

# TechTopics No. 102

## Tapered bus

On occasion, we are asked to provide tapered bus in our equipment. Use of tapered bus was a relatively common practice many decades ago, but has been largely eliminated due to changes in the codes and regulations, most notably the National Electric Code® (NEC) (NFPA 70®).

What is tapered bus? In its simplest form, it is based on the idea that if there are a large number of feeders on a bus, as you move further from the source, the load current will decrease (as current is drawn off by feeders upstream), and therefore the main bus can be reduced in size and will still be able to handle the continuous current of the application. A hypothetical example is shown in Figure 1.

In this example, the user has specified that the main bus at the most-downstream end only has to be rated for the current for which the loads are configured. The last four feeders are  $300\text{ A} + 200\text{ A} + 400\text{ A} + 200\text{ A} = 1,200\text{ A}$ , so the user specifies 1,200 A main bus for this portion of the lineup. While this concept seems appealing at first glance, it is not a good practice, and should never be used.

Figure 1: Example

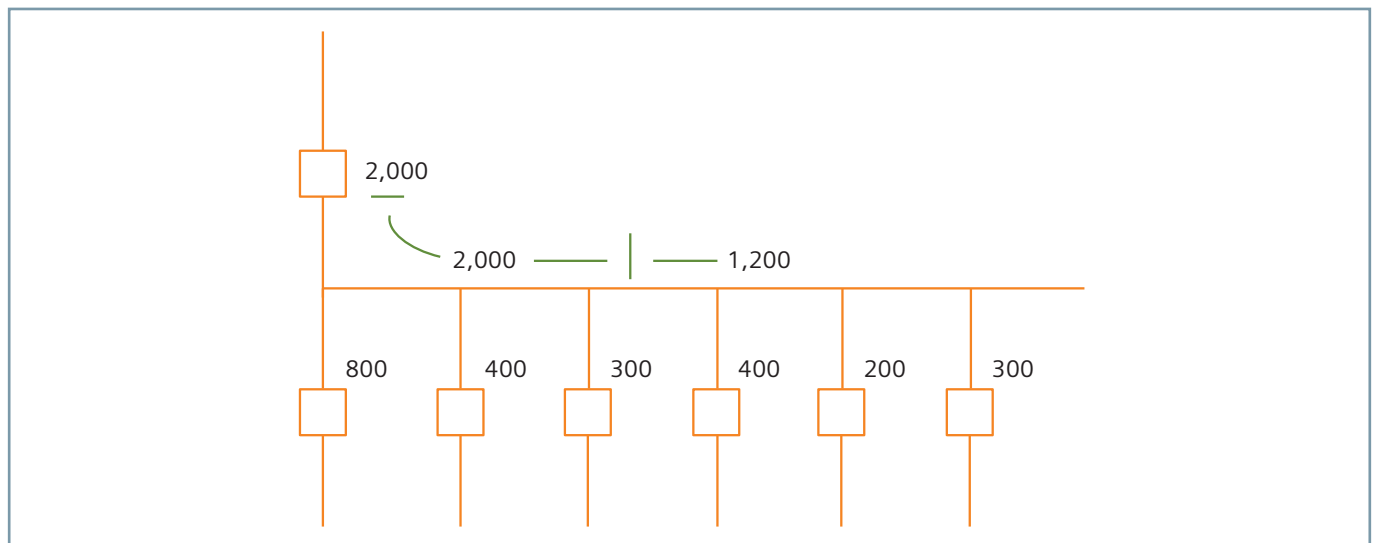
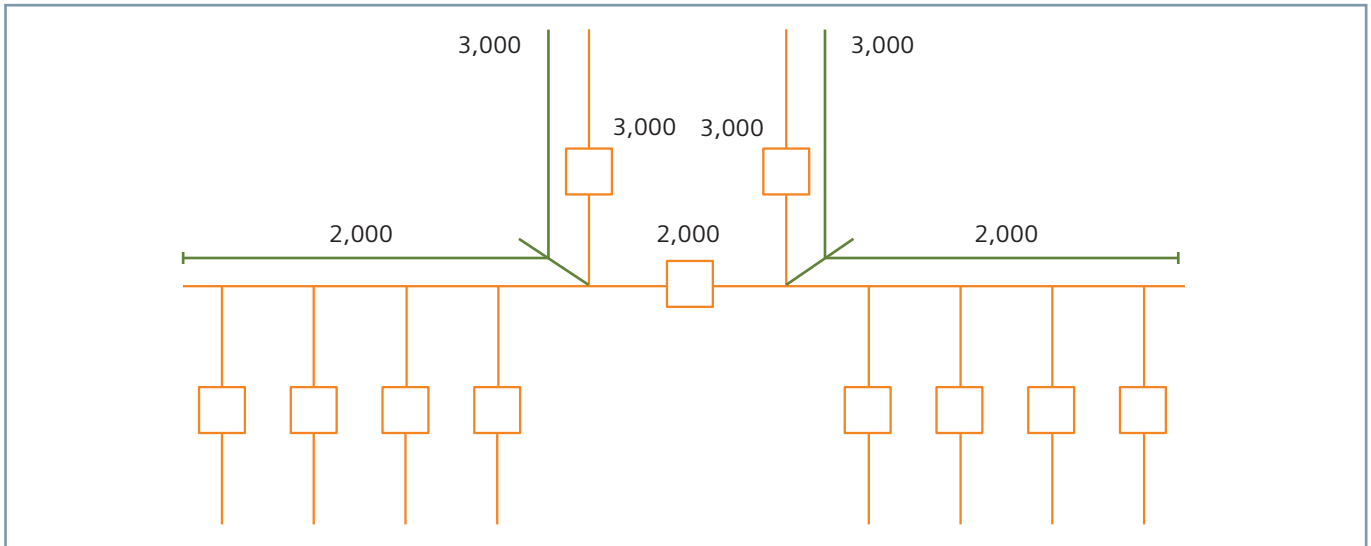


Figure 2: Example



A second example, actually more prevalent and perhaps reasonable engineering practice, is shown in Figure 2. In this example, the main and tie circuit breakers are located at the center of a double-ended switchgear installation, with the main circuit breakers sized for 3,000 A and the rest of the equipment sized for 2,000 A. The tie circuit breaker is also 2,000 A and is normally open. The overall system design is based on the concept that 3,000 A will only be required when one of the main circuit breakers is open, the tie circuit breaker is closed, and a single source is carrying the entire load. The load on either side of the substation will never exceed 2,000 A, so all of the buses are actually operated within their ratings.

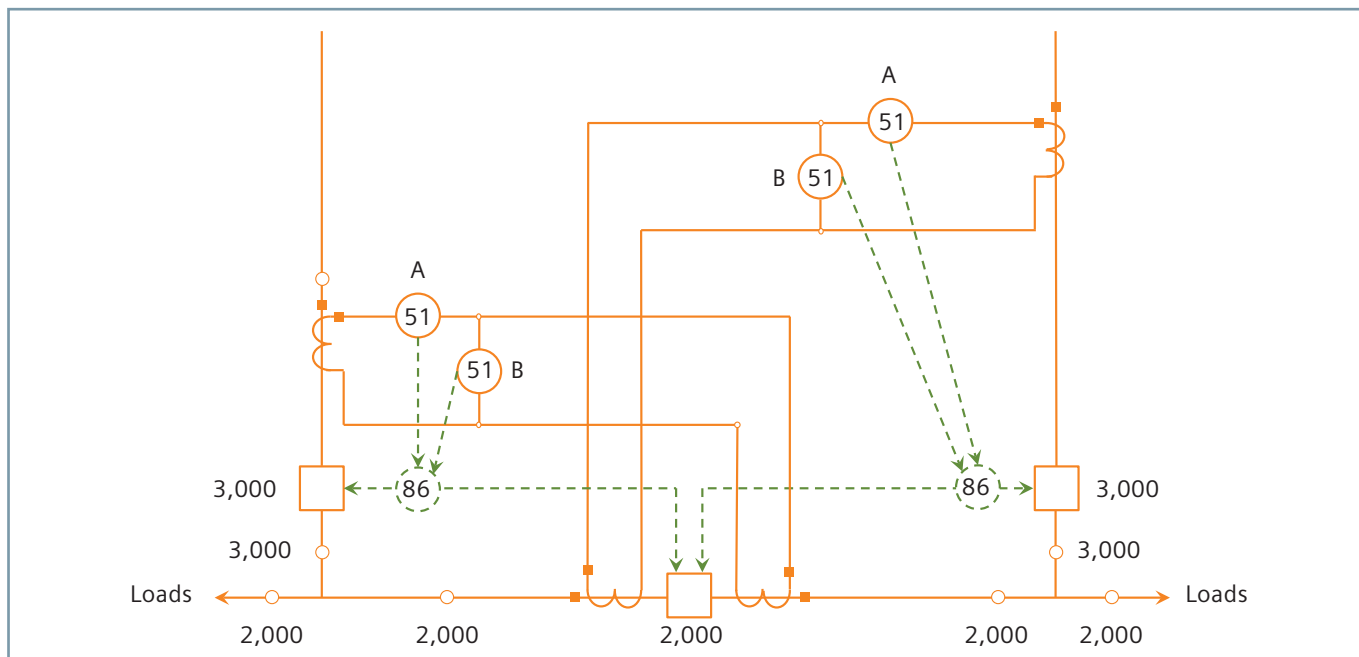
Earlier, the NEC was mentioned. The NEC treats a situation of tapered bus as a tap, covered in article 240.21. The code allows taps under certain circumstances, provided that the termination of the tapped conductors contains an overcurrent protective device of the proper current rating. It does not allow a tap to terminate in multiple circuits unless there is overcurrent protection that protects the tap section at its current rating. So, the NEC prohibits the situation in Figure 1 on page 1.

But, what about Figure 2? This situation may be permitted, depending on the design. If the configuration of the equipment is such that the 2,000 A bus is protected at its continuous current rating of 2,000 A, the NEC permits it. How would this be accomplished? A protection scheme referred to as "partial bus differential" is used. It can have various forms, but the simplest form is shown in Figure 3 on page 3. The current transformers on the main circuit breakers are connected to overcurrent relays (device 51, A) set for 3,000 A. The main circuit breaker current transformers are also connected to the tie circuit breaker current transformers and to another set of overcurrent relays (device 51, B), and these relays are set for 2,000 A. The scheme works because the current which flows to the other end of the substation (through the tie circuit breaker) is subtracted from the current flowing through the main circuit breaker, and therefore the "B" relays see only the difference in current. When the tie circuit breaker is open, the "B" relays will provide protection for their section of main bus at the 2,000 A rating. The "A" relays only become a factor when the tie circuit breaker is closed and the current through the main circuit breaker is above 2,000 A.

The scheme shown in Figure 3 on page 3 works under any operating scenario, including:

- Two mains closed and tie open
- One main closed, other main open and tie closed
- Two mains and tie closed.

Figure 3: Example



When the overcurrent relays detect a short circuit or an overload on their protected main circuit breaker, tie circuit breaker or main bus section, a lockout relay (device 86) trips the main circuit breaker and the tie circuit breaker, removing the fault from the protected sections.

Another aspect of this protection scheme is that it avoids introducing additional time delay for the main circuit breakers to obtain selectivity. In a conventional scheme, feeder circuit breakers have one time delay, the tie circuit breaker has additional time delay, and the main circuit breaker has even longer time delay for tripping. In this scheme, the extra time delay for the tie circuit breaker is avoided.

Unless a protection scheme such as a partial differential scheme is used to protect the bus at the current rating of the bus, an arrangement such as is shown in Figure 2 is not permitted under the NEC.

Siemens' practice has been that tapered bus is not furnished as shown in Figure 1, and tapered bus as shown in Figure 2 is only furnished when the equipment includes overcurrent protection (such as in Figure 3) that protects the buses at current levels no higher than their ratings.

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