



Surface Mount PCF Well



# DESIGN, DEVELOPMENT AND TESTING OF A VOLTAGE RIDE-THRU SOLUTION FOR VARIABLE SPEED DRIVES IN OIL FIELD APPLICATIONS

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# Introduction

- Boscan Oil Field (Maracaibo, Venezuela)
- 255 km of exposed 24 kV line
- High exposure of lightning and temporary faults
- Field uses Electrical Submersible Pumps (ESP), Beam Pumps and Progressive Cavity Pumps (PCP) all on Variable Speed Drives (VSD)
- PCP's have 8 hours of downtime for short duration 3-10 cycle events – very costly
- Ride-thru required for VSD's on PCP's



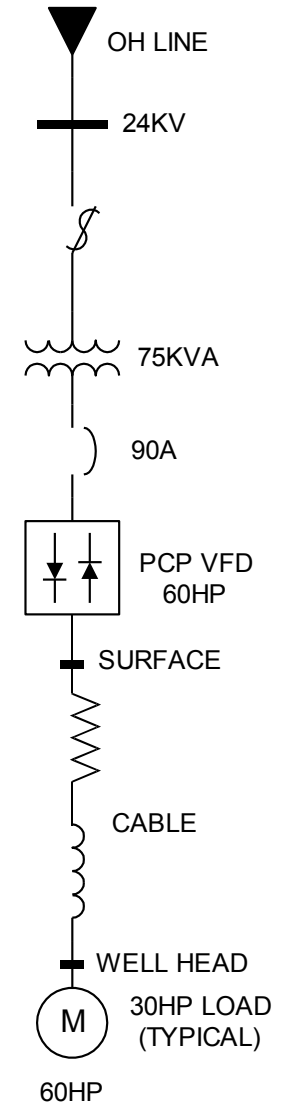
# Equipment Specification

- Typical single line diagram of system
- Table II – Site Specific Requirements

| Specification                     | Target                  |
|-----------------------------------|-------------------------|
| Ride-through time                 | 250 ms minimum*         |
| Min acceptable DC bus voltage     | 90 % of nominal         |
| Max power on 60 hp PCP drive      | 30 hp**                 |
| Maximum voltage disturbance       | Full interruption (0 V) |
| Firmware adjustments to drives*** | None                    |
| Target cost per drive             | \$10k                   |
| Enclosure                         | NEMA 3R (outdoor)       |

- \* 250ms allows for the typical recloser operating times of 180ms or 200ms for this application
- \*\* Typical loading on PCP drives
- \*\*\* With multiple vendors/drives, Chevron was reluctant to modify existing firmware on each drive

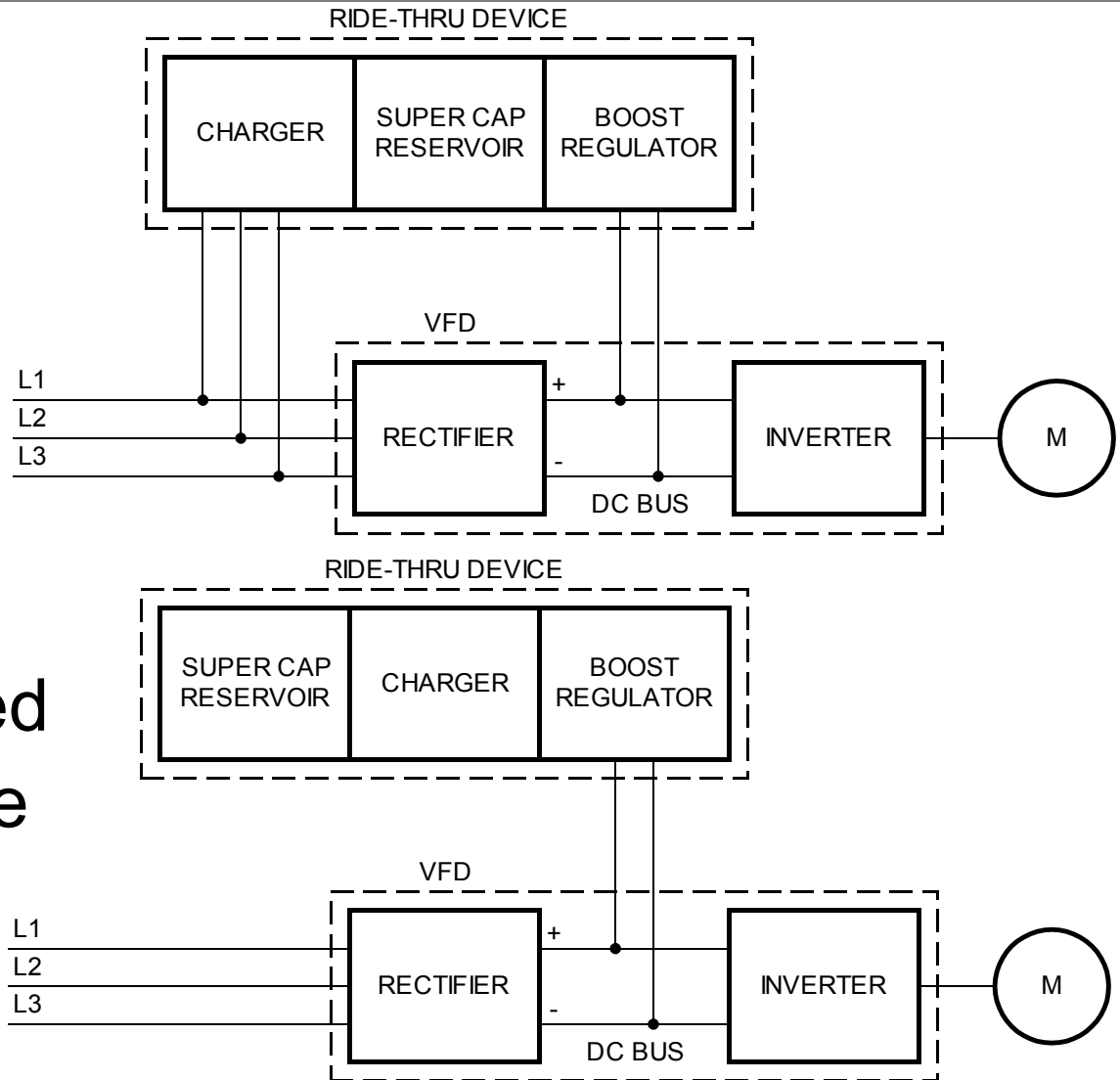
- Solution must work for existing and retrofit applications



# Equipment Specification

## Ride-thru designs

- AC charged capacitor
- Capacitor charged with existing drive charging circuit





# Prototype Development

Table III – Prototype Specification

| Requirement                    | Specification           |
|--------------------------------|-------------------------|
| Ride-through time              | 700 ms*                 |
| Nominal Voltage                | 480 V                   |
| Maintained DC Bus Voltage      | 90 % of nominal         |
| Ride-through type              | Ultra-capacitors        |
| Capacitor Rating               | 22 kW/50 kJoules        |
| Maximum voltage disturbance    | Full interruption (0 V) |
| Firmware adjustments to drives | None                    |
| Actual Cost per Drive          | \$9-12 k                |
| Enclosure                      | NEMA 3R (outdoor)       |
| Connection Type                | 3-phase plus DC Bus     |
| Protection Type                | Fuse and Disconnect     |
| Dimensions                     | 42"X36"X16"             |

\* Based on expected loading of 30 hp on the 60 hp drive

# Prototype Development

(AC) Charging Circuit

DC Bus Regulator

Ultra-capacitors





# Prototype Testing

- Test Results Summary
  - Excellent ride-thru of 700 ms (42 cycles) at 0V for the existing 60 hp PCP drive loaded to 30 hp.
  - At 40 hp load (higher than the normal loading on these drives), the ride-thru exceeded 300 ms.
  - The minimum requirement of 250 ms was met for both loading conditions which would allow for all expected recloser operations. This allowed for application of the same ride-thru module on all existing PCP drives (retrofit) operating at various load levels.
  - Comparable results were recorded on a new 60 hp drive. Actually, the prototype gave slightly better performance on the new drive as it was able to withstand 1000 ms (60 cycles) at 0V.



# Field Results

- 6 Units in Operation
- 4 Months of Operating Time
- 95.5% Availability Increased to 99.2%
- Increased Production by 1440 Barrels per unit
- At \$50/barrel Resulted in Revenue of \$72,000 (USD) per Unit in 4 mo.
- Total Revenue = \$432,000 (USD) for 6 Units
- Payback on Investment (Less than 2 months!)





# Conclusions

- System design was highly reliable (reclosers) but sags and interruptions (recloser operations) were common
- Evaluated multiple solutions to coordinate with reclosers and sags
- Considerations included technical feasibility, cost and time for implementation
- Selected solution included ultra-capacitors for ride-through
- Designed solution is appropriate for new and retrofit applications
- Technical value is very high
- Payback on investment is very short
- Solution is very appropriate for oil field applications