

Application of Multi-function Motor Protection Relays to Variable Frequency Drive Connected Motors

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There are
still a few
seats open
in the front



Agenda

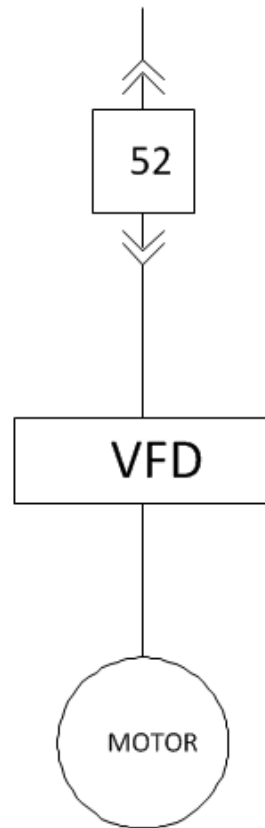
- Introduction
- Source side VFD fault protection
- Load side motor protection
- Impacts of bypass switch



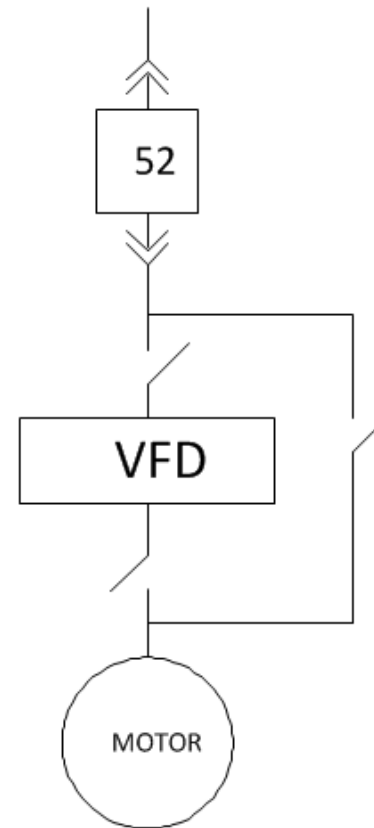
Introduction

- Typical roles of protection
 - VFD provides motor protection
 - Fuse or relay provides VFD protection
- Alternate motor protection may be desired
 - Owner's standards
 - Bypass switches
 - Improvement on VFD thermal model

Introduction - Dedicated VFDs

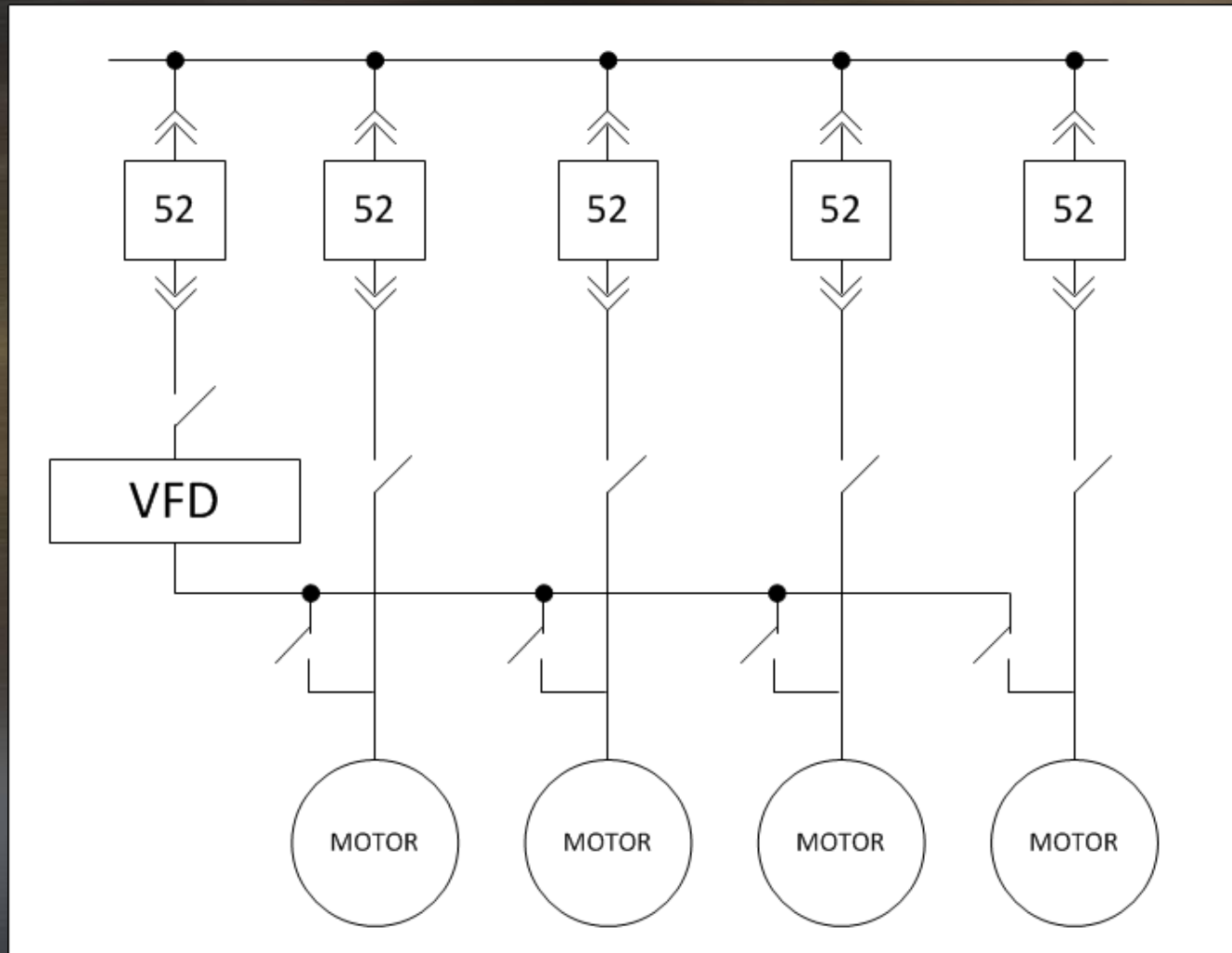


(a): Dedicated VFD



(b): Dedicated VFD with
bypass switch

Introduction - Shared VFDs



Introduction

VFD Internal Motor Protection Features

- Phase short circuit current limited by drive design
- Motor circuit is typically ungrounded so no ground short circuit current
- Load impedance monitoring to detect phase faults
- Basic thermal model – stator heating (I^2R) with limited RTD biasing

Introduction

VFD Internal Motor Protection Features

- Constant V/Hz over operating frequency
- Power quality functions on source – primarily for drive protection
 - Over/under-voltage
 - Over/under-frequency
 - Harmonic analysis

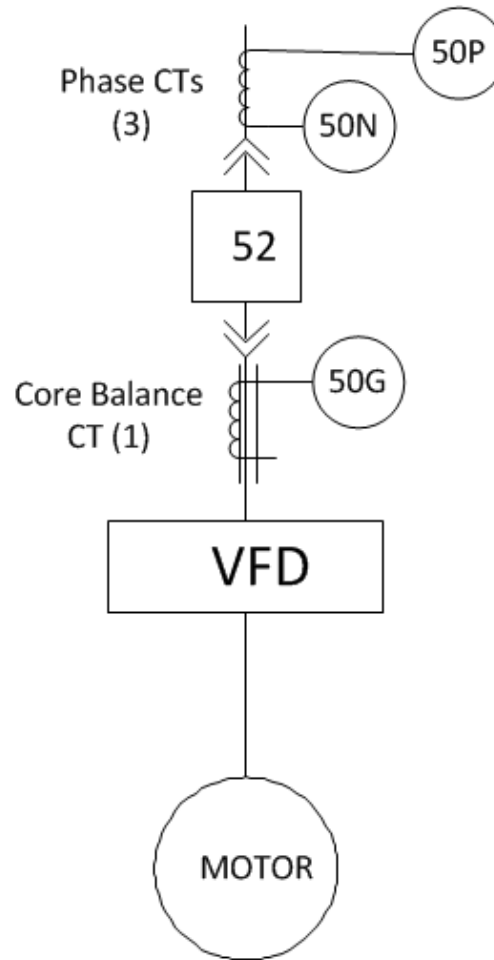


Hang in there - the fun starts any minute

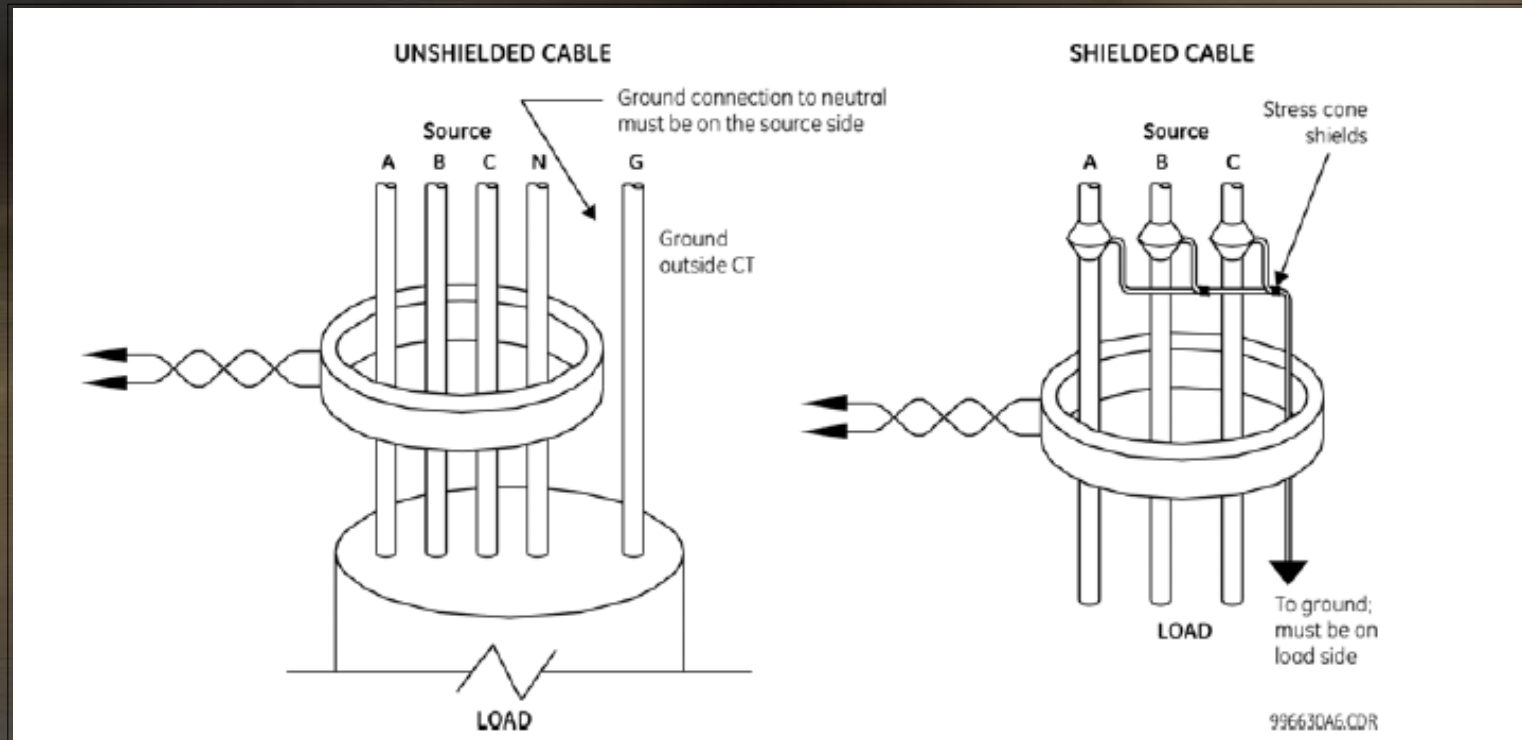
Source Side VFD Protection

- VFD is a load
- Source side protection is for VFD not for the motor
- Short circuit protection - Starters
 - Fuses (type E typical)
- Short circuit protection - Breakers
 - Instantaneous phase over-current (50P) for short circuit
 - Instantaneous neutral over-current (50N) for solidly grounded or low impedance grounded systems
 - Define-time ground over-current (50G) for high-impedance grounded systems (core-balance CT)

Source Side VFD Protection



Source Side VFD Protection



Zero-Sequence Core Balance CT Installation



Let's bring this into focus

Load Side Motor Protection

- Relay frequency tracking – matched to the drive operating range (20 – 65 Hz typical)
- CTs must be on the load side – Consider operating characteristics over frequency range
 - “C” rated CTs will typically work
 - Excitation curves are drawn for 60 Hz – can be scaled for other frequencies (V_{exc} changes linearly with applied frequency)
 - Saturation is typically not a concern since fault current is limited by the drive

Load Side Motor Protection

- VTs, if required, must be on the load side – Consider operating characteristics over frequency range
 - Optional – thermal model will work OK without VTs
 - Delta connected
 - Some drives don't like the added inductance of the VTs – ask the VFD manufacturer
 - Soft start of the drive prevents damage if the motor is started during back-spin but....VTs are required if you want to use back-spin protection

Load Side Motor Protection

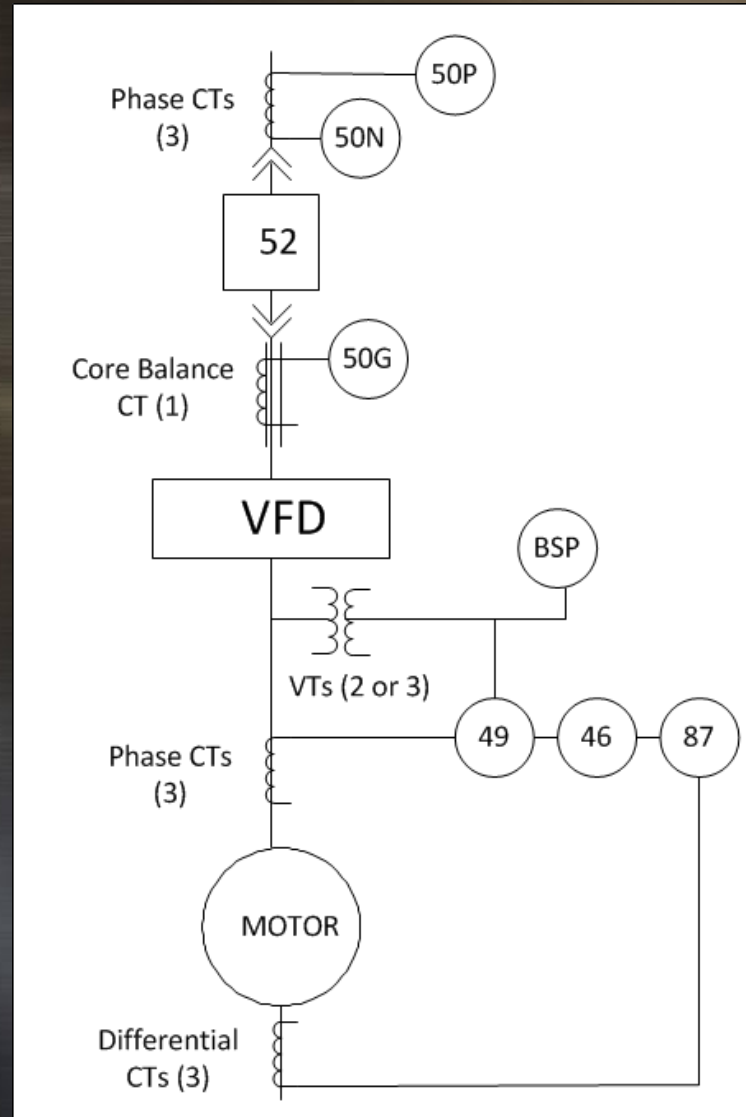
- Thermal model (49) – relay model more advanced than VFD model:
 - Stator winding I^2R heating
 - Stator core flux density heating (V/Hz - VTs required)
 - Negative sequence unbalanced current rotor heating
 - Stator RTD biasing
 - Stator core harmonic current heating

Load Side Motor Protection

- Short circuit protection:
 - Limited value
 - Over-current elements (50/51) not applicable - drive limits available short circuit current
 - Stator differential will work – non-60 Hz CT performance critical (core-balance CT approach best)
- Negative sequence over-current (46) element for VFD open-phase or malfunction
- Back-spin protection for special cases

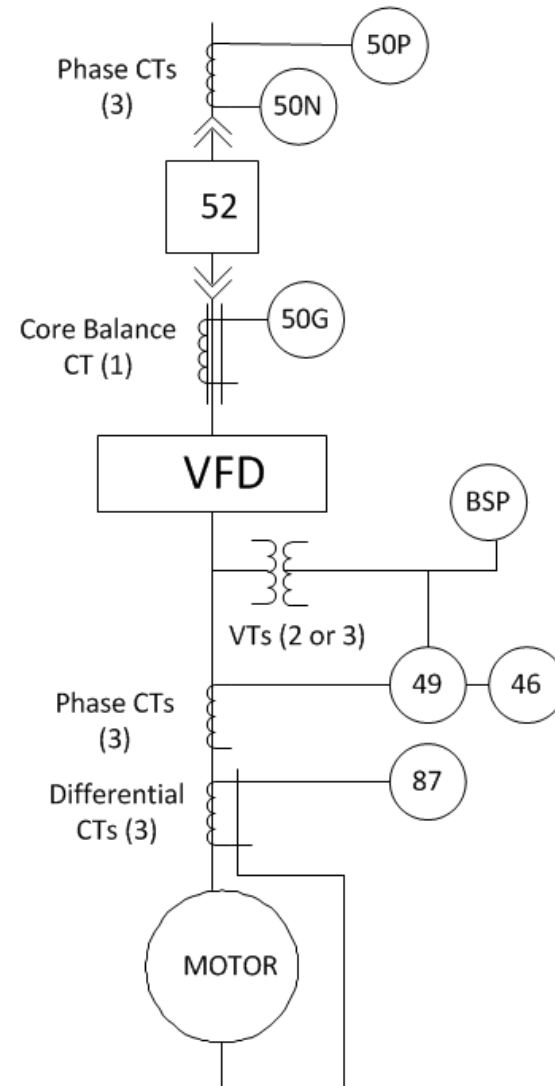
Load Side Motor Protection

2 - CT
differential



Load Side Motor Protection

Core-balance differential





Relax, get that hungry look out of your eyes - this is almost over

Impact of Bypass Switches

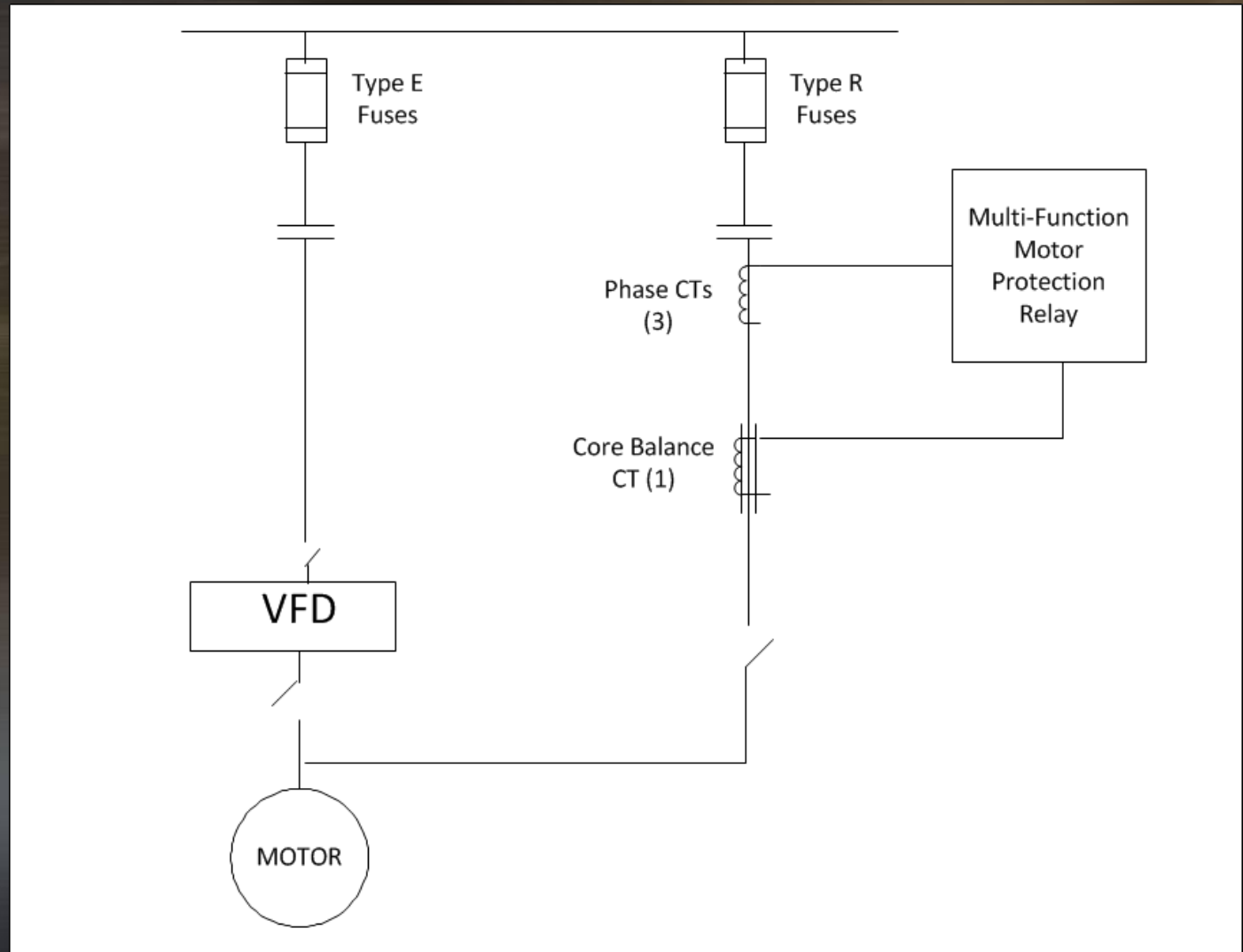
- Bypass switch changes function of protection at source breaker
 - Short circuit protection for drive
 - Thermal protection when bypassed
- Need separate fused starters for normal and bypassed mode
 - Type E fuse normally
 - Type R fuse with motor relay when bypassed

Impact of Bypass Switches

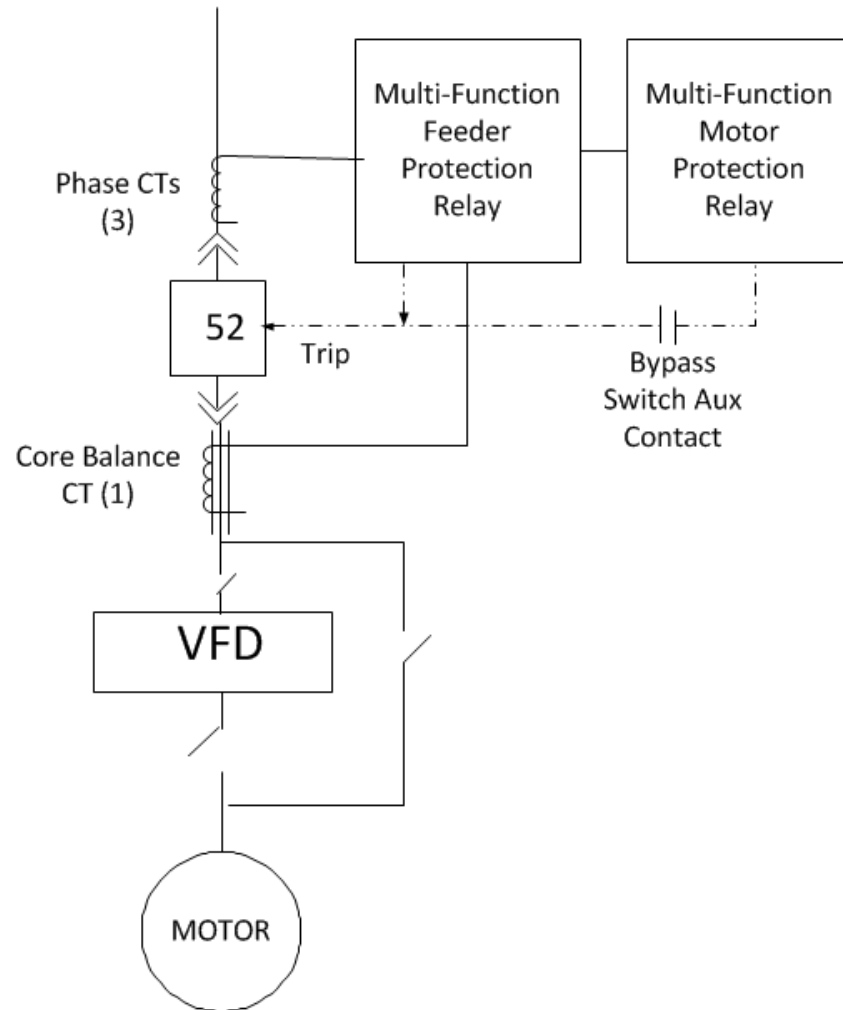
- Separate relays for separate breakers (shared VFDs, etc.)
- Change relay functions for shared breaker
 - Thermal element (49) is not an inverse-time over-current!
 - Take care when changing setting groups – element blocking may be better
 - Source-side thermal protection won't have correct data prior to bypass
 - Load-side motor protection best since thermal model always has correct data

Impact of Bypass Switches

Starters
require
different
fusing
when
bypassed

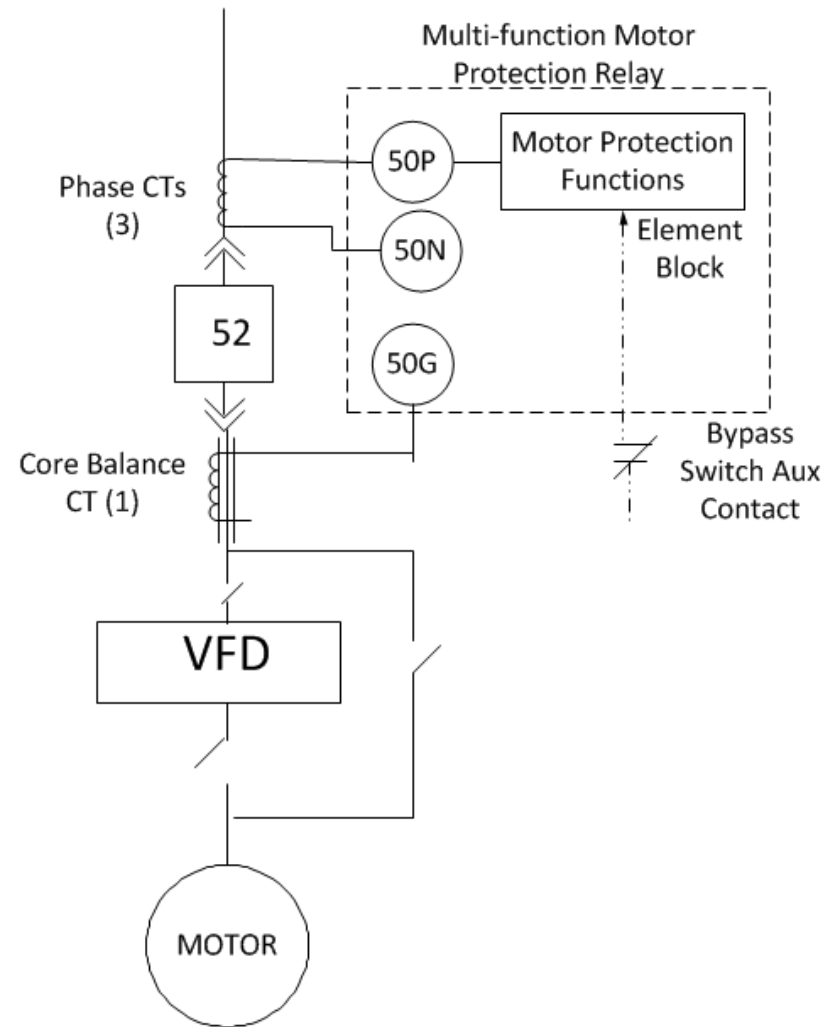


Shared
breaker with
separate
feeder and
motor relays



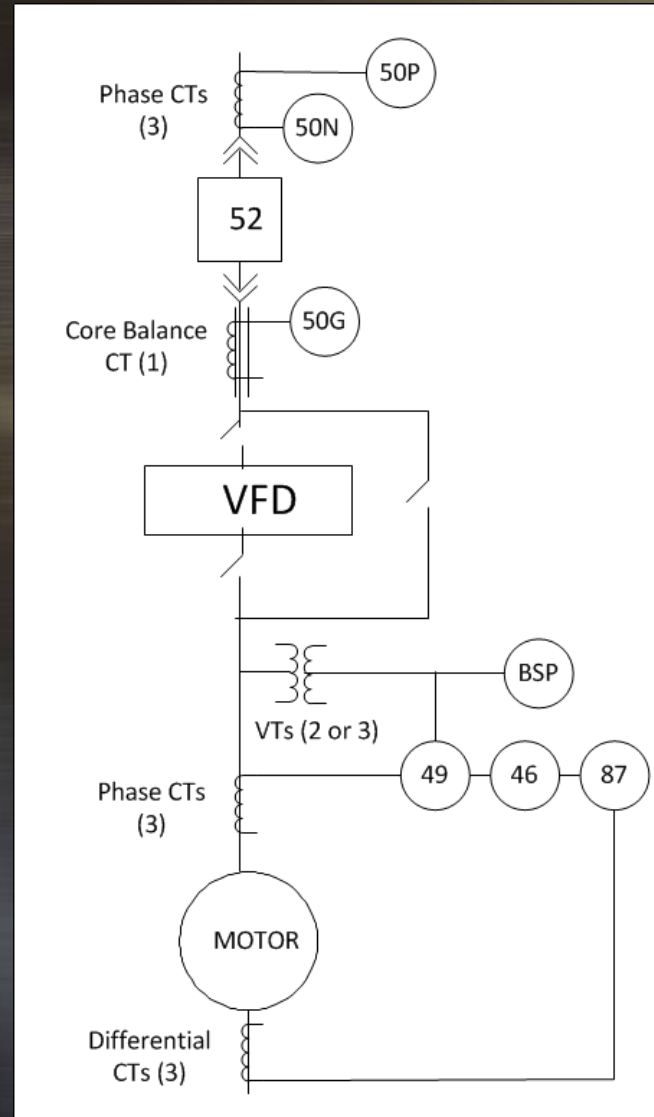
Impact of Bypass Switches

Shared
breaker with
shared relay



Impact of Bypass Switches

Shared
breaker with
load side
motor relay



Conclusions

- Motor protection relays can be successfully applied to VFD fed motors
 - Source side
 - Load side
- Drives and motors fed by contactors require different fusing types
- Proper frequency tracking in a load side relay is critical
- VTs on the load side of the VFD need special consideration by the VFD manufacturer
- Protective relaying is **FUN!!**

Thank You

Questions?