7SG13 Delta

Protection and Control Relays

Document Release History

This document is issue 2010/02. The list of revisions up to and including this issue is:

Pre release

2010/02	Document reformat due to rebrand
2005/02	Improved VTS Feature added
2004/07	CB fail application note added
2004/03	Updated Performance Specification
2003/02	v2 Page 1: removed invalid references Page 5: corrected invalid 'List of Tables'
2003/01	First issue

Software Revision History

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Section 1: Introduction

1.1 Introduction

This document covers the plant supervision elements and their applications found in the range of relays, as listed below. A Diagrams and Parameters document which covers each individual model is available, which lists the functions and connections available in that model.

- 50BF, Circuit breaker fail element
- 74CT, CT supervision
- 74VT, VT supervision
- 74TC, Trip circuit supervision

Notes

1. The following notational and formatting conventions are used within the remainder of this document:

- Setting: Elem *Setting name*
- Setting value: **value**
- Alternatives: [1st] [2nd] [3rd]

2. The purpose of this document is to describe the capabilities and functionality of Plant supervision elements. Separate User Manual documents describe how to set up and operate the equipment: apply configuration, settings and passwords, view instruments and set default instruments, and retrieve fault data.

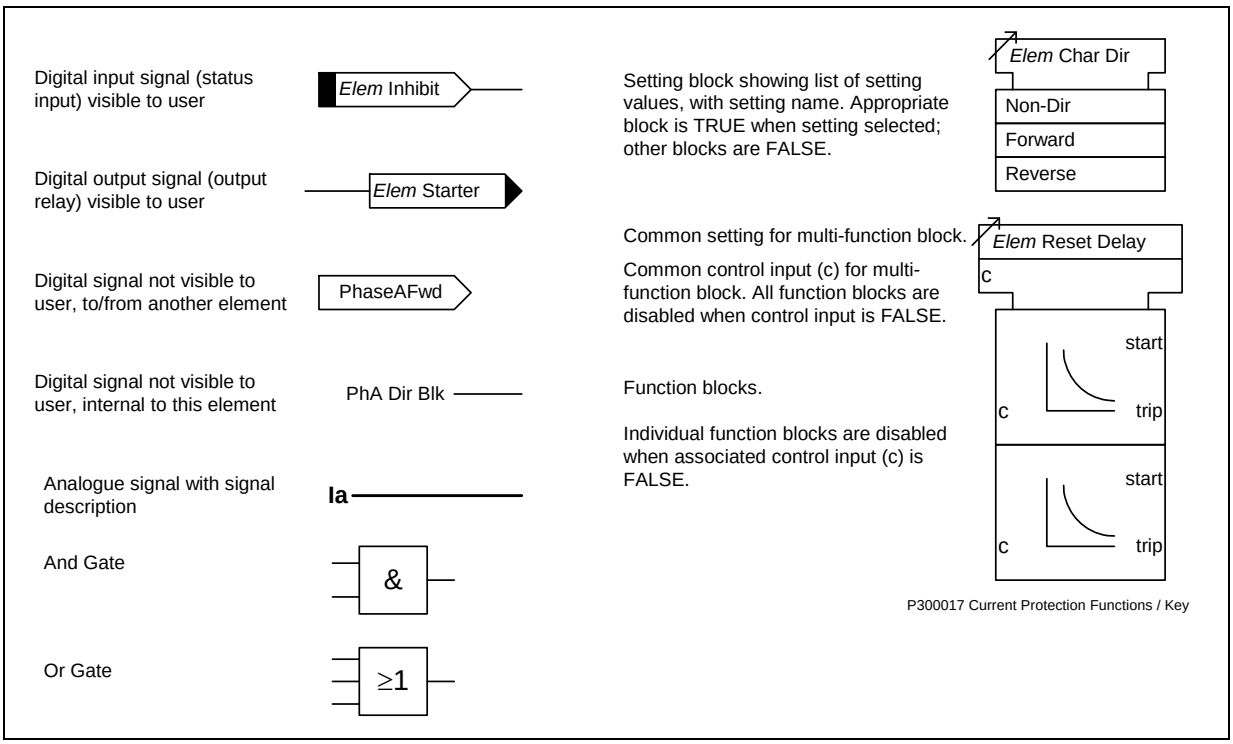

Figure 1-1 Key to Functional Block Diagrams

Section 2: Element Definitions

2.1 Circuit Breaker Supervision

2.1.1 Circuit Breaker Failure Element (50BF)

2.1.1.1 Description

The circuit breaker fail element is a two-stage element that can be used for re-tripping and back-tripping. Following a trip the continued energisation of any protection trip element, external starting signal and any of the 3 phase currents being above the ***Elem* Level** indicates that the fault has not yet been cleared. If any of these signals remain for the ***Elem* Time 1** time then ***Elem* 1** output operates. Following this, ***Elem* 2** output will operate after ***Elem* Time 2** time if current level is still above element setting. Both ***Elem* 1** and ***Elem* 2** can be mapped to any output contact or LED.

Table 2-1 Typical Settings Circuit Breaker Fail Element

Setting name	Range (**bold** = default)	Units	Notes
***Elem* Time 1** ***Elem* Time 2**	Off, 0.02, 0.03…**1.00**…20.00	s	
***Elem* Level**	0.05, 0.1… **0.2**…2	xIn	
Sub-menu: **Output Relays** ***Elem* 1** ***Elem* 2**	_, 1 for each output contact		

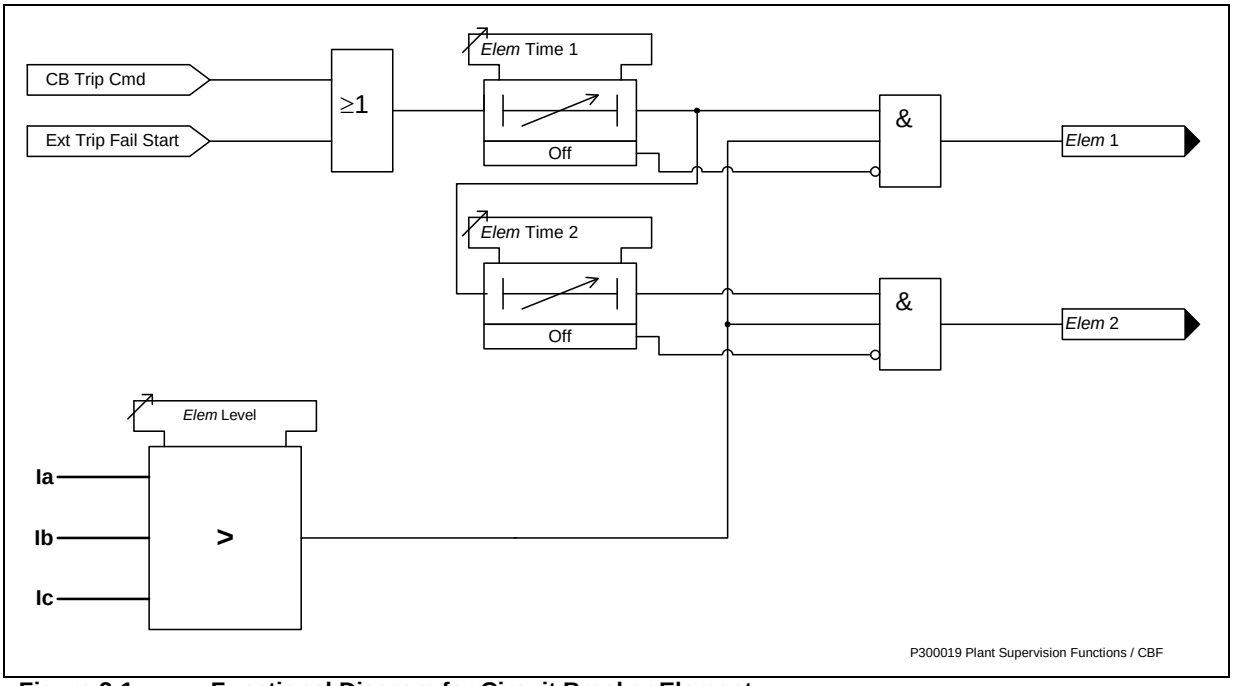

Figure 2-1 Functional Diagram for Circuit Breaker Element

2.1.1.2 Specification

Element Parameters

The element will take the following parameters, unless otherwise specified in the appropriate Diagrams and Parameters document.

	Parameter	Value
t_{cycle}	Element cycle time	20 ms

Reference

	Parameter	Value
t_{CBF1}	Delay Time 1	1.0 s
t_{CBF2}	Delay Time 2	1.0 s
	Ambient temperature	20 °C

Operate and Reset Time (from External Start)

	Attribute	Value
	CB Fail 1 operate	t_{CBF1}, ± 1 % or ± t_{cycle}
	CB Fail 2 operate	t_{CBF1} + t_{CBF2}, ± 1 % or ± t_{cycle}
	Repeatability	± 1 % or ± t_{cycle}
	Overshoot	< 2 x t_{cycle}
	Disengaging time	< 30ms

2.2 CT and VT Supervision

2.2.1 CT Supervision Element (ANSI 74CT)

2.2.1.1 Description

If no current is detected in one phase, while current is flowing in the other two phases, for a period defined by ***Elem* Failure Time**, CT failure is detected and can be mapped to any output relay or LED. The threshold for current flowing (i.e. CT healthy) is ***Elem* Current Threshold**.

Table 2-2 Typical Settings CT Supervision Element

Setting name	Range (**bold** = default)	Units	Notes
Elem	**Enabled**, Disabled		
***Elem* Failure Time**	20,30…**1000**, 1100…20000	ms	
***Elem* Current Threshold**	**0.05**, 0.10…2.50	xIn	
Sub-menu: **Output Relays**			
Elem	_, 1 for each output contact		

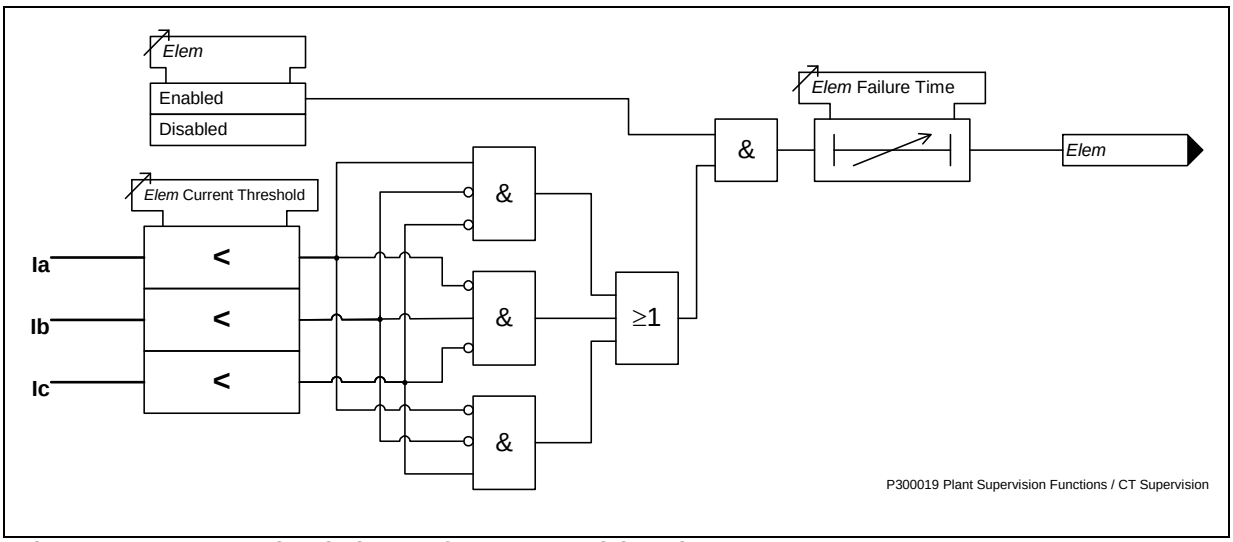

Figure 2-2 Functional Diagram for CT Supervision Element

2.2.1.2 Specification

Element Parameters

The element will take the following parameters, unless otherwise specified in the appropriate Diagrams and Parameters document.

	Parameter	**Value**
t_{cycle}	Element cycle time	20 ms
f_{nom}	Nominal frequency	50 Hz
f_{cutoff}	Upper cut-off frequency	200 Hz

Reference

	Parameter		**Value**
In	Nominal current		1, 5 A
I_{thresh}	Current Threshold		0.5 x*In*
t_f	Delay setting		1000 ms
I	Applied current (for operate time)	healthy CT phases	5 xI_{thresh}
		failed CT phase	< 0.01 x*In*
	Frequency		f_{nom}
	Ambient temperature		20 °C

Current Threshold

	Attribute		**Value**
I_{curr}	CT failed current level		100 % I_{thresh}, ± 5 % or ± 10 mA
	Reset level		110 % I_{curr} ± 5 % or ± 10 mA
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz harmonics to f_{cutoff}	≤ 5 %

Operate and Reset Time

	Attribute		**Value**
t_{basic}	Basic operate time	1x In to 0 A	< 25 ms
	Operate time		$t_f + t_{basic}$, ± 1 % or ± t_{cycle}
	Repeatability		± 1 % or ± t_{cycle}
	Variation	f_{nom} - 3 Hz to f_{nom} + 2 Hz harmonics to f_{cutoff}	≤ 5 %

2.2.2 VT Supervision Element using NPS (ANSI 74VT) (1 or 2 Phases Lost)

Superseded by element described in section 2.2.3 in February, 2005.

2.2.2.1 Description

It is normally expected that the presence of negative sequence voltage in a power system would be accompanied by negative sequence current. The presence of a negative sequence voltage without an equivalent level of negative sequence current can therefore be used to indicate a VT failure.

The element has a setting for voltage and current levels, ***Elem* Vnps Level** and ***Elem* Inps Level**. If the negative sequence voltage exceeds its setting while the negative sequence current does not exceed its setting for 100 ms, VT failure is detected.

It can be chosen by setting whether to inhibit voltage-based protection elements (e.g. directional overcurrent) from the feature using the ***Elem* Mode** setting. Additionally, blocking of the phase-fault voltage based protection elements can be independently deselected using the ***Elem* PF Inhibit** setting.

Table 2-3 Typical Settings VT Supervision Element (1 or 2 Phases Lost)

Setting name	Range (**bold** = default)	Units	Notes
Elem	**Disabled**, Enabled		
***Elem* PF Inhibit**	**Disabled**, Enabled		
***Elem* Inps Level**	0.05, **0.10**…2.00	xIn	
***Elem* Vnps Level**	1, 2…**7**…100	V	
***Elem* Mode**	**Alarm Only**, Alarm & Inhibit		
Sub-menu: **Output Relays**			
***Elem* VT Failed**	_, 1 for each output contact		

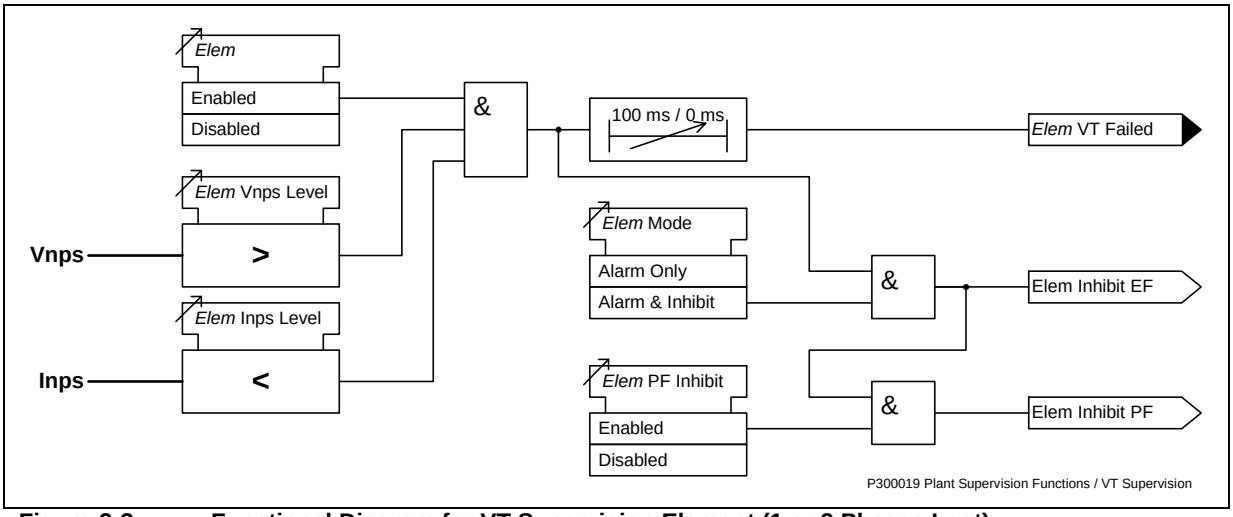

Figure 2-3 Functional Diagram for VT Supervision Element (1 or 2 Phases Lost)

2.2.2.2 Specification

Element Parameters

The element will take the following parameters, unless otherwise specified in the appropriate Diagrams and Parameters document.

	Parameter	**Value**
t_{cycle}	Element cycle time	10 ms
f_{nom}	Nominal frequency	50 Hz

Reference

	Parameter	**Value**
Vn	Nominal voltage	63.5 V
In	Nominal current	1, 5 A
Vs	Vnps Level	7.0 V
Is	Inps Level	0.10 x*In*
	Frequency	f_{nom}
	Ambient temperature	20 °C

Operate and Reset Level

	Attribute		**Value**
V_{op}	Voltage operate level		100 % *Vs*, ± 5 % *Vn*
	Voltage reset level		≥ 95 % V_{op}
V_{blk}	Current operate level		100 % *Is*, ± 5 % *In*
	Current reset level		≤ 105 % V_{blk}
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

2.2.3 VT Supervision Element using NPS (ANSI 74VT) (1, 2 or 3 Phases Lost)

Implemented in all Relay models from February, 2005.

2.2.3.1 Description

1 or 2 phases lost

It is normally expected that the presence of negative sequence voltage in a power system would be accompanied by negative sequence current. The presence of a negative sequence voltage without an equivalent level of negative sequence current can therefore be used to indicate a one or two phase VT failure.

The element has a fixed NPS voltage level of 0.15 xVn and a setting for NPS current level ***Elem* Inps Level**. If the negative sequence voltage exceeds its level while the negative sequence current does not exceed its level for more than ***Elem* Delay** then a VT failure will be detected.

3 phases lost

Under normal load conditions PPS voltage of approx 1 xVn would be expected along with PPS load current. If we see PPS load current but no PPS voltage this is possibly a three phase fuse failure, to ensure that this is not caused by a 3 phase close up fault the PPS current must also be below the fault level.

The element has a fixed PPS voltage level of 0.75 xVn, a fixed PPS current load level of 0.1 xIn and a setting for PPS current fault level ***Elem* Ipps Level**. If positive sequence voltage is below its level while positive sequence current is above the load level and below three phase fault level for more than ***Elem* Delay** then a VT failure will be detected.

External MCB

The element has an input, **Ext Trig *Elem*,** to allow the VTS element to be triggered by an external MCB operating.

Once a VT failure condition has occurred the output is latched on and is reset by any of the following:-

Voltage is restored to a healthy state i.e. PPS voltage being above its level while NPS voltage is not above its level,

The external reset **Ext Reset *Elem*** being triggered and VT failure condition no longer exists,

The element being inhibited or disabled.

Table 2-4 Typical Settings VT Supervision Element (1, 2 or 3 Phases Lost)

Setting name	Range (**bold** = default)	Units	Notes
Elem	**Disabled**, Enabled		
***Elem* Inps**	0.05,**0.10**…1	xIn	
***Elem* Ipps**	0.05, 0.10…**10**…20.00	xIn	
***Elem* Delay**	0.03, 0.03…**10**…20,20.1…100.101…1000	s	
Sub-menu: **Status Inputs**			
Inhibit *Elem*	_, 1 for each status input		
Ext Trig *Elem*			

Setting name	Range (**bold** = default)	Units	Notes
Ext Reset *Elem*			
Sub-menu: **Output Relays**			
Elem	_, 1 for each output contact		

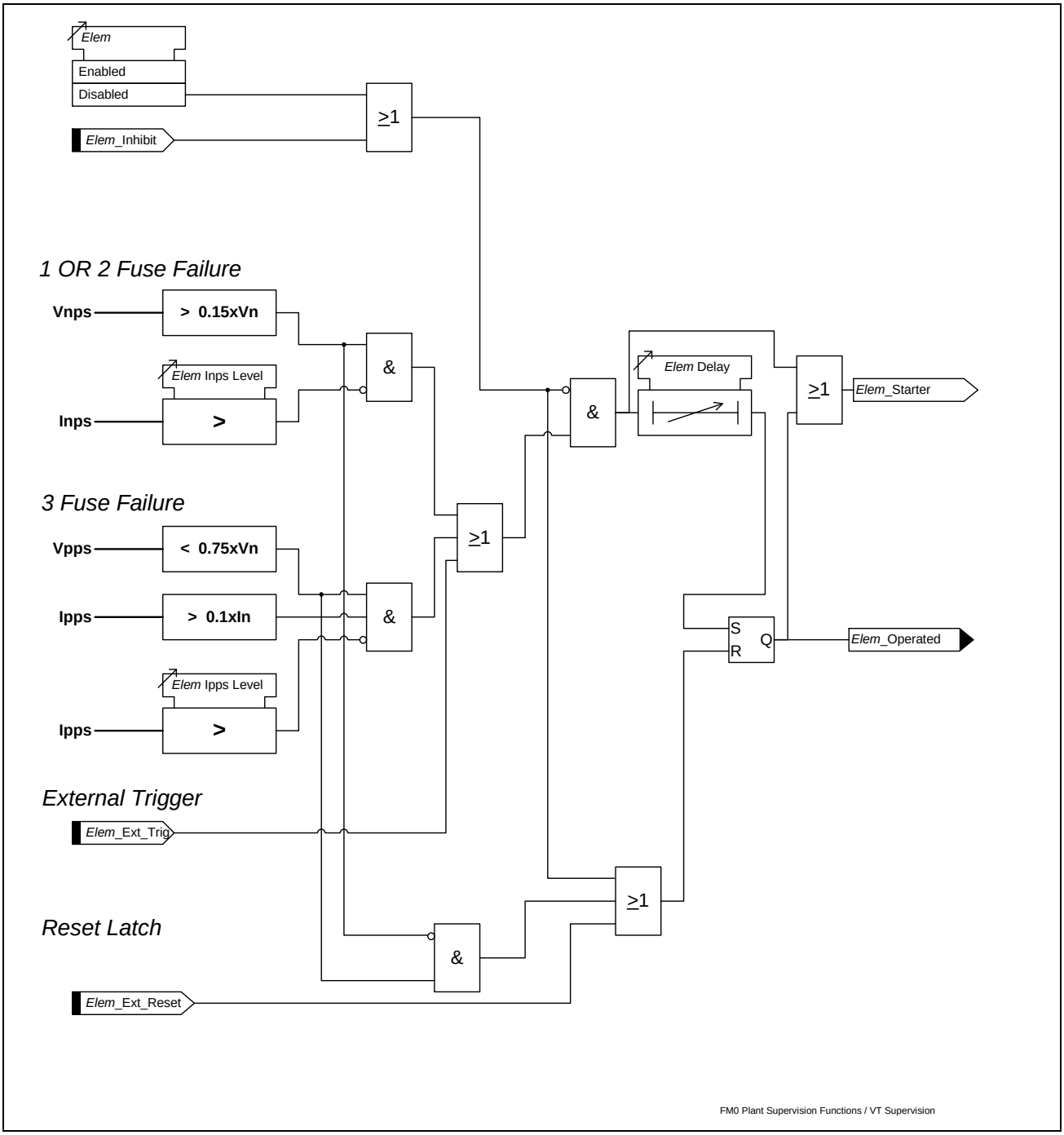

Figure 2-4 Functional Diagram for VT Supervision Element (1, 2 or 3 Phases Lost)

2.2.3.2 Specification

Element Parameters

The element will take the following parameters, unless otherwise specified in the appropriate Diagrams and Parameters document.

	Parameter	Value
t_{cycle}	Element cycle time	10 ms
f_{nom}	Nominal frequency	50 Hz

Reference

	Parameter	Value
Vn	Nominal voltage	63.5 V
In	Nominal current	1, 5 A
V_{nps}	Vnps Level	0.15 x*Vn*
I_{nps}	Inps Level	0.1 x*In*
I_{pps}	Ipps Load Level	0.1 x*In*
IF_{pps}	Ipps Fault Level	10 x*In*
V_{pps}	Vpps Level	0.75 x*Vn*
t_d	Delay setting	0.03…1000 s
	Frequency	f_{nom}
	Ambient temperature	20 °C

Operate and Reset Level

	Attribute		Value
V_{NPSop}	Voltage NPS operate level		100 % V_{nps}, ± 5 % *Vn*
	Voltage NPS reset level		90 % V_{NPSop}, ± 5 % *Vn*
V_{PPSop}	Voltage PPS operate level		100 % V_{pps}, ± 5 % *Vn*
	Voltage PPS reset level		110 % V_{PPSop}, ± 5 % *Vn*
I_{NPSblk}	Current NPS operate level		100 % I_{nps}, ± 5 % x*In*
	Current NPS reset level		90 % I_{NPSblk}, ± 5 % x*In*
I_{PPSblk}	Current PPS operate level		100 % IF_{pps}, ± 5 % x*In*
	Current PPS reset level		90 % I_{PPSblk}, ± 5 % x*In*
$I_{PPSload}$	Current PPS operate level		100 % I_{pps}, ± 5 % x*In*
	Current PPS reset level		90 % $I_{PPSload}$, ± 5 % x*In*
	Repeatability		± 1 %
	Variation	-10 °C to +55 °C	≤ 5 %
		f_{nom} - 3 Hz to f_{nom} + 2 Hz	≤ 5 %

Operate and Reset Time

	Attribute		**Value**
t_{basic}	Basic operate time	0V to 2 x *Vs*	32 ms ± t_{cycle}
	Operate time		t_d + t_{basic}, ± 1 % or ± t_{cycle}
	Repeatability		± 1 % or ± t_{cycle}
	Variation	f_{nom} - 3 Hz to f_{nom} + 2 Hz harmonics to f_{cutoff}	≤ 5 %

2.3 Trip Circuit Supervision

2.3.1 Trip Circuit Supervision Element (ANSI 74TC)

2.3.1.1 Description

An application of the trip circuit supervision element is given in section 3.2.

Trip circuits to be monitored should have a status input connected in the circuit such that the status input is normally energised. The status input must be mapped to **Trip Cct Fail** and must not be inverted. If the input becomes de-energised, due to a trip circuit failure, an alarm is given.

A fixed 400ms time delay prevents failure being incorrectly detected during circuit breaker operation. If the contacts of the circuit breaker take longer than 400ms to change state an additional delay can be added using the status input drop off delay.

Table 2-5 Typical Settings Trip Circuit Supervision Element

Setting name	Range (**bold** = default)	Units	Notes
Trip Cct Super	**Disabled**, Enabled		
Sub-menu: **Output Relays**			
Trip Cct Fail	_, 1 for each output contact		
Sub-menu: **Status Inputs**			
Trip Cct Failed	_, 1 for each status input		

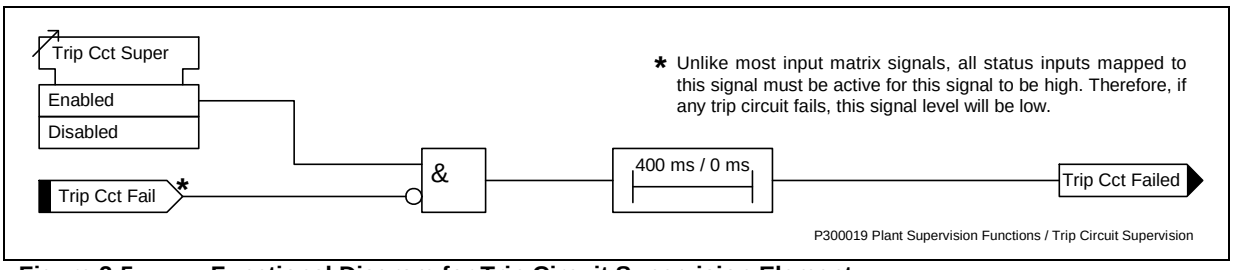

Figure 2-5 Functional Diagram for Trip Circuit Supervision Element

Section 3: Application Notes

3.1 VT Supervision (74VT)

Although VTs rarely fail themselves, VT Supervision presents a much more common application than CT Supervision because of the failure of protective Fuses connected in series with the VTs.

When a VT fails, the voltage levels seen by the protection become unbalanced. A large level of NPS voltage is therefore detected - around 0.3Vn for one or two VT failures. However this condition would also occur for a system fault. To differentiate between the two conditions, the relay uses NPS current to restrain the VTS algorithm as show in the accompanying table.

NPS Voltage	NPS Current	Decision
> Setting	> Setting	System Fault
> Setting	< Setting	VT Failure

Following a VT Failure, the level of NPS current would be dependant solely upon load imbalance - perhaps 0.1In as a maximum.

NPS voltage and current quantities are used rather than ZPS since the latter makes it difficult to differentiate between a VT failure and a Phase-Phase fault. Both conditions would generate little or no ZPS current.

There are possible problems with using NPS quantities due to load imbalances. These would also generate significant levels of NPS current and so possibly cause a VT failure to be missed. This problem can be overcome by careful selection of settings, however, setting the NPS current threshold above the level expected for imbalance conditions.

VTS would not normally be used for tripping - it is an alarm rather than fault condition. However the loss of a VT would cause problems for protection elements that have voltage dependant functionality. For this reason, the relay allows these protection elements - under-voltage, directional over-current, etc. - to be inhibited if a VT failure occurs.

Once a VT Failure has been detected, the condition can only be reset by NPS voltage falling below the setting level - by replacing the fuse or VT. If the NPS current rises above its setting, indicating a system fault, the VTS will reset and remove the inhibit to the protection elements.

3.2 Trip Circuit Supervision

A status input can be used to supervise the trip circuit with the associated circuit breaker open or closed. A low value of d.c. current is passed through the entire trip circuit to monitor the auxiliary supply, the trip coil, its auxiliary switch, the C.B. secondary isolating contacts and the relevant wiring. If monitoring current flow ceases, the energised status input drops off and if it is user programmed to operate one of the output relays, this relay gives a contact output to signal **Trip Circuit Fail**. In addition, an LED on the relay can be programmed to operate. A user text label can be used to define the operated LED i.e. “Trip CCT Fail”.

A scheme, based on the Electricity Association H6 scheme, is shown in Figure 3-1.

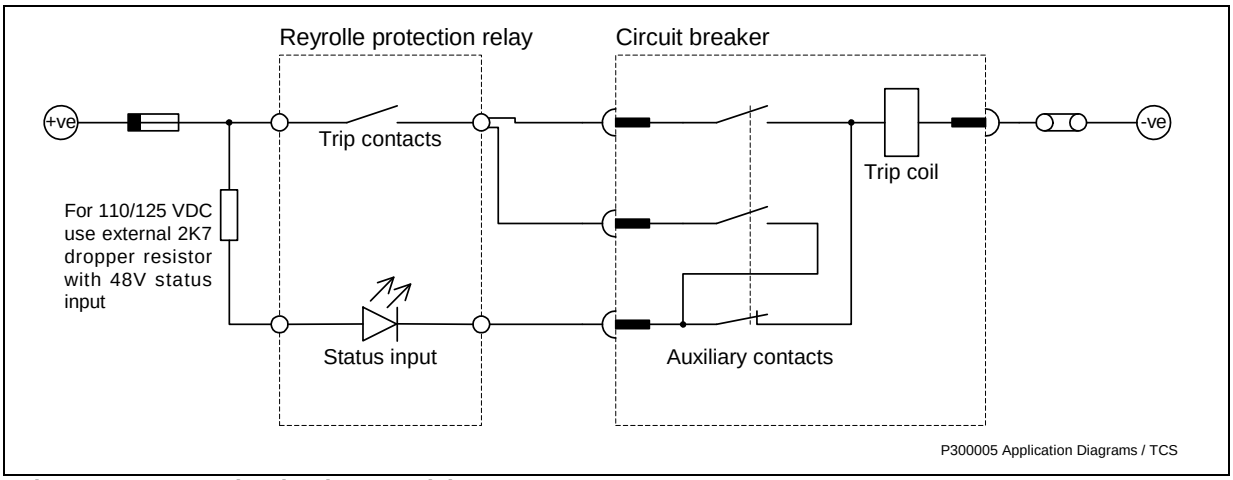

Figure 3-1 Trip Circuit Supervision

3.3 Circuit Breaker Fail Protection

The relay incorporates a two-stage circuit breaker fail feature. If a designated trip relay operates and the circuit breaker fails to open, the protection algorithm continues to run for as long as current, above the starter level or CBF level detector setting, continues to flow and a continuous trip output is given. This combination of conditions is programmed to start a definite time lag feature designated “CB Fail 1”. This function can be programmed to energise an output relay when the C.B. fail time delay is completed. At the same time operation of this timer starts a second time lag feature designated “CB Fail 2” and if the trip outputs already initiated do not stop the current flow through the relay, another relay can be programmed through the output matrix to trip a further breaker e.g. a bus section circuit breaker.

Schemes

These timers support schemes as follows:

- Single stage CB fail, where all adjacent upstream infeeds are tripped after DTL1 on detection of a CB fail occurrence.
- Two stage CB fail, where stage 1 DTL outputs attempt to re-trip the faulted CB in stage 1 time delay and when this fails the stage 2 time delayed output trips the relevant adjacent infeeds.

The circuit breaker fail feature can also be used to implement a multi-stage tripping scheme.

Setting Calculation

The time delay setting applied to the CB fail protection must be in excess of the longest CB operate time + relay reset time + a safety margin

Typically, 80 ms + 42 ms + 50 ms = 175ms (approximately)