

# Understanding National Electric Code (NEC) tap rules

## How do they apply to circuit breaker terminals?



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**Circuit breakers are often used to supply current to more than one load. This separation of the circuits can occur directly from the load-side cable terminals of the circuit breaker.**

The 2014 National Electrical Code (NEC) includes a number of requirements and specifications related to incoming feeder taps. This white paper will clarify those rules to ensure that panel builders and integrators maintain required electrical safety and avoid potential issues with local electrical inspectors by correctly applying the code articles.

### **NEC 2014 edition electrical code tap rules**

The NEC article dealing with overcurrent protection of feeder taps is article 240.21(B). These rules are often referred to as the NEC “tap rules”.

There are five tap rules related to feeder circuit taps:

- Taps Not Over 3 m (10 ft.) Long
- Taps Not Over 7.5 m (25 ft.) Long
- Taps Supplying a Transformer  
[Primary Plus Secondary Not over 7.5 m (25 ft.) Long]
- Taps over 7.5 m (25 ft.) Long
- Outside Taps of Unlimited Length

The NEC has some very specific requirements for each of the tap rules which we will review in further detail.

This paper will provide several application examples for the use of circuit breaker terminals to tap branch or feeder circuits from molded case circuit breakers (MCCBs) and insulated case circuit breakers (ICCBs). Many other configurations (besides those discussed in this paper) are possible. Please refer to the manufacturer’s published data concerning circuit breaker terminals such as wire size, tightening torque, temperature rating of conductors and conductor material type, i.e. copper or aluminum.

### **Tap conductor definition from 240.2 of the National Electrical Code (NEC), 2014 edition**

Before discussing how to apply the tap rules, we must know what a tap conductor is. NEC says it is:

“A conductor, other than a service conductor, that has overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors that are protected as described elsewhere in 240.4.”

## The NEC tap rule

Next, let's look at the specific NEC requirements for the two most commonly used feeder tap rules:

**(1) Taps not over 3 m (10 ft.) long.** If the length of the tap conductors does not exceed 3 m (10 ft.) and the tap conductors comply with all of the following:

- The ampacity of the tap conductors is
  - a. Not less than the combined calculated loads on the circuits supplied by the tap conductors, and
  - b. Not less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or not less than the rating of the overcurrent protective device at the termination of the tap conductors.Exception to b: Where listed equipment, such as a surge protective device(s) [SPD(s)], is provided with specific instructions on minimum conductor sizing, the ampacity of the tap conductors supplying that equipment shall be permitted to be determined based on the manufacturer's instructions.
- The tap conductors do not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply.
- Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which extends from the tap to the enclosure of an enclosed switchboard, switchgear, a panelboard, or control devices, or to the back of an open switchboard.
- For field installations, if the tap conductors leave the enclosure or vault in which the tap is made, the ampacity of the tap conductors is not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors.

**(2) Taps not over 7.5 m (25 ft.) long.** Where the length of the tap conductors does not exceed 7.5 m (25 ft.) and the tap conductors comply with all the following:

- The ampacity of the tap conductors is not less than one-third of the rating of the overcurrent device protecting the feeder conductors.

- The tap conductors terminate in a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This device shall be permitted to supply any number of additional overcurrent devices on its load side.
- The tap conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

A highly simplified paraphrasing of the NEW tap rules has two main points:

1. A conductor rated a minimum of 10% of the ampacity of a feeder conductor may be tapped from the feeder provided its length is not greater than 10 feet and it terminates in an appropriately sized overcurrent protective device.

2. A conductor rated a minimum of 33% of the ampacity of a feeder conductor may be tapped from the feeder provided its length is not greater than 25 feet and it terminates in an appropriately sized overcurrent protective device.

## Addressing the need for tap conductors

Some panel builders may use power distribution blocks to distribute electrical power to multiple loads but many power distribution blocks have a low short circuit current rating (SCCR). Since their usage will lower the SCCR of the entire assembly, a better alternative solution may be to distribute branch circuits directly from the circuit breaker's terminals. In order to do this, the circuit breaker terminal must have provisions to accept more than one cable per phase.

Terminals for larger circuit breakers often have the ability to accept two or more conductors and some circuit breaker manufacturers may have multi-conductor lugs available as an accessory for smaller circuit breakers. Normally, multi-conductor lugs on larger-frame circuit breakers are used to supply a single large load from a single circuit breaker, but this need not be the only application for these lugs. These multi-conductor lugs may also be used to split or distribute the cables to feed more than one smaller load from the circuit breaker by using the NEC tap rules.

### Notes for application examples in this paper:

1. All wire size ampacity references are for copper conductors.
2. Conductor ampacities were taken from the 75°C column of Table 310.16 in the 2014 Edition of the National Electrical Code.
3. Although conductors with insulation temperature ratings higher than 75°C may be used, the ampacities may not exceed those shown in the 75°C temperature column.
4. Circuit breakers are used in these examples but other overcurrent protective devices such as fusible disconnect switches may also be used.



### Short circuit current ratings

Power distribution blocks may serve the purpose of distributing electrical circuits; their function is to provide a means to tap smaller conductors from a larger conductor, provided the tapping rules are followed. Conductors equal to the full ampacity of the circuit breaker must be extended to the power distribution block, and then properly sized taps may extend from the power distribution block to an overcurrent protective device.

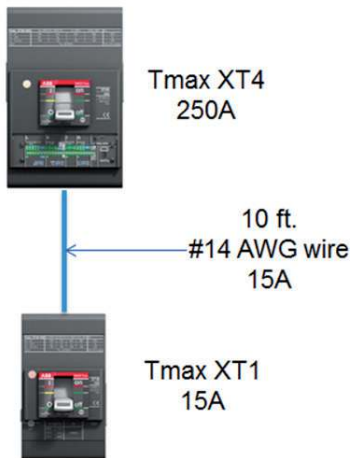
Even though the NEC tapping rules are followed, the short circuit current rating (SCCR) of the circuit may be limited to a low value. Untested and unmarked power distribution blocks have a SCCR of only 10,000 amps which may severely limit the SCCR of an assembly. The use of multi-conductor terminals for circuit breakers can overcome this limitation. Listed and approved multi-conductor circuit breaker terminals take on the same SCCR as the circuit breaker to which they are connected, allowing you to build a panel without having to reduce the SCCR. Also, by using the multi-conductor terminal lugs and making the tap connection at the circuit breaker terminals, the need for additional connection points is eliminated and panel space is saved.

### Misapplications

It is important to understand misapplication of the tap rules to avoid design or field installation errors; Figures 1-3 illustrate application examples of feeder taps that are not in compliance with the NEC requirements.

**Figure 1 – Taps not permitted**

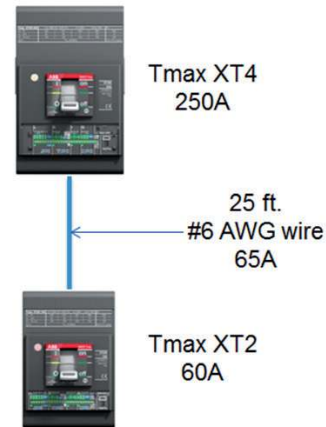
In Figure 1, the 10 ft. tap rule is not in compliance with the NEC because the #14 AWG wire is not at least 10% of the rating of the upstream overcurrent protective device.



In this case, the #14 AWG wire is correctly sized based on the ampacity of the Tmax XT1 circuit breaker to which it is feeding. However, the conductor is sized less than 10% of the rating of the Tmax XT4 250A circuit breaker from which the tap originates, so it does not comply with the NEC tap rules. In order to make this example comply with code, the conductor must be less than 10 feet in length and the wire must be sized for at least 25 amps, therefore, changing the #14 AWG wire to a #10 AWG wire would bring the example into compliance with the NEC tap rule.

**Figure 2 – Taps not permitted**

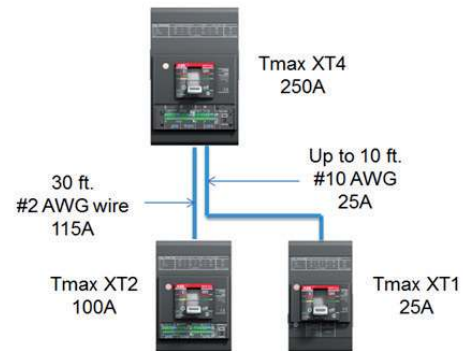
Figure 2 illustrates an example of the 25 ft. tap rule that is not in compliance. The conductor is within the 25 ft. limit allowed, but the #6 AWG wire is not sized to be at least 33% of the rating of the Tmax XT4 250A circuit breaker. A #4 AWG wire would be the



minimum wire size allowed in this example because it would be rated for 85 amps and thus meet the 33% minimum rating requirement of the upstream overcurrent protective device.

**Figure 3 – Taps not permitted**

Figure 3 illustrates a Tmax XT4 frame circuit breaker with a 250 amp trip unit, with two circuit breakers tapped from it: one with a 10 ft. tap and the other a 25 ft. tap. In this example, the 10 ft. tap is in compliance but the 25 ft. tap is not because of the excessive wire length. While multiple taps may be used, designers and installers must be careful to meet all of the code requirements to be a valid installation.



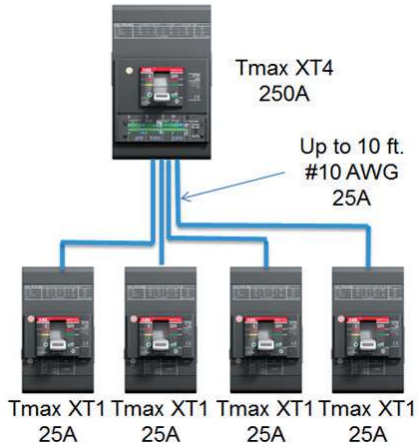
In this example, the 10 ft. feeder tap is in compliance with the NEC because the #10 AWG conductor is at least 10% of the rating of the upstream overcurrent protective device and the length does not exceed the 10 ft. limit. Unfortunately the #2 AWG conductor is not in compliance with the 25 ft. tap rule. Even though the conductor is at least 33% of the rating of the upstream overcurrent protective device, the wire length is 30 ft., exceeding the maximum length allowed, 25 ft.

Often, an industrial control panel or NEC installation requires a circuit breaker to be used as a main device, with lower ampacity circuits tapped from it. The following examples illustrate the correct usage of taps derived directly from circuit breaker terminals.



**Figure 4 – Tmax XT4 circuit breaker**

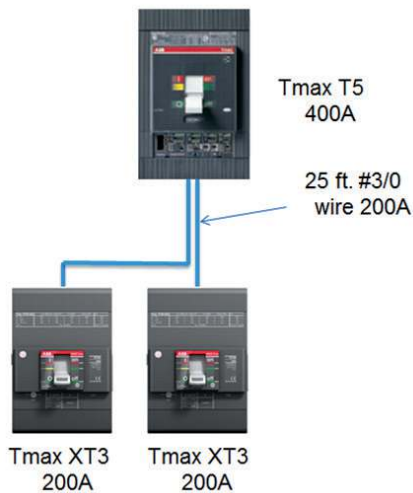
Figure 4 illustrates use of a Tmax XT4 circuit breaker with a 250 amp trip unit being tapped directly from the circuit breaker terminals. The 10 ft. tap rule states that a cable rated for at least 10% of the rating of the upstream protective device must be used. In this example, we see that multiple taps are used coming from a single circuit breaker as long as all of the taps comply with the NEC requirements.



The 10 ft. taps are in compliance with the NEC because the #10 AWG conductors are at least 10% of the rating of the upstream overcurrent protective device and the lengths do not exceed the 10 ft. limit. The multi-conductor cable lug of the Tmax XT4 is UL listed as a circuit breaker accessory and can accept up to six cables per phase within the range of #14 – 2 AWG. This allows the possibility of having up to six taps coming from one circuit breaker. Note that a downstream circuit breaker with a lower rating may be used as long as the conductor is still sized at a minimum of 25 amps.

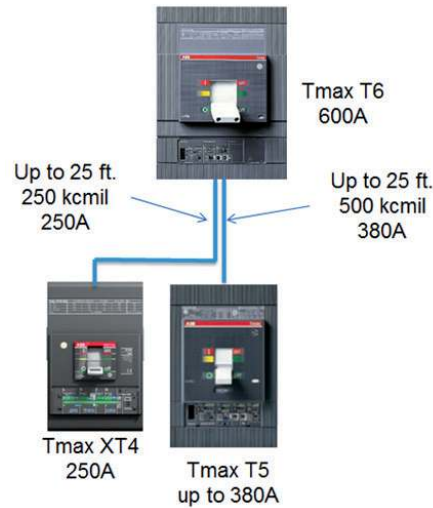
**Figure 5 – Tmax T5 circuit breaker**

The Tmax T5 circuit breaker has terminals available that can accept two wires per phase within the range of 3/0 to 250 kcmil. Figure 5 illustrates a Tmax T5 circuit breaker with taps going to two Tmax XT3 200A circuit breakers. Taps are shown at full capacity for each breaker.



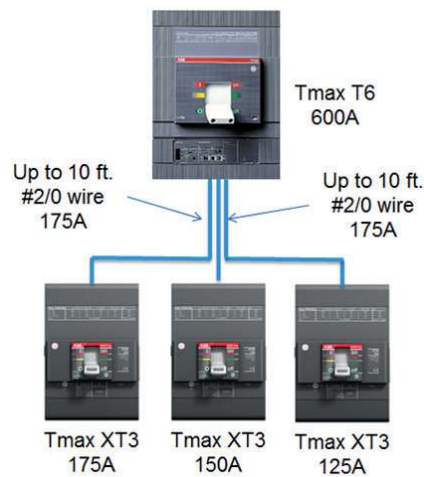
**Figure 6 – Tmax T6 circuit breaker**

The Tmax T6 600A circuit breaker in Figure 6 has two smaller breakers tapped from its terminals. The K6TH lug kit accepts two cables per phase, from 250-500 kcmils. By using a single 250 kcmil conductor out as a tap up to 25 ft. in length, one can supply a circuit breaker up to 250 amps (A Tmax XT4 250A is shown in the example to represent this.). By using a 500 kcmil conductor, which is the maximum wire size accepted by the K6TH lug kit, a circuit breaker up to 380 amps may be supplied. The adjustable electronic trip unit settings of the Tmax T6 breakers makes this possible.



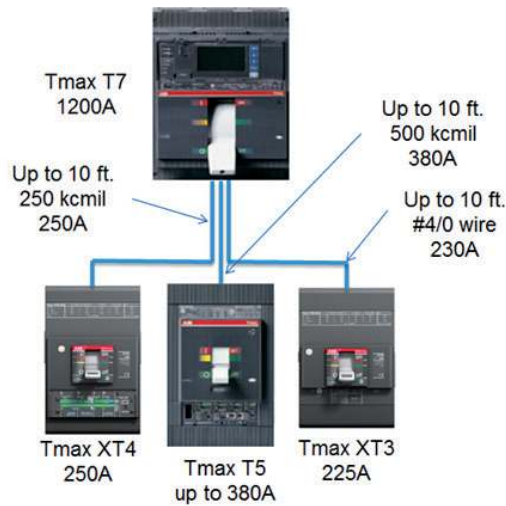
**Figure 7 – Tmax T6 circuit breaker**

In this example, the Tmax T6 600A circuit breaker has three taps connected to it. The K6TJ lug kit accepts wires within the range of #2/0-400kcmil. The minimum wire size (#2/0) is rated at 175 amps, so there is no problem meeting the 10% of the rating of the circuit breaker requirement. Circuit breakers smaller than 175 amps may also be used, provided the cable is sized according to what the cable lugs can accept. Figure 7 shows the Tmax XT3 125A circuit breaker tapped from the Tmax T6 600A circuit breaker, since the smaller frame Tmax XT1 and XT2 cannot accept the #2/0 conductor. The #2/0 is the smallest that can be installed in the K6TJ lug kit of the Tmax T6.



**Figure 8 – Tmax T7 circuit breaker**

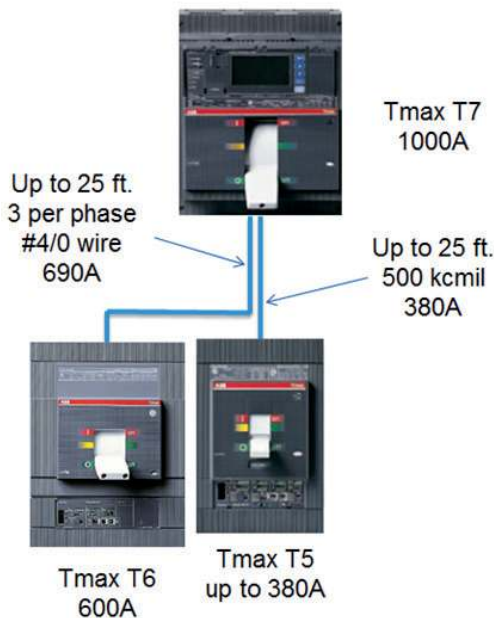
Figure 8 illustrates a Tmax T7 1200A circuit breaker used with three 10 ft. taps. The KT7X1200-3 lug kit accepts four cables per phase



from 4/0-500kcmil. In this example, we demonstrate a range of frame sizes is demonstrated with circuit breaker ratings that can be tapped using a single conductor from the Tmax T7 circuit breaker. It should be noted that lower ampere ratings of circuit breakers can be used, as long as the terminal lug will accept the proper conductor size. In this example, a Tmax XT3 60A circuit breaker, or a Tmax XT4 rated as low as 25A, can be substituted in place of the 225A circuit breaker.

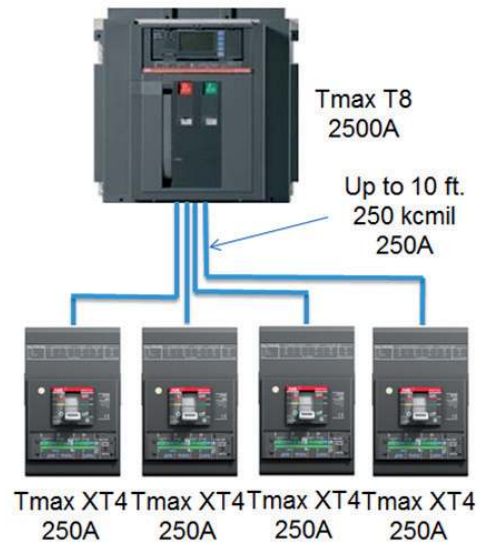
**Figure 9 – Tmax T7 circuit breaker**

Figure 9 illustrates a Tmax T7 1000A circuit breaker used with two 25 ft. taps. As evident in Figure 8, the KT7X1200-3 lug kit accepts four cables per phase from 4/0-500kcmil, but in this example we will show that a tap can be more than one cable per phase. Here we demonstrate a tap using three per phase #4/0 cables connected to a Tmax T6 600A circuit breaker and a single 500 kcmil conductor connected to a Tmax T5 circuit breaker.



**Figure 10 – Tmax T8 circuit breaker**

Figure 10 illustrates a Tmax T8 2500A circuit breaker used with four 10 ft. taps. The K8TL lug kit accepts four cables per phase from #1/0 – 750 kcmil, to create a tap at 10% of the circuit breaker rating (250A) using a Tmax XT4 250A circuit breaker and a single 250 kcmil cable per phase. Larger taps can also be created using larger cables or multiple cables per phase. Another lug kit available for the Tmax T8 circuit breaker, the K8TM, accepts six cables per phase from #1/0 – 750 kcmil, thereby expanding the options available for creating taps.



Power distribution blocks are often used in industrial control panels and NEC installations for tapping circuits; however, higher SCCRs can be achieved and panel space can be saved through the use of multi-conductor terminals on circuit breakers.



### Summary

Feeder rules apply to every industrial control panel. That makes it critical that panel builders and integrators understand the requirements laid out in the NEC tap rules.

This white paper provided both an explanation of these rules apply and a number of examples clarifying the rules. The correct application of these rules ensures proper protection of the equipment controlled by the panel, as well as the safety of those working on or near the attached equipment.

## Circuit Breaker Cable Lugs

### Tmax, Tmax XT and Formula Circuit Breakers

Frame size	Number of conductors per phase	Wire size	Catalog number (set of 3)
A1	1	14 AWG - 2	KA1080-3
	1	4 AWG - 1	KA1100-3
XT1	1	14 AWG - 1/0	KXT1CU-3PC1
	6	14 AWG - 2 AWG	KXT1MC-3PC
XT2	1	14 AWG - 1/0	KXT2CU-3PC1
	1	14 AWG - 1/0	KXT2CUAL1-3PC4
	6	14 AWG - 2 AWG	KXT2MC-3PC
XT3	1	14 AWG - 1/0	KXT3CUAL1-3PC
	1	4 AWG - 300 kcmil	KXT3CUAL2-3PC
	6	12 AWG - 2 AWG	KXT3MC-3PC
A2	1	1 AWG - 300 kcmil	KA2225-3
	1	300 - 350 kcmil	KA2250-3
XT4	1	14 AWG - 1/0	KXT4CUAL1-3PC2
	1	4 AWG - 300 kcmil	KXT4CUAL2-3PC2
	1	250 - 350 kcmil	KXT4CUAL3-3PC2
	1	14 AWG - 1/0	KXT4XCU-3PC1 3
	1	10 AWG - 250 kcmil	KXT4CU-3PC
	1	250 - 350 kcmil	KXT4CUAL3-3PC2
	6	12 AWG - 2 AWG	KXT4MC-3PC
T5	1	250 kcmil - 500 kcmil	KT5300-3
	2	3/0 - 250 kcmil	KT5400-3
T6	2	250 - 500 kcmil	K6TH
	3	2/0 - 400 kcmil	K6TJ
T7	4	4/0 - 500 kcmil	KT7X1200-3
T8	4	1/0 - 750 kcmil	K8TL
	6	1/0 - 750 kcmil	K8TM

1 FC Cu Terminals for copper cables only

2 Not available for XT4X up to 150A

3 For use with the XT4 X version up to 150A only. Note XT4X from 175-250A uses the standard 250A CU lug.

4 IEC rated only

#### References

– NFPA 70, The National Electrical Code, 2014

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