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Relay Protection in DG-units

Master Thesis

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Background

- 575 Small-Hydropower Plants(1-10 MW) in Norway(2015)
- Areas with high degree of DG
- Keep DG-units online during disturbances
- Conflict of interest between DSO, DG-owner and supplier

Approach

- Current requirements
- Industry practice
- Case study



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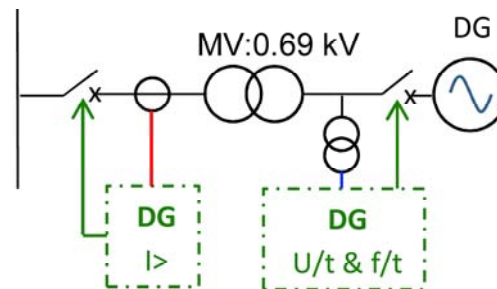
Current Requirements

- SINTEF report «Tekniske retningslinjer for tilknytning av produksjonsenheter med maksimum aktiv effektproduksjon mindre enn 10 MW»(2006)
- REN 3000-series

Generator Protection examples

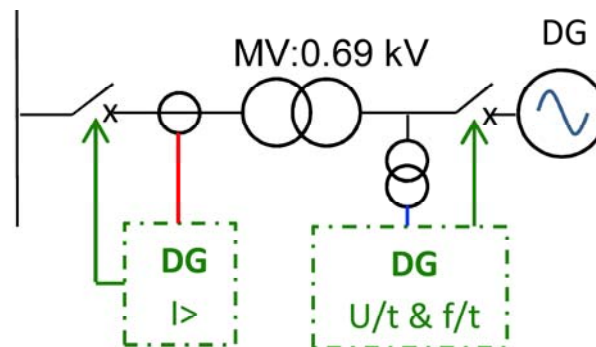
	REN/SINTEF		DG2		1-3 MVA		3-6 MVA		Bruvolllelva		Ullestad/Tverråna	
Parameter	Value	Time	Value	Time	Value	Time	Value	Time*	Value	Time	Value	Time
f \gg	51 Hz	0.2 s	51 Hz	0.2 s	51 Hz	0.2 s	51 Hz	0.3 s	51 Hz	0.2 s	51 Hz	0.2 s
f \ll	48 Hz	0.2 s	48 Hz	0.2 s	49 Hz	0.2 s	49 Hz	0.3 s	49 Hz	0.2 s	48 Hz	0.2 s
U \gt	1.10 pu	1.5 s	1.08 pu	5.5 s	1.07 pu	0.5 s	1.08 pu	1.5 s	1.07 pu	1.5 s	1.06 pu	1.5 s
U \gg	1.15 pu	0.2 s	1.17 pu	0.2 s	1.20 pu	0.2 s	1.15 pu	0.2 s	1.15 pu	0.2 s	1.15 pu	0.2 s
U \lt	0.85 pu	1.5 s	0.85 pu	1.5 s	0.93 pu	0.5 s	0.92 pu	1.5 s	0.90 pu	1.5 s	0.85 pu	1.5 s
U \ll	0.50* pu	0.2 s	0.50 pu	0.2 s	0.80 pu	0.2 s	0.80 pu	0.2 s	0.80 pu	0.2 s	0.50 pu	0.2 s

- Documented settings not equal real settings



Grid Protection examples

	Bruvoll-elva		Ullestad/Tverråna		DG2	
Parameter	Value	Time[s]	Value	Time[s]	Value	Time[s]
U>	N/A	N/A	1.10 pu	1.70	N/A	N/A
U<	N/A	N/A	0.85 pu	10.00	N/A	N/A
U<<	N/A	N/A	0.50 pu	0.20	N/A	N/A
I>	1.25 pu	1.50	N/A	N/A	N/A	N/A
I>>	3.97 pu	0.05	N/A	N/A	N/A	N/A
Uo>	0.23 pu	3.00	N/A	N/A	N/A	N/A
Io>>	N/A	N/A	N/A	N/A	0.10 pu	0.04
Io>>	N/A	N/A	N/A	N/A	0.05 pu	0.06





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Summary

Generator Protection

- Indications of conservative settings
- Lack of or defective documentation

Grid Protection

- Formal requirements and guidelines