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Deployment of Medium Voltage Drives: ESP - SAGD Applications

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Introduction

- Upstream customers seek:
- Improved processes;
- Reduce life cycle costs
- Increase profit and reliability

Siemens studied the installation of Medium Voltage Drives in Electrical Submersible Pumps and they found OPEX savings and reduced installation and floorplan costs

Introduction

- Cost savings between LV and MV drives (last 20 years)
- Technical advantages and increased reliability
- Decreased total cost of ownership
- ESP applications demand increased reliability
  - high cost of downtime
  - significant replacement costs of downhole equipment
- This paper contrasts significant benefits
  - reduced total installation footprint
  - greatest reliability of down-hole/subsea pumping equipment

Contemporary Alternatives: LV Drive

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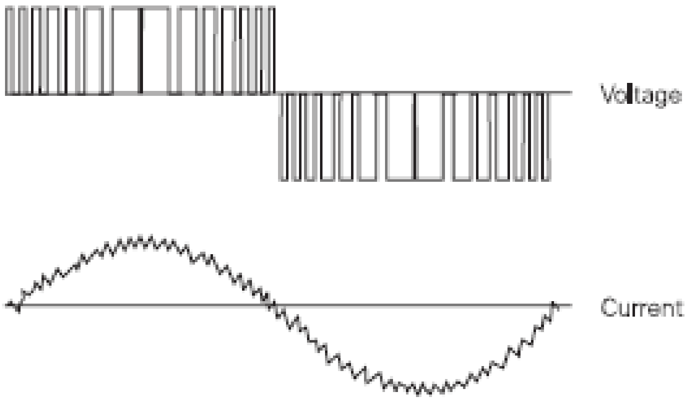
- DC Link Voltage ~ 750 – 900V (input @ 480-600V)
- Step voltage up to 1800 volt peaks
- Multi-Tap output SUT: Step up Transformer
- Filter required to protect cable + ESP motor
    - Technical challenges are:
- Low speed torque control, up to 15Hz(+) jump starting
- Capacitive charging / reflected wave output filter
- Input system voltage sensitivity, up to 90 minutes lost production



Contemporary Alternatives: MV Class Drive

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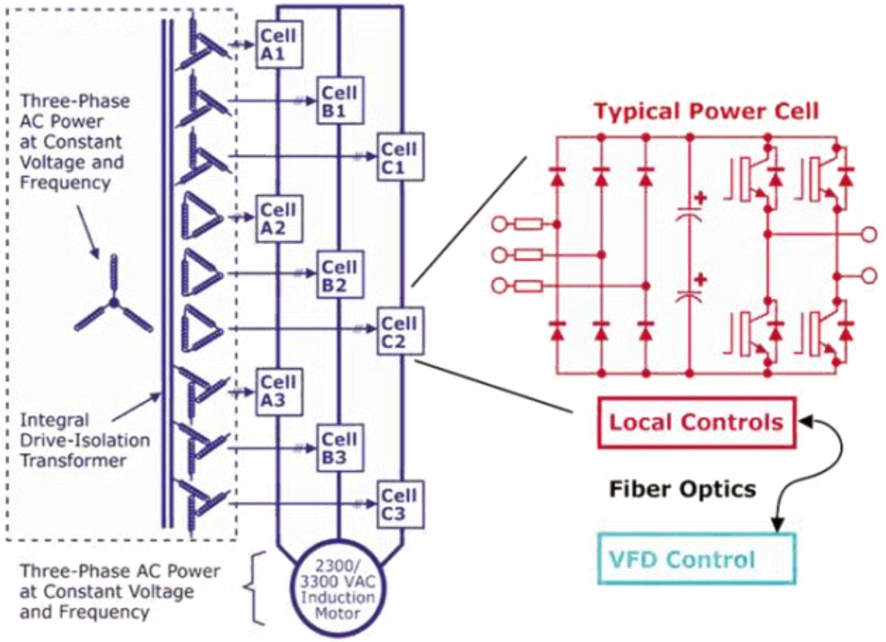
- Input Transformer accepts LV or MV input
- Cascaded H-Bridge, PWM
- Motor friendly output voltage
- Ramp from zero Hz, soft starting
- Supports long cable up to 2.2 km
- Input System V drop ride through
- Reduced operating losses
- Higher uptime = more production



System Efficiency Comparison

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LV AFD system

- 99% Input XFMR
- 95% Input Filter optional
- 96% 6p-24p LV Drive
- 98% Output Filter
- 98% XFMR 30-36 tap
- **88-91%**

cable losses not included

NEW: MV AFD system

- Integral xfrm
- 18 pulse MV Drive
- *Output Filter Rare*
- **96.5%**

Essentials of Thermal ESPs

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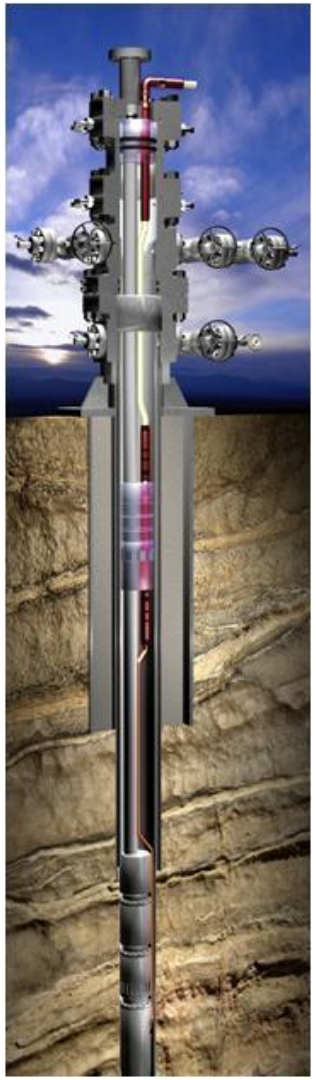
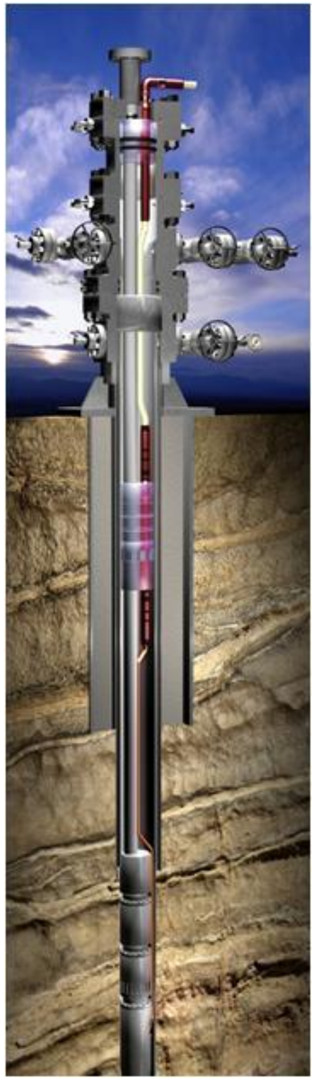
- High steady state heat environment (> 220°C)
- High water content in produced fluids
- Sour composition (H2S and CO2 ~ harmful acids)
- Sand in the fluids (>=1%, contributes to erosion)
- Multiphase production of fluids, gas and steam can lead to cavitation
- Viscosity variations require tight torque and speed control
- Steam break-through vaporizes produced fluids



ESP Application Design Challenges

- ESP design target operating life typically 36 months
- Motor rating differs for various applications
- Harsh ambient conditions vary widely
- Multiphase production (fluids and gas) can lead to cavitation
- Product viscosity variations
- Steam break-through vaporizes produced fluids
- Long cable runs
- Typically installed in remote locations

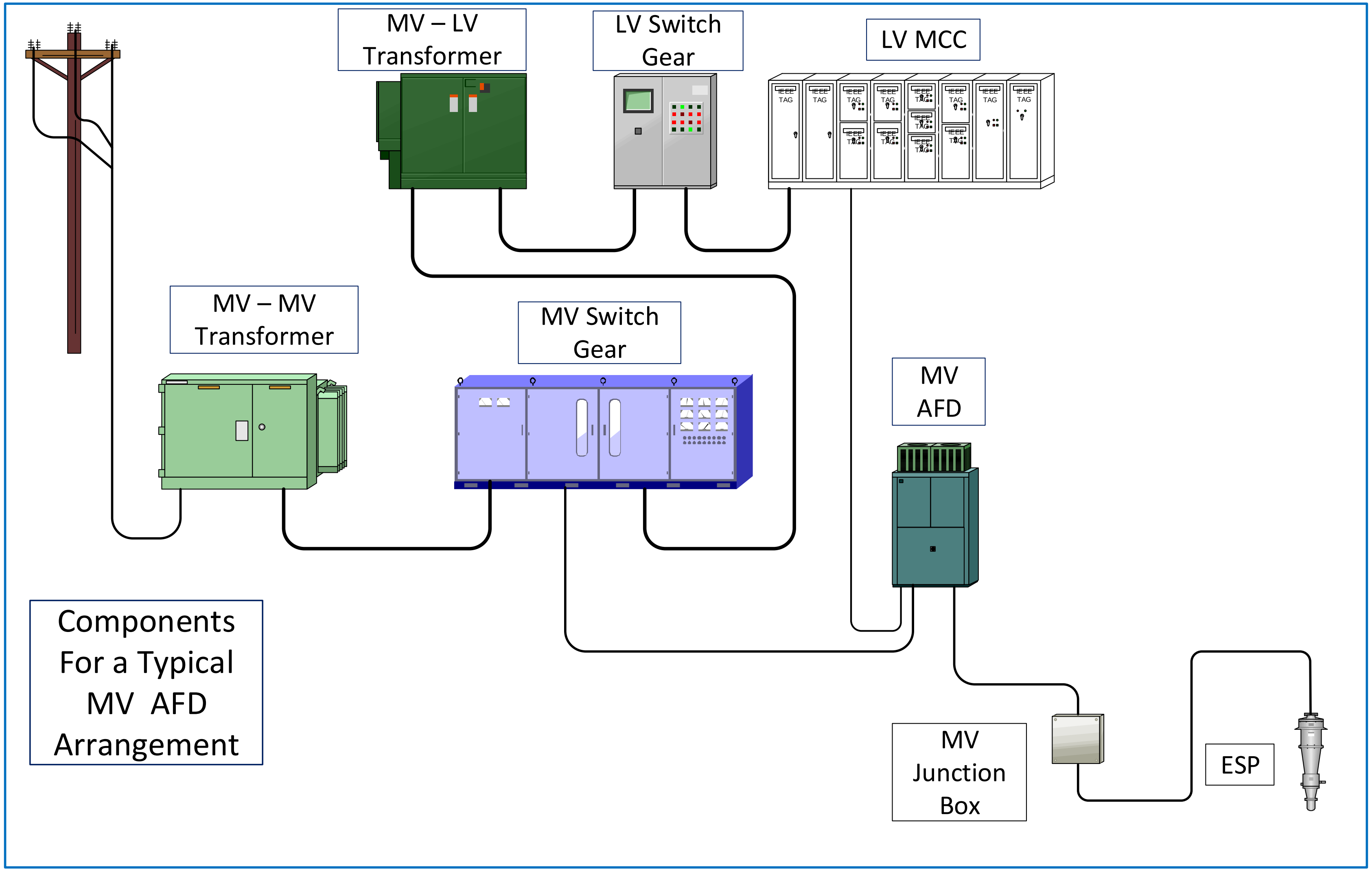


AFD Application Challenges

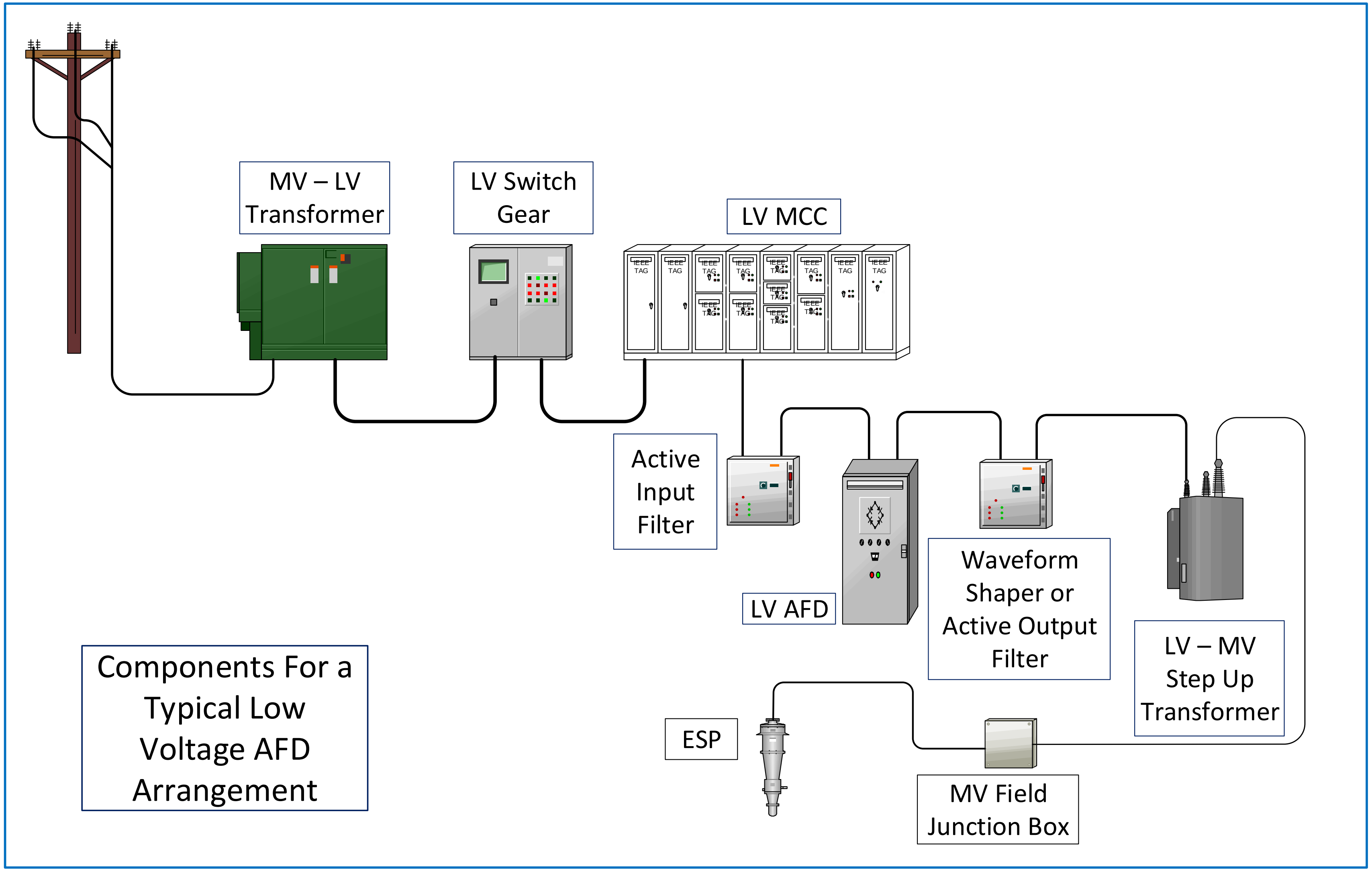
- Client standardized on ESP motor size (150 HP)

When considering modularization of electrical, found:

- MV Input / MV Output Drives = High CAPEX and Medium TIC
- LV Input / LV Output AFD = Low CAPEX and High TIC
- LV Input / MV Output AFD = Medium CAPEX and Low TIC
- each in analysis



MV – LV Transformer
LV Switch Gear
LV MCC
MV – MV Transformer
MV Switch Gear
MV AFD
Components For a Typical MV AFD Arrangement
MV Junction Box
ESP


MV – LV Transformer
LV Switch Gear
LV MCC
Active Input Filter
LV AFD
Waveform Shaper or Active Output Filter
LV – MV Step Up Transformer
ESP
MV Field Junction Box
Components For a Typical Low Voltage AFD Arrangement

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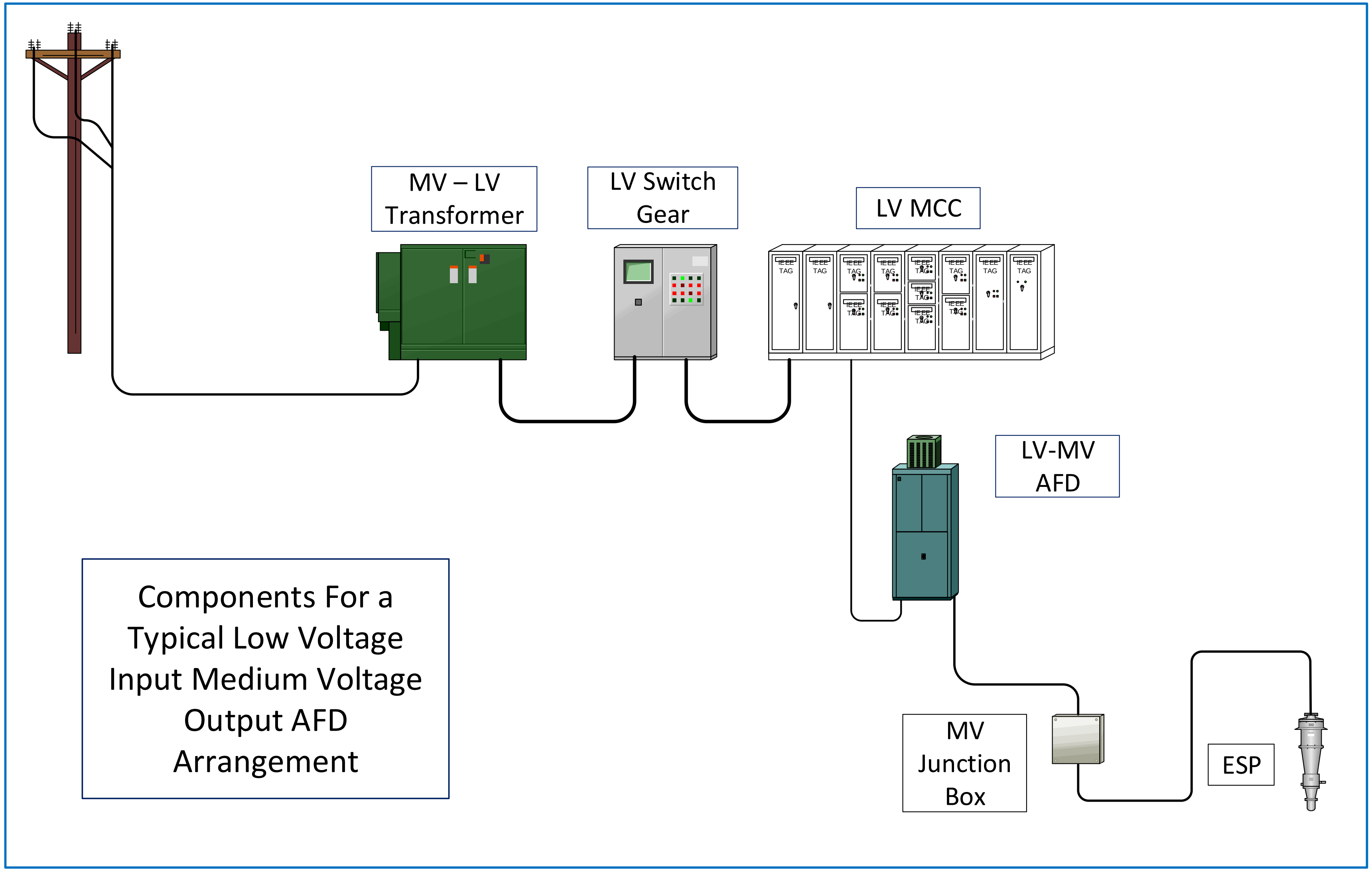

Break Even - LV/LV vs LV/MV AFD

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- Industry assumption is that LV / LV AFD present a lower CAPEX on smaller ESP even with filtering and additional field costs
- Each application unique = TIC should be fully reviewed
- Early studies indicate ~150+ HP = lower TIC using LV / MV drives solutions for ESP
- The first units delivered in November 2017, since then installed and currently undergoing commissioning

Direct AFD-Motor Connection Advantages

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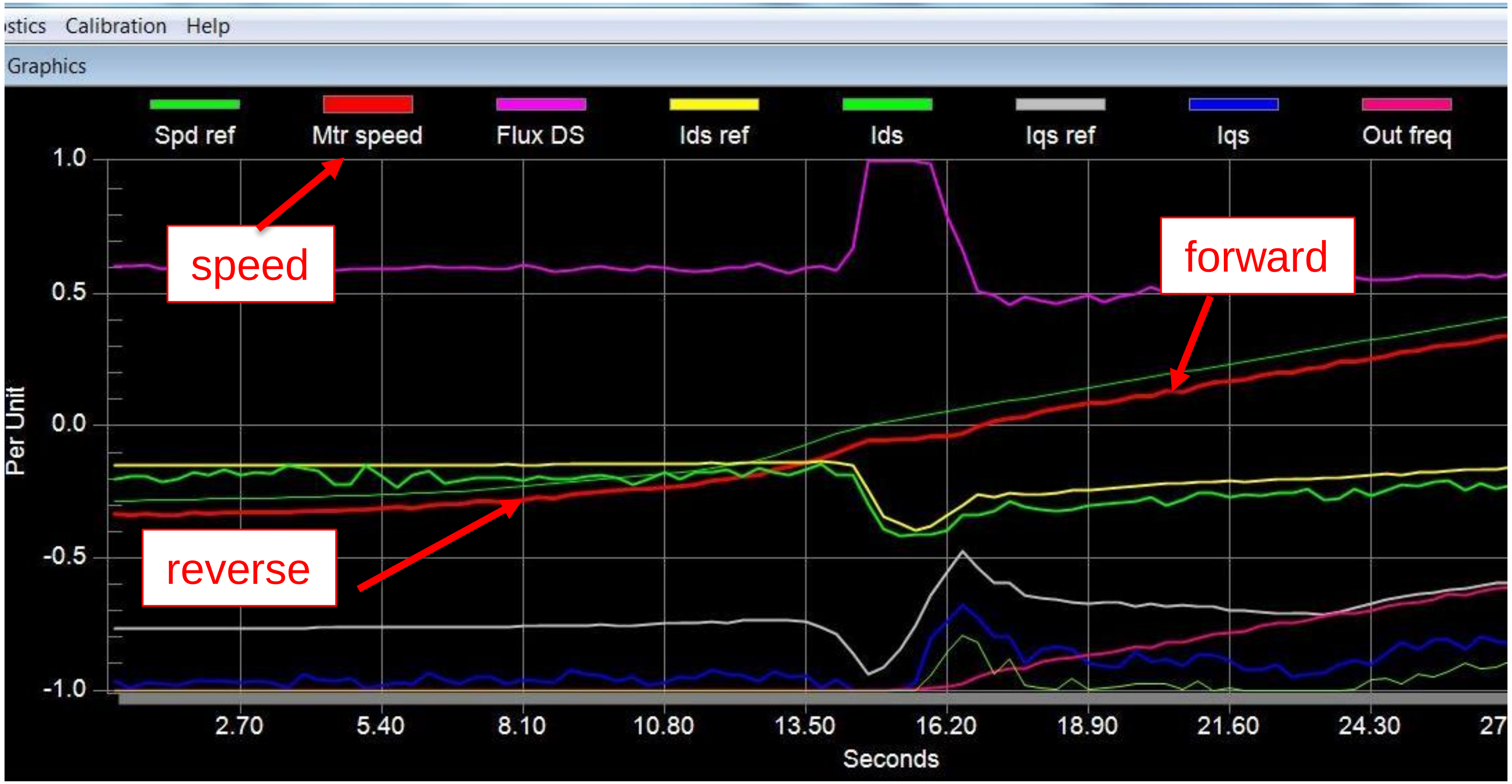
- Allows easier catching of back-spinning load
- Reduced mechanical impact, no boost start required
- Vector control, enabling virtual metering
- Increased efficiency
- Allows AFD to detect Vgnd: Predicts and avoids fail to ground

Benefits: MV class AFD, Load Back-spin



Catching a back-spinning load minimizes loss of production

Removing SUT - Precise Vector Control

STARTING;

SUT requires >0 frequency

DC not allowed

7-15+ Hz boost causes motor inrush

MV class AFD ramps from 0 Hz

Linear ramp-up

No mech transient introduced

Lower amps per unit of torque

Unit	Approximate	MV	LV step-up
Hz	Start f	0.2 Hz	7-15 Hz
PU A	Starting Torque	1 PU	0.2 PU
PU	Torque Oscillations	None	0.5 PU
	Starting Shock (Mech)	Low	High
	Voltage Spikes	Low-Med	Med-High
	Starting Stator Saturation Transformer Saturation	None None	Likely Likely

Removing SUT – Virtual Flow Meter

- Wellpads use mechanical flowmeter, $
- Precise vector control - manages motor torque
- Obtaining motor speed and torque value, flow can be measured/calculated from pump curves
- Elimination of mechanical metering skid = save $$$
- Currently under field validation

V/HZ to Vector Control

Initial site measurements indicate increased system efficiency of 4-7%

Reduction of motor current for comparable production

This is on top of overall system efficiency gains on the MV class AFD vs LV system

MV Class AFD – Undervoltage Ride-through

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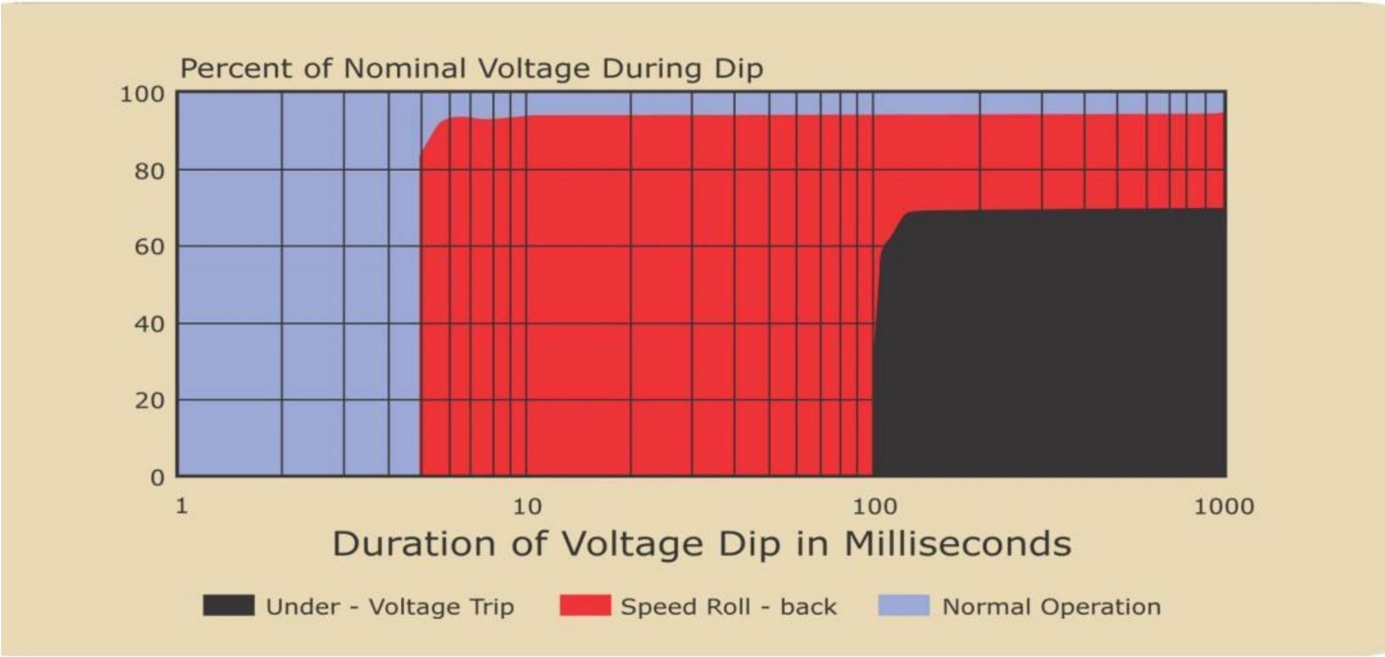
Tripping = production loss

Improved ride-through equates to reduced loss of production compared to LV AFD

AFD still active down to 55% input volts



Next Steps

- Deployment of Outdoor/NEMA 4 model
- Continuing testing and data collection at site
- Adjusting existing installed base of drives (scalar to vector) to record and review operational improvement
- Testing “Virtual Flow Meter” - accurate torque and speed signal from drives
- Data collected reveals increased efficiency with lower motor current
  - normally reflects longer motor life

Future Developments

- Seek to continually decrease equipment cost
  - Size, footprint, economies of scale
- Continue collection of operational data
- Confirming design target downhole component life
- Productization of virtual flow meter (digitalization)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Thank you.
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