

Dimmer Doubling Fact Sheet

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Introduction

ETC's Patented Dimmer Doubling technology allows you to increase the number of individually controlled dimmer channels in your Sensor or Unison dimming system without adding dimmer modules or running additional cable. The key to Dimmer Doubling is the Dimmer Doubler and advanced software available only in ETC Sensor and Unison dimming systems.

Since its introduction in 1992, we have received many questions concerning the electrical aspects of Dimmer Doubling, formerly known as Multiplexing. This document will answer the most commonly asked questions about Dimmer Doubling.

The Dimmer Doubler is installed between a ETC dimmer module and two or four ETC Source Four 77 Volt 550 Watt fixtures. It splits the output of this single dimmer into two separately controlled outputs. You can then use an ETC control console (or any other type of console equipped with an electronic patch and DMX protocol) to independently control the output of the two fixtures.

To take advantage of the benefits of ETC Dimmer Doubling technology, the following elements are required:

- Source Four Fixtures with NEMA L5-R15 connectors and 550W, 77V HPL lamps
- Dimmer Doublers with UL Listed type input and NEMA L5-R15 output connectors
- Sensor or Unison dimming equipment
- Control Console with electronic patch and a minimum of one DMX512 output.

Note Each DMX 512 output can control 256 dimmers operating as 512 Dimmer Doubled channels. Systems with more than 256 dimmers must have at least two DMX 512 outputs in both the rack and the console.

Q1: Will Dimmer Doubling increase the capacity of an existing ETC Sensor dimming system?

A1: Dimmer Doubling will not increase the capacity of a dimming system. The current (amperage) capacity of the dimmers and mains supply are the limiting factors here. Dimmer Doubling will increase the controllable dimmer channels in a ETC Sensor dimming system.

Example: One Dimmer Doubled circuit can carry two control channels, each dimming 1 or 2 Source Four 77V 550W fixtures.

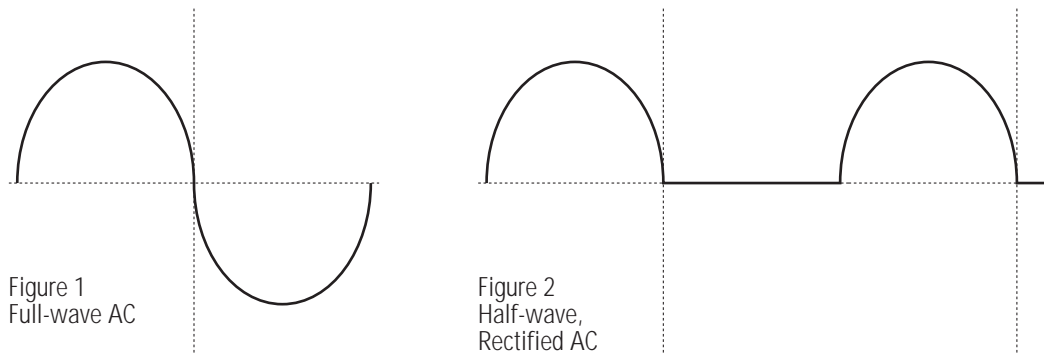
Q2: How does Dimmer Doubling Work?

A2: The firing mode of the dimmer is changed so that the positive and negative half cycles of the SCR firing are controlled separately. A splitter Y cable with two diodes (Dimmer Doubler) is then attached to the pigtail to feed the positive power half cycles to one output and the negative power half cycles to another output of a Dimmer Doubler. The separate positive and negative control allows the two Dimmer Doubler channels, (A and B) to be varied in intensity independently, sharing the same original circuit wiring.

Q3: Is the output of a Dimmer Doubler AC or DC voltage?

A3: The output to each fixture is half-wave AC. The diodes that are in the Dimmer Doubler change the full-wave AC (Figure 1) into half-wave rectified AC voltage (Figure 2). As you can see in figure 2, the voltage on each Dimmer Doubler channel is returning to 0v each half cycle. The New IEEE Standard Dictionary of Electrical and Electronics Terms (IEEE Std. 100 1992) gives the following definitions for clarification on the differences between half-wave rectified AC and DC voltages:

- **Half-wave rectification:** A single rectifier provides half-wave rectification. Because of its poorer efficiency and larger alternating-current component, half-wave rectification is usually employed in non critical low-current circumstances.
- **Direct Current:** A unidirectional current in which the changes in value are either zero or so small that they may be neglected.



Q4: Do I need special plugs or switches to deal with arcing on DC voltages?

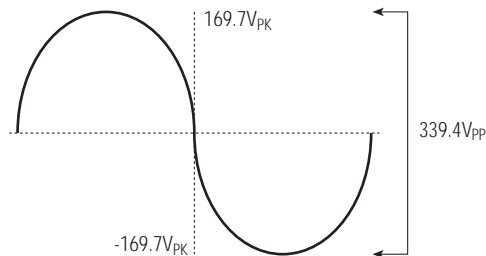
A4: No, there is no increased risk of switch or plug arcing, because the voltage on each Dimmer Doubler channel is returning to 0V each half cycle. (See A3 for the characteristics of half-wave regulated AC voltages.)

Q5: Can I use Dimmer Doubling with my other 120V lighting fixtures?

A5: No, Dimmer Doubling is designed specifically for Source Four Product 77V HPL lamps. It is not intended for use with any other devices (120V fixtures, inductive ballasts, motors, PSU's for scrollers, or gobo-rotators.) However it is utilized on a dimmer by dimmer basis.

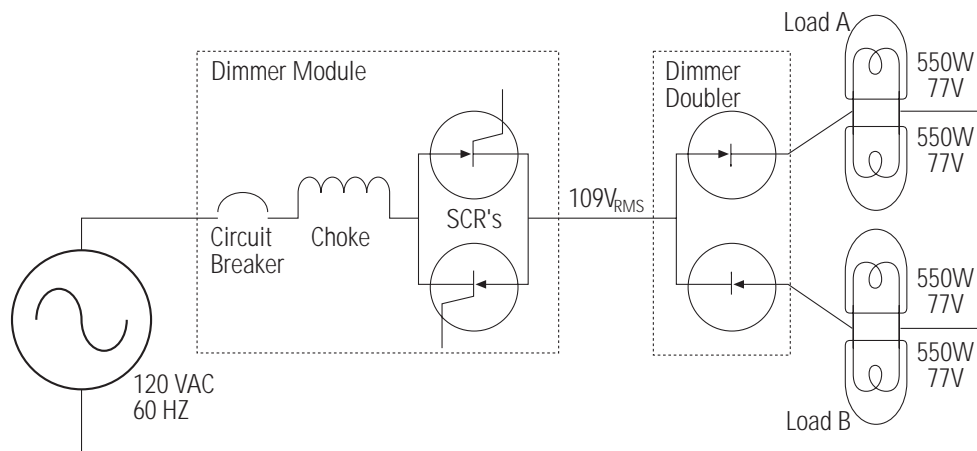
Q6: Will my 77V HPL lamp have a reduced lamp life running at 80V?

A6: The voltages and currents throughout a Dimmer Doubler confuse many people. This is because most people assume them to be linear additive values. They are not, they are non linear RMS (root mean square) values.



The Peak to Peak voltage of a standard 120V_{RMS} circuit is approximately 339.4V_{PP} (Peak to Peak voltage). Half-wave voltage is 169.7V_P (Peak Voltage) and 84V_{RMS}. So why use a 77V lamp? This is to allow for regulation. The Sensor CEM uses a feature known as "Scale Voltage" to regulate dimmers' output to compensate for power fluctuations and differences in load circuit resistance. On a Dimmer Doubled circuit, voltage is regulated to 77V_{RMS} maximum, so there is no risk of reduced lamp life.

Looking at a typical system of four 77V 550W Source Fours arranged two per half-cycle, the maximum currents and voltages are as follows:



I_{MAX} (Circuit Breaker) = 20.2 A _{RMS}	V_{SOURCE} (Circuit Breaker) = 120V _{RMS}
I_{MAX} (Load A) = 14.3 A _{RMS}	V_{DDA} (Load A) = 77V _{RMS}
I_{MAX} (Load B) = 14.3 A _{RMS}	V_{ddb} (Load B) = 77V _{RMS}

Note All the values on the previous page can be obtained from the following definitions of RMS current and RMS voltage, or through the appropriate measurement with a true RMS meter.

$$V_{RMS} = \sqrt{\frac{1}{\Phi} \cdot \int_0^{\Phi} (V_{PK} \cdot \sin(\Phi))^2 d\Phi}$$

$$I_{RMS} = \sqrt{\frac{1}{\Phi} \cdot \int_0^{\Phi} (I_{PK} \cdot \sin(\Phi))^2 d\Phi}$$

Q7: Will a Dimmer Doubler system present less risk of electric shock like other DC voltage systems?

A7: The Dimmer Doubler's output is half-wave AC and ETC does not claim that Dimmer Doubling has a lesser risk of electrocution than other AC lighting loads. The benefit of Dimmer Doubling is to have more independently controlled dimmer channels, with the same level of electrical safety as standard 120V dimming systems.

Q8: Is it true that Dimmer Doubling generates more harmonics than a standard phase angle dimming system?

A8: Even order harmonics are generated by a Dimmer Doubler when only one load is on, (A or B only). The amplitude of these harmonics are half of the equivalent 120V_{RMS} phase angle dimmed load. When both A and B circuits are used on a Dimmer Doubler, it generates less even and more odd order harmonics. In fact when both A and B loads are at equal levels, only odd order harmonics are generated, (the same as a 120V_{RMS} phase angle dimmed load). When this happens the amplitude of the harmonics returns to the typical levels found in a conventional dimming system. All of these things were taken into account when calculating the safe use of Dimmer Doubling Rules.

Q9: Don't the IEEE 519-1992 and IEC1000-3-2: 1995 Recommended Practices and Requirement for Harmonic Control in Electrical Power Systems state that DC voltages must not be detectable at the supply transformer?

A9: IEEE 519-1992 and IEC1000-3-2:1995 are recommended practice or guidelines for EEs to use when they are designing DC power supplies, and do not apply to Dimmer Doubling.

Q10: Will Dimmer Doubling saturate my Mains transformer and cause an over current condition?

A10: ETC has conducted a study on the effect of Dimmer Doubling on a mains transformer. Some transformers perform better than others, so we have developed a **Safe Dimmer Doubling Rule**, stated below, for using Dimmer Doubling in a dimming system with any Mains transformer.

Note This rule is designed with a worse case scenario in mind. That means any lighting look brought up at the console will have no adverse effect on the Mains transformer if the Dimmer Doubled fixtures were installed according to the **Safe Dimmer Doubling Rules**. The electrician will only have to know the maximum number of 77V 550W HPL lamps that he can use per phase on the A or B channels of the Dimmer Doublers.

The Safe Dimmer Doubling Rule #1, or

How many Dimmer Doubled fixtures can my Mains transformer support?

Take the Volt/Ampere (VA) rating of a transformer – our example uses 250KVA – and divide it by 10,300. The number 10,300 comes from 3 phases x 1/4 of the current on the Mains transformer x 120V x 7.15A (the current of one 77V 550W HPL lamp).

$$\frac{VA}{3 \cdot 4 \cdot 120V \cdot 7.15A} = L_{AorB} \qquad \frac{VA}{10,300} = L_{AorB}$$

To simplify this equation, just take the KVA rating of the transformer and divide it by 10.3

$$\frac{KVA}{(10.3)} = L_{AorB} \qquad \frac{250}{10.3} = 24.3$$

Now round 24.3 down to 24, and this is the maximum number of Dimmer Doubled 77V HPL lamps that can be assigned to any A or B channel of a phase.

Note Because similar Dimmer Doubled fixtures on the A and B channel will tend to cancel each other's saturating effect, it is best to "balance" Dimmer Doubled fixtures across the A and B channel of each phase, just like normal lighting loads are balanced between transformer phases 1, 2 and 3.

Now if you evenly loaded A and B channels of Dimmer Doublers and balanced across three phases, the maximum number of 77v HPL lamps in this system can be 144. This number is calculated by taking the L_{AorB} and multiplying it by 3 phases and 2 (which represents the A & B channels of a Dimmer Doubler.) This can be simplified to L_{AorB} multiplied by 6.

$$L_{AorB} \cdot 3 \cdot 2 = L_{Total} \qquad L_{AorB} \cdot (6) = L_{Total}$$
$$24 \cdot (6) = 144$$

Rule #2, Sizing a Mains Transformer for (x) 77V HPL Lamps

To determine the size of a mains transformer needed to supply a known number of Dimmer Doubled 77V 550W HPL lamps (LP_{DD}), multiply the number of 550W lamps by 1.717, and the result is the KVA rating of the mains transformer required. In the example, $LP_{DD}=144$ multiplied by 1.717. The result, 247,248 VA, is rounded up to 250 KVA.

$$LP_{DD} \cdot (1.717) = \text{KVA}$$

$$144 \cdot (1.717) = 247.248 \text{ (250KVA)}$$

Note The number of lamps to be used (144) must be divided by 6 to find the maximum number of 77V 550W HPL lamps per A or B side of each Dimmer Doubled phase (circuit).

Q11: If I use 4x550W 77V HPL lamps (2200W) won't the RMS current be 29A, 9 Amps over the rating of the circuit breaker in the dimmer module?

A11: Dimmer Doubled circuit breakers are correctly sized. The voltages and currents in a Dimmer Doubler circuit are not linear additive values. They are non-linear Root Mean Square (RMS) values (See A6 for a full explanation on RMS). Looking at a typical system of four 77V 550W Source Fours arranged two per half-cycle, the maximum currents at the circuit breaker is $20.2A_{RMS}$

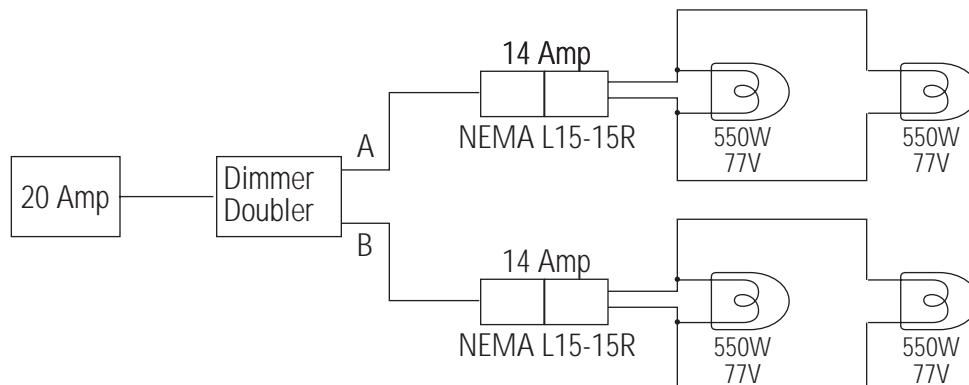
Note Dimmer Doublers are designed for a maximum of two 77V 550W lamps per A or B channel, a total of four lamps per Dimmer Doubler.

Q12: Are there special electrical codes to address DC voltages in a Dimmer Doubled system?

A12: All code issues have been addressed in the use of Dimmer Doubled half-wave regulated AC voltages (See A3 for half-wave regulated AC voltage characteristics).

Q13: Does a Dimmer Doubled system use different connectors for different voltages?

A13: Yes, to address the different voltages within a Dimmer Doubled system, ETC uses a 15A NEMA L5-15R Twist-lock connector for the 77VAC. The maximum current draw for one side of a Dimmer Doubler is 14.3A at 77V. The NEMA L5-15R Twist-lock connector is rated at 15A 125V. The input to the Dimmer Doubler is 120VAC 20A and the connector is rated accordingly. **The Dimmer Doubler is UL and cUL listed.**



Q14: Will I damage anything if I accidentally plug a 120V fixture into a dimmer circuit that is set up for Dimmer Doubling without a Dimmer Doubler in line?

A14: No, the connectors before the Dimmer Doubler will always carry AC voltages, and is intended for resistive loads only. (See A4 on characteristics of half-wave regulated AC voltages.) The voltages on the connector before the Dimmer Doubler will always be lower than the line voltage. This means if a 120V incandescent fixture was accidentally plugged into the connector before the Dimmer Doubler it would have no negative effect other than reduced light output levels. The only time this accidental condition would cause a problem is with an inductive load (transformers, ballasts, motors, etc.) In this case the inductive device will saturate because of the asymmetrical waveform. Caution should be taken when using inductive loads and dimmer doubling in the same system, as possible damage to the inductive loads may occur.

Q15: According to which electrical code will a Dimmer Doubler be tested?

A15: A Dimmer Doubler would fall under the electrical code of " Multipole Branch-Circuit Cable Connectors" Section 520-67. The Dimmer Doubler has one 15A connector on the A and B output adequately rated for the 14.3A maximum current possible on the circuit. The input to the Dimmer Doubler has a 20A connector for the 20A maximum possible for this connector. (See A6 and A13 for full details on voltages and currents throughout a Dimmer Doubler.)

Q16: Will Dimmer Doubling increase the number of loads I can use in my current Sensor Dimming System?

A16: Dimmer Doubling increases the number of individually controlled dimmer channels in a Sensor dimming system. (See A1 for more information on the advantages of Dimmer Doubling.) But, Dimmer Doubling does not increase the maximum load that can be connected to a dimming system or the number of luminaries that can be used.

Q17: Can I use my standard 120V lighting fixtures with a Dimmer Doubler?

A17: No, Dimmer Doubling is not intended to support any 120V lighting fixtures. Dimmer Doubling is a feature that has been specifically designed for use with ETC Source Four products. To take advantage of the benefits of ETC Dimmer Doubling technology, the following elements are required:

- Source Four Fixtures with NEMA L5-R15 connectors and 550W, 77V HPL lamps
- Dimmer Doublers with UL Listed input and output connectors
- Sensor or Unison dimming equipment
- Control Console with electronic patch and a minimum of one DMX512 output.

Q18: Do I need any special extension cables to use Dimmer Doubling?

A18: No, Dimmer Doublers are usually very close to the Source Four fixtures and do not require extension cables.

Q19: Do I need to do any additional planning to avoid overloading my dimmer module's rating?

A19: No, if you follow the **Safe Dimmer Doubling Rules** in this document when setting up your dimming system (see A10 for Safe Dimmer Doubling Rules), then no other special planning or precautions need to be observed. Any lighting look can be brought up in any manner and there is no increased risk of circuit breaker tripping or transformer overloading than in a conventional lighting system. (See A11 for proper loading of a Dimmer Doubler.)

Q20: Can I change my existing 120V Source Fours to operate at 77V with Dimmer Doubling?

A20: Yes, ETC sells 77V Source Four burners and 120V Source Four burners that can be swapped between any Source Four Fixture. To change a fixture from 120V to 77V just remove the rear 120V burner assembly and replace it with a 77V unit.

Q21: Will both channels of my Dimmer Doubler go off if one of the bulbs burns out?

A21: No, if a Dimmer Doubled lamp burns out it will not trip the circuit breaker or stop the other half of the Dimmer Doubler from operating. If any part of the Dimmer Doubler has a short circuit condition both sides of the Dimmer Doubler will stop operating when the circuit breaker trips.

Q22: How do I control the B output on a Dimmer Doubler?

A22: Dimmer Doubling requires two DMX channels to control each dimmer. We use DMX channel 1 to control dimmer 1A. This means DMX channel 257 will control dimmer 1B. By adding 256 to any dimmer number you can figure out the Dimmer Doubler's B channel DMX address. This is carried out in the DMX patch and transparent to the console operator.

Q23: Will there be DC present at my pigtail if I forget to turn off Dimmer Doubling after use?

A23: Turning off Dimmer Doubling is necessary when reconfiguring for conventional dimmer use, but DC voltage is never present anywhere in a Dimmer Doubling system. (See A13 for more information about connector voltages and currents in a Dimmer Doubler. See A3 for the characteristics of half-wave regulated AC voltages.)

If any further clarification is needed please call the Dimming Product Manger at (608) 831-4116.