Transformer Energisations

A technical review of the latest P28 issue and what this means for new connections

The latest Engineering Recommendation (EREC) P28 issue 2 became applicable to all new connections on the 23rd May 2019. This latest revision, published by Energy Networks Association (ENA), provides new assessment criteria and limits on the allowed flicker and voltage fluctuations as a result of connected equipment.

The move towards distributed generation and renewable technologies has introduced new factors that effect the distribution and transmission system. Due to this the original EREC P28 issue 1, published in 1989, has been replaced with issue 2.

One of the more significant updates relates to the assessment of voltage fluctuations caused by the energisation of transformers. Here the method of assessment, event categorisation and prescribed limits have been revised. In P28 issue 1 the voltage limit was pretty clear – no more than 3% after 30ms from the energisation event. There were some greater allowances granted for less frequent events, but the majority had to comply with this 3% limit. Issue 2 replaces this limit with defined voltage variation envelopes for each event frequency category.

Category	Voltage Dip Limits [%]			
	Max	30ms	100ms	2sec
Frequent	6	-	3	-
Infrequent	10	-	6	3
Very infrequent	12	-	10	3

Category	Max Events
Frequent	More than 4 per month
Infrequent	4 per calendar month
Very infrequent	1 in 3 calendar months

The above tables define the voltage dip limits at the various times following the energisation event, categorised for different event frequencies. These are defined envelopes that prescribe the voltage

limits. Another significant change when it comes to transformer energisations is the residual flux assumption used in simulations, previously it was 0.8, but it is now 0.5. Further to this, in issue 1 the resultant voltage dip considered was arrived at by the 50th percentile of a number of switching events, but now the maximum value is considered.

As can be seen, the new issue brings about a fair few changes – some of these provide a more generous allowance for the connection, and some will make compliance more onerous. This technical review aims to highlight the effects of issue 2 on new connections, by carrying out simulations on a range of hypothetical scenarios and assessing these against the new and old P28 standards.

The hypothetical scenarios consider a range of typical transformer sizes, across typical fault levels at 11kV and 33kV connection voltages. Generic transformer inrush characteristics have been used to obtain these results.

Transformer Size	Fault Level [MVA]	Case Number	Voltage Dip [%]			P28 Issue 1			P28 Issue 2		
			30ms After	100ms After	Max	Frequent	Infrequent	Very Infrequent	Frequent	Infrequent	Very Infrequent
1 MVA	1000	31	0.2	0.2	0.3	C	C	C	C	C	C
	750	32	0.2	0.3	0.4	C	C	C	C	C	C
	500	33	0.3	0.4	0.6	C	C	C	C	C	C
	300	34	0.5	0.7	1	C	C	C	C	C	C
	200	35	0.7	1	1.5	C	C	C	C	C	C
	100	36	1.4	1.7	2.8	C	C	C	C	C	C
	50	37	2.3	2.6	4.7	C	C	C	C	C	C
2 MVA	1000	38	0.3	0.5	0.6	C	C	C	C	C	C
	750	39	0.4	0.6	0.9	C	C	C	C	C	C
	500	40	0.6	0.9	1.3	C	C	C	C	C	C
	300	41	0.9	1.4	2	C	C	C	C	C	C
	200	42	1.3	1.9	2.9	C	C	C	C	C	C
	100	43	2.3	3.1	5.2	C	C	C	NC	C	C
	50	44	3.7	4.3	8.5	NC	C	C	NC	C	C
3 MVA	1000	45	0.5	0.7	1	C	C	C	C	C	C
	750	46	0.6	0.9	1.3	C	C	C	C	C	C
	500	47	0.9	1.4	1.9	C	C	C	C	C	C
	300	48	1.4	2.1	3	C	C	C	C	C	C
	200	49	2.1	2.8	4.3	C	C	C	C	C	C
	100	50	3.6	4.3	7.5	NC	C	C	NC	C	C
	50	51	5.5	5.6	12	NC	C	C	NC	NC	C
5 MVA	1000	52	0.8	1.2	1.7	C	C	C	C	C	C
	750	53	1	1.6	2.2	C	C	C	C	C	C
	500	54	1.5	2.3	3.2	C	C	C	C	C	C
	300	55	2.5	3.3	5	C	C	C	NC	C	C
	200	56	3.4	4.4	7	NC	C	C	NC	C	C
	100	57	5.2	6.2	12	NC	C	C	NC	NC	C
	50	58	8.4	7.5	18	NC	NC	C	NC	NC	NC
10 MVA	1000	59	1.7	2.4	3.2	C	C	C	C	C	C
	750	60	2.2	3	4.2	C	C	C	NC	C	C
	500	61	3.1	4	6.2	NC	C	C	NC	C	C
	300	62	4.6	5.8	9.4	NC	C	C	NC	C	C
	200	63	6.3	7.1	13	NC	NC	C	NC	NC	NC
	100	64	9.5	8.9	20	NC	NC	C	NC	NC	NC
	50	65	12.9	9.6	28	NC	NC	NC	NC	NC	NC
20 MVA	1000	66	3.3	4.2	6.2	NC	C	C	NC	C	C
	750	67	4.2	5.1	7.9	NC	C	C	NC	C	C
	500	68	5.7	6.5	11	NC	C	C	NC	NC	C
	300	69	8.2	8.1	16	NC	NC	C	NC	NC	NC
	200	70	10.8	9.1	21	NC	NC	NC	NC	NC	NC
	100	71	14.1	9.9	29	NC	NC	NC	NC	NC	NC
	50	72	17.3	9.9	36	NC	NC	NC	NC	NC	NC

Table 1 - 33kV simulations

Transformer Size	Fault Level [MVA]	Case Number	Voltage Dip [%]			P28 Issue 1			P28 Issue 2		
			30ms After	100ms After	Max	Frequent	Infrequent	Very Infrequent	Frequent	Infrequent	Very Infrequent
1 MVA	250	1	0.8	0.09	1	C	C	C	C	C	C
	200	2	1	1.2	2	C	C	C	C	C	C
	150	3	1.3	1.5	2	C	C	C	C	C	C
	100	4	1.9	2.1	3	C	C	C	C	C	C
	50	5	3.4	3.7	6	NC	C	C	NC	C	C
	25	6	5.9	5.7	11	NC	C	C	NC	NC	C
2 MVA	250	7	1.6	1.9	3	C	C	C	C	C	C
	200	8	1.9	2.3	3	C	C	C	C	C	C
	150	9	2.5	3	4	C	C	C	NC	C	C
	100	10	3.6	4	6	NC	C	C	NC	C	C
	50	11	6.2	6.2	11	NC	NC	C	NC	NC	C
	25	12	9.9	8.3	18	NC	NC	C	NC	NC	NC
3 MVA	250	13	2.3	2.7	4	C	C	C	C	C	C
	200	14	2.8	3.2	5	C	C	C	NC	C	C
	150	15	3.6	4	6	NC	C	C	NC	C	C
	100	16	5	5.3	9	NC	C	C	NC	C	C
	50	17	8.3	7.5	15	NC	NC	C	NC	NC	NC
	25	18	12.4	9.2	23	NC	NC	NC	NC	NC	NC
5 MVA	250	19	3.6	4	6	NC	C	C	NC	C	C
	200	20	4.3	4.7	8	NC	C	C	NC	C	C
	150	21	5.4	5.6	10	NC	C	C	NC	C	C
	100	22	7.3	7	13	NC	NC	C	NC	NC	NC
	50	23	11.2	8.8	20	NC	NC	NC	NC	NC	NC
	25	24	15	9.5	28	NC	NC	NC	NC	NC	NC
7.5 MVA	250	25	5	5.2	9	NC	C	C	NC	C	C
	200	26	6	5.9	10	NC	C	C	NC	NC	C
	150	27	7.3	6.8	12	NC	NC	C	NC	NC	NC
	100	28	9	8	17	NC	NC	C	NC	NC	NC
	50	29	12.8	8.6	23	NC	NC	NC	NC	NC	NC
	25	30	16.2	8.9	29	NC	NC	NC	NC	NC	NC

Table 2- 11kV simulations

At first view of the results shown in table 1 and 2, it seems as though issue 2 of P28 leads to more non-compliance cases than issue 1. However, due to changes in the event frequency categorisation within issue 2 this is not actually the case. Things become clearer when these results are further broken down by event frequency.

Two transformer energisations per month

In issue 1 this would have been considered frequent but in issue 2 is considered infrequent. This provides a greater voltage dip allowance for connections falling within this event frequency. Thus, cases 5, 10, 15, 16, 19, 20, 21 and 25 which would have been non-compliant under issue 1 would now be fully compliant under issue 2.

Five transformer energisations per month

This is considered frequent by both issue 1 and 2. Thus, issue 2 provides a reduced voltage dip allowance as now the maximum value over the energisation event is considered. This would result in non-compliance under issue 2 for cases 9, 14, 43, 55 and 60 where compliance would have resulted from issue 1.

One transformer energisation in three months

Issue 1 would have considered this infrequent where issue 2 considers it very infrequent. Thus, providing more allowance and a now compliant result for case 11.

One transformer energisation per month

This is defined as infrequent in both issues and so results in a reduced allowance and non-compliant result for cases 6, 26, 51, 57 and 68 under issue 2.

One transformer energisation per year

This is defined as very infrequent under both issues and so also results in a reduced allowance and non-compliance for cases 12, 17, 22, 27, 28, 58, 63, 64 and 69 under issue 2.

In summary

As can be seen, one of the more significant factors effecting results under the new issue is the event frequency categorisation. Where issue 2 results in a Less onerous categorisation compliance will be easier to achieve. Conversely, for event frequencies considered under the same category the new issue can make gaining compliance harder. As was the case under the old issue, new connections require in depth modelling and analysis to confirm compliance with this latest issue on a case by case basis.

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