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Motor Starting - Sustained and Instantaneous Voltage Dip

1.0 Introduction

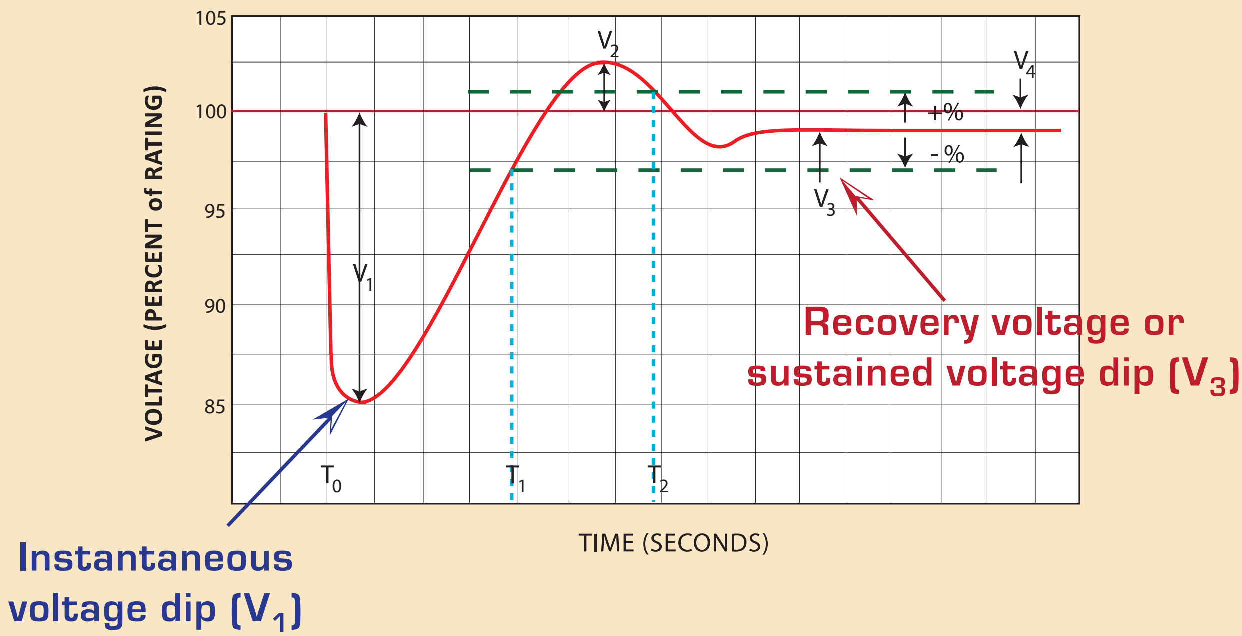
When starting electric motors with a standby generator, it is important to understand the effect of the voltage dip when calculating the sizing criteria.

This information sheet discusses the effects voltage dip can have on an electrical system and considerations that should to be taken when designing and specifying an electrical system with motor loads.

2.0 Instantaneous Voltage Dip (IVD)

Most manufacturers of alternators and generator sets measure for the instantaneous voltage dip as the primary factor for motor load sizing. Both National Electrical Manufacturers Association (NEMA) and DOD Military (MIL) standards also recognize the initial voltage dip as the primary criteria.

Genset transient voltage versus time for sudden load change



V_1 = **Voltage dip**
V_2 = **Maximum transient voltage overshoot**
V_3 = **Recovery voltage**
V_4 = **Steady-state regulation**

T_0 = **Point at which load is applied**
T_1 = **Time to recover to a specific band**
T_2 = **Time to recover to and remain within the specified band**

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Examples of IVD and its consequence are

- Represents the actual maximum voltage dip experienced when an induction motor load is applied.
- Maximum voltage dip due to motor inrush current normally occurs within 5 cycles and then quickly recovers with the automatic voltage regulator (AVR) sensing the drop and increasing current flow to the alternator field.
- Industry generally regards a 30% to 35% IVD as the standard to start a motor, and the proper operation of the other equipment connected to the generator.
- Generally only between 1 and 4 seconds lapse before recovery time but this can be extended dependant on the motor load and genset combination.
- Any larger % dip could cause problems with sensitive loads and result in adverse issues such as starter motor 'chatter' and /or drop out, some static UPS units to malfunction, overheating, extended load acceleration times, circuit breakers or other protective devices to open and engine-generator shutdowns to operate.

3.0 Sustained Voltage Dip (SVD)

This is also called the recovered voltage or the voltage level that the generator recovers to after the instantaneous dip. The sustained voltage value is determined by applying stepped load increases until the alternator does not recover to 90% of sustained voltage.

4.0 Why is 90% SVD Considered

This recognizes that over-current protection devices are affected by the heat in the system. As such, it defines the concept of continuous loads and the 90% rule in order to try and offset the effects of heat in the system when sizing a CB.

5.0 Comparing IVD with SVD

By definition IVD and SVD are very different. The following should be noted when comparing IVD and SVD:

- With no direct relationship between IVD and SVD - any correlation can be misleading in performance terms.
- Their maximum KVA values are different. Maximum starting KVA (SKVA) based on a sustained voltage of 90% can show a much larger value, but the voltage dip is almost always much greater than 35%.
- Specifications should call for instantaneous voltage dip value for SKVA at a given voltage dip for a consistent comparison thereby ensuring correct operation of sensitive loads

6.0 When to Consider Evaluating IVD or SVD

Instantaneous Voltage Dip (Why it is normally a primary consideration for motor starting systems)

- Motor starting is recognized as a complete system performance issue with IVD considered the primary criteria influencing a motor starting system. Ignoring the complexities and dynamics of IVD, without the proper prototype tests and system modeling, can result in an improperly sized generator.
- If a large motor system can tolerate long start times the initial voltage dip is less important. However, it is important to review alternator damage curves to determine if high inrush currents, when starting large, slow-starting motors and will exceed the equipment's design limits.

Sustained Voltage Dip (Why it is considered a secondary criteria for motor starting systems)

- SVD is calculated by ignoring the initial instantaneous dip despite most industry experts (including NEMA and MIL standards) considering it to be the primary criteria. As such, only considering SVD is not a comprehensive system performance solution or approach when calculating equipment sizes in a motor starting system.
- It significantly understates the actual voltage dip experienced by equipment and motors connected to the generator, which can result in motor starters dropping out and other equipment malfunctions due to a higher IVD exceeding the maximum SKVA calculated for the application.
- If the sustained SKVA is larger than the instantaneous voltage dip SKVA value, then the sustained SKVA must be ignored as the motor starter would drop out and not see the additional SKVA.

7.0 Fundamentals for Successful Motor Starting.

- Sufficient IVD and SKVA – the motor rotates, starter contacts hold in and no other loads affected
- Sufficient generator set torque – the motor rotates and does not stall out
- Sufficient HP/kW and exciter forcing – motor accelerates and reaches operational speed and voltage

Note! The maximum KVA at 90% sustained voltage values are larger than instantaneous SKVA at 35% voltage dip

8.0 Key Recommendations and Conclusions.

A) SVD and IVD values are not the same and should therefore not be compared
B) Neither approach should be the ONLY method used for motor starting sizing calculations
C) Instantaneous VD is used as the primary criteria for motor starting sizing
D) Sustained VD SKVA cannot exceed IVD SKCA at the required voltage dip level (SVD SKVA can overstate the maximum KVA)
E) Use the IVD SKVA value in specifications for proper motor starting and operation of other connected equipment
F) Trust the sizing software of major manufacturers for the dynamics of motor starting

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