	TMdrive-P10, -10  In case of IGBT converter	TMdrive-P30, -30  In case of IGBT converter	TMdrive-P50, -50  In case of IGBT converter	TMdrive-P70, -70 	TMdrive-P80, -80 	Trans- former Cells  In case of 4.16 V	Trans- former Cells  In case of 3.3 kV	Trans- former TM-XL55 	Trans- former TM-XL75 	Trans- former TM-XL80 	Trans- former Cells 	Non-regen. Regen 

Customer Success, Every Project Every Time!

Questions?