# Solar Energy

*The OEM and Installers Guide to Control Components for Solar Power Applications*



c3controls.com

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Everything under control.

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# About c3controls

Since 1976 c3controls (c3controls.com) has provided OEMs and electrical equipment builders a comprehensive portfolio of industrial control products that meet the most demanding applications. By maintaining strict control over the development and manufacturing of all products, c3 can provide customers extraordinary value through unmatched quality, competitive pricing, same-day shipping and a 36-month product warranty. This vertically integrated approach coupled with a direct sales model brings c3 closer to the end-user, fostering a degree of innovation that leads the industry.






# Glossary of Solar Terms

**Active Solar Technologies:**
Mechanical or electrical devices that actively convert solar energy into another form of energy. The two major segments are photovoltaics (PV) and concentrated solar power.

**Array / String:**
A collection of solar panels wired into a circuit in order to generate electricity as a system.

**Balance of System (BOS):**
All components other than solar panels that help harvest, convert, distribute and store solar energy.

**Battery Bank:**
A system of batteries that store excess energy generated from solar panels for future use.

**Charge Controller:**
A device that regulates the electric charge entering and exiting the battery bank in order to prevent overload.

**Combiner Box:**
A unit that combines the output of numerous solar panel strings into one for connection to an inverter.

**Concentrated Solar Power:**
The active process of using mirrors and lenses to concentrate sunlight in order to heat a fluid and generate electricity.

**Disconnect Switch:**
A switch used to interrupt the flow of electricity and isolate a circuit. Solar DC disconnects separate the panel array and the inverter. Solar AC disconnects separate the inverter and the electrical grid.

**Inverter:**
A device that converts direct current (DC) power from solar panels into alternating current (AC) power. The three most common types are string inverters, microinverters, and power optimizers + string inverters.

**Kilowatt-hour (kWh):**
Standard unit measuring how much energy is used to run an object for one hour. 1 kWh equals 1,000 watts used in one hour.

**Micro-inverter:**
An inverter that converts DC to AC directly from the back of each solar panel, no string inverter needed.

**National Electric Code (NEC):**
The NEC, or National Fire Protection Association (NFPA 70), is the adoptable standard in the United States for safe electrical design, installation and inspection. Article 690 addresses safety standards for the installation of solar PV systems.

**Off-Grid Solar:**
An independent solar energy system that is not connected to the utility's electrical grid.

**On-Grid Solar:**
A solar energy system that is tied to and works with the local utility's electrical grid. The grid-tied system uses net metering to feed excess power to or draw needed power from the grid.

**Passive Solar Technologies:**
Structures that utilize the sun's energy without the use of external devices such as cool roofs, green roofs and radiant barriers.

**Photovoltaics (PV):**
Relating to the active process of solar panel PV cells directly converting sunlight into electricity.

**Power Optimizer:**
A DC/DC converter connected to each solar panel in a PV system. These smart modules condition DC power before sending it to a string inverter for AC conversion.

**Solar Farm:**
A large scale, grid connected collection of photovoltaic solar panels.

**Solar Panel:**
A collection of solar PV cells which convert sunlight into electricity. A typical residential solar application contains around 20 panels.

**String Inverter:**
The most common type of inverter that connects multiple solar panel strings and converts the total DC input into an AC output.

**Switchboard Panel:**
A combination of switching devices used to manage and protect solar energy systems.

**Transformer:**
A device used to increase or decrease AC power from input to output.

# Solar Energy: A Hot Topic

Our sun is a free, limitless, easily accessible and clean source of energy. The amount of sunlight that strikes Earth in just 90 minutes is enough to meet the entire world's energy consumption for a full year. It is no surprise that solar energy has been a *hot topic* of discussion worldwide in order to reduce greenhouse gas emissions, mitigate climate change and save some dollars.

The solar market will continue to experience rapid growth — the Solar Energy Industries Association (SEIA) is aiming for solar power to account for 30% of ALL electricity by 2030 — and 40% by 2035! Due to huge demand, technology has been continually advancing to more effectively and economically capture, store and distribute the sun's energy. As a result, solar energy has become a notably efficient resource in many sectors such as residential and commercial buildings, as well as industrial manufacturing applications.

Different sectors require different solar technologies and applications. Today, photovoltaics (PV) is the most recognized method of harnessing solar energy, followed by concentrated solar power systems. However, regardless of how electricity from solar energy is generated, it *must* be safely managed.

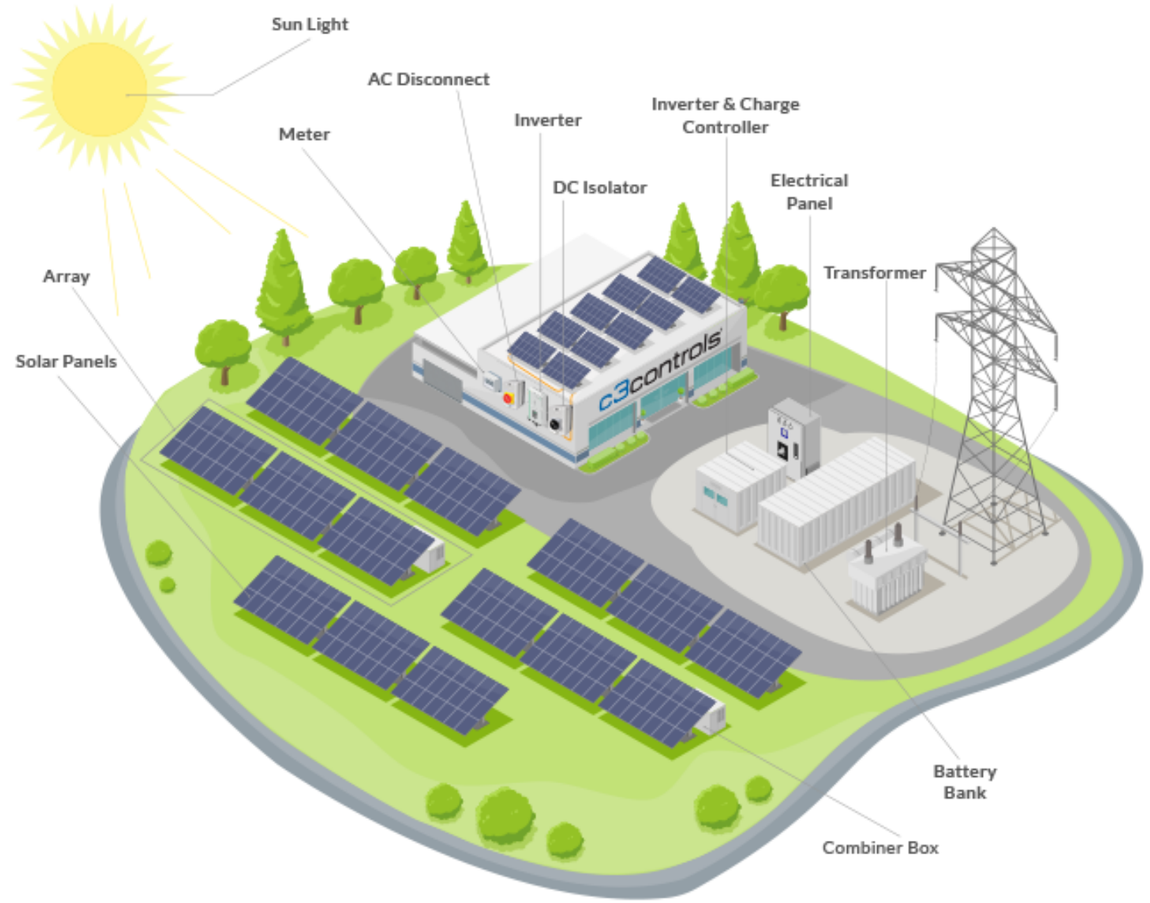
Managing electricity is where c3controls comes in — that's what we do. With more than 50 years of experience manufacturing quality electrical controls, we maintain strict control over our design and manufacturing processes to deliver reliable products built for demanding applications. Our vertically integrated approach allows us to operate efficiently, respond quickly to changing market conditions, and provide the fast delivery you need for solar energy applications, including:

- **Combiner Boxes**
- **Disconnects**
- **Inverters**
- **Control Panels**
- **& more!**

With over seventeen million product configurations from c3controls and custom UL 508A-certified panel solutions from Covenant Panelworks (CPW), you have a trusted source for complete electrical control solutions. Contact us today and discover how our expertise can help you build reliable, efficient solar energy systems.

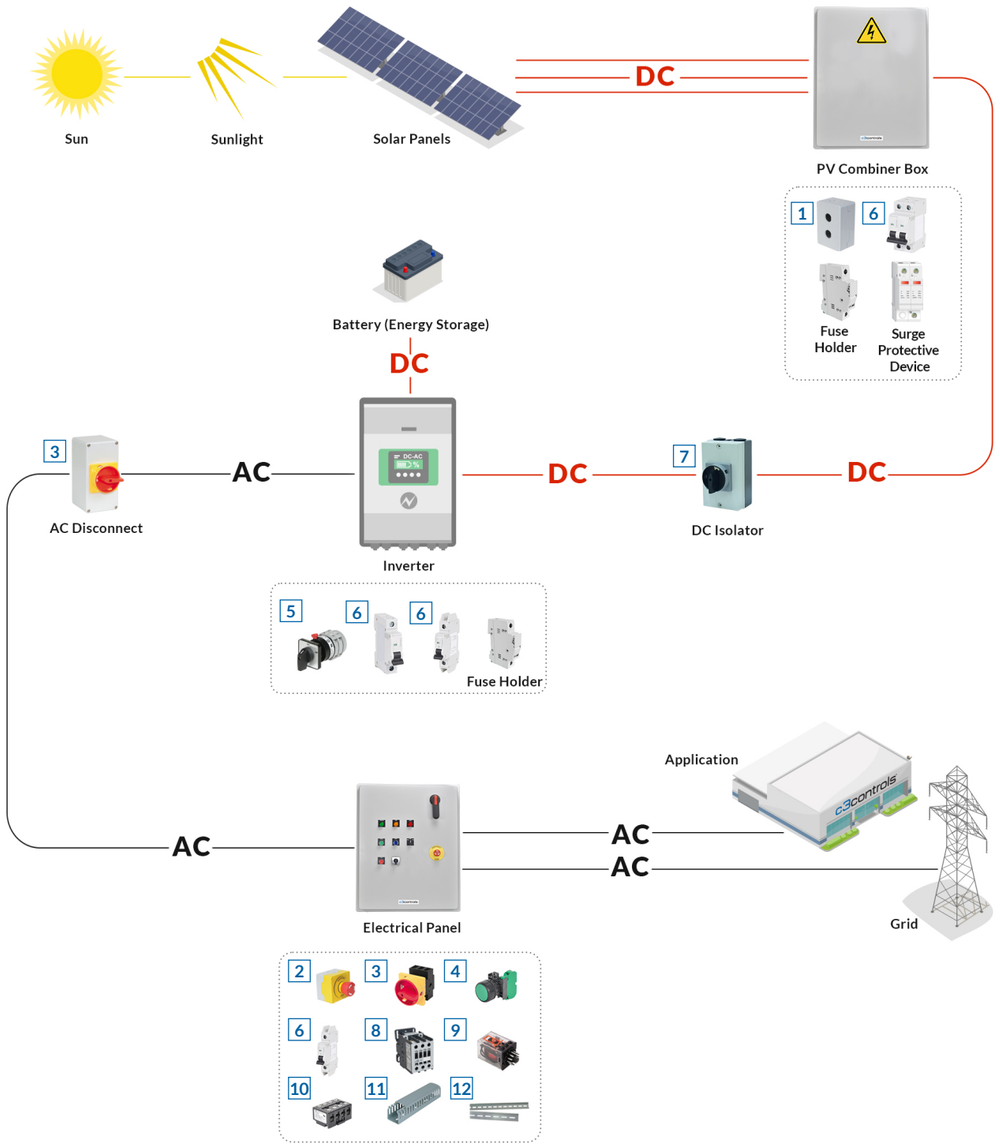
# Solar Isometrics

*Here's an example of an active solar photovoltaic system:*



# Solar Energy Example and Control Components

*c3controls has component and finished solutions for all your solar energy needs.*




*For illustration purposes only. Other solutions may be applicable depending on your sector (residential/commercial/utility) and application design requirements.*

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | **Enclosures** | Polyester, Polycarbonate and Die Cast Aluminum constructions | Accommodates 22mm and 30mm pilot devices, and disconnect switches | Options up to four holes, or unpunched | A variety of seals to keep dust and moisture out of the enclosures | UL Listed and CSA certified |
| 2 | **22mm IEC E-Stops** | Non-Illuminated and Illuminated versions | UL Listed Polycarbonate enclosure rated for Type 1, 2, 3, 3R, 4/4X, 12, 13, and IP66 | Meets EN418 Safety of Machinery global compliance standards | Operating temperatures from -40 to +55° C (-40 to + 131° F) | UV and corrosion resistant |
| 3 | **UL 98 Disconnect Switches** | Door mount and panel/base mount | Suitable for use as a Dead-front switch, Feeder disconnect, Service disconnect, or Motor Disconnect | 30 - 100 Amps in 3, 4, and 5 pole configurations | Motor loads up to 50HP @ 600V AC | Operating handles rated for Type 1, 2, 3, 3R, 4/4X, 12, 13, and IP65 |
| 4 | **Pilot Devices** | Modular range of 30mm, 22mm, 16mm, and 13mm | Type 1, 2, 3, 3R, 4/4X, 12, and 13 | Non-Illuminated, Illuminated and Keyed Operators in both maintained and momentary operations | Color-coded, snap-on contact blocks with angled captive screws and pressure plates | Full voltage, multi-voltage, resistor, and dual input light units in a wide range of voltages up to 600VAC/VDC |
| 5 | **Cam Switches** | Certified as Manual Motor Controllers per UL | Rated 10A to 32A up to 690V AC | Switch configurations in 45°, 60° & 90°, and up to 6 poles | A variety of operator types including key lock, lever, and lockable lever | Operators mount in a standard 22.5mm hole |
| 6 | **DC & AC Miniature Circuit Breakers** | UL 489 & UL 1077 | 1, 2, 3 and 4 Pole combinations | 10kA SCCR @ 480Y/277VAC | Current ratings up to 63 Amps | B, C and D curve ratings |
| 7 | **DC Isolator** | 4 Pole in series, rated 16 - 32 Amps | Reliable switching up to 1,000 VDC | Guaranteed arc suppression ensures disconnection from load circuits | Installation options in both door and panel-base mount | Operating handles rated for Type 1, 2, 3, 3R, 4/4X, 12, 13, and IP65 |
| 8 | **IEC Contactors** | 9 to 105 Amps | 100kA SCCR @ 480V and 600V with Class J fuses | AC and DC - electronic coil control on DC devices | Integral auxiliary | Up to 75 HP @ 400V (55kW @ 400V) |
| 9 | **General Purpose Relays** | Octal base, square base, flange mounted and miniature | Only 14mm wide | Transparent housing | Pole combinations available in SPDT, DPDT, 3PDT and 4PDT | Carrying current rating 5A-25A |
| 10 | **High Density Terminal Blocks** | 4, 6, and 12 point in a single molded housing | Rated for 600V, 30A continuous service | Replacement for GE CR151 and EB27B06S terminal blocks | Integrated 35mm DIN rail snap and panel mounting construction | Captive screws with spring-return open terminals |
| 11 | **Wire / Cable Duct** | 13 Selectable dimensions from 25mm wide up to 80mm, and up to 2m in length | Narrow and Wide Slot | Rigid “U” shaped duct with non-slip cover in gray or white | Optional adhesive backing | |
| 12 | **DIN Rail** | 35mm rails in steel and aluminum | 1m (3.28ft) or 2m (6.56ft) lengths | Each simply fasten by screws to the mounting surface | Standard package quantities, or pallet options available | |

# High Density Shorting Terminal Block

series TB high density

*Designed for the solar market.*




c3controls' new **High Density Shorting Terminal Block** is an addition to our popular line of innovative and user-friendly High Density Terminal Blocks (HDTB). Expanding upon our feature rich HDTB, the Shorting Block provides ease of connecting systems to applications such as current transformers, switchgear, and tap points.

- 30A (unprepared wire) and 60A (prepared wire) @600V AC ratings.
- Out of the box and ready to install! Screws come in the backed out position with convenient spring-return open terminals for easy wiring.
- Individual blocks can be quickly added or removed without disturbing adjacent blocks.
- Brass shorting strip to easily short terminals. Terminals can be shorted as per customer requirement.
- Accommodates #18 to #10 AWG (unprepared) and #18 to #4 AWG (prepared) - up to two (2) ring lugs.
- Transparent cover available for added safety and protection (required to mount marking strip).
- Marking strip available for easy identification.
- Directly interchangeable with GE EB27B06S terminal blocks.

*For more information on our HDTB Shorting Block including technical specifications, CAD drawings, and product certifications, visit c3controls.com/HDTB-SB.*



# UL 98 Non-Fused Disconnect Switches

series DS

*Versatile switching as a service disconnect, feeder disconnect, and more!*

c3controls' line of **UL 98 Non-Fused Disconnect Switches** features a compact design for use in the most versatile applications. These switches are the perfect solution for machine builders looking for service disconnects, feeder disconnects, and more!

- Suitable for use as a Dead-front switch, Feeder disconnect, Service disconnect, and as a Motor Disconnect for motors up to 50HP at 600VAC.
- 200kA short circuit rating at 600V AC with Class J or Class T fuses.
- Compact, space-saving design – devices rated from 30A to 100A are only 70mm wide reducing panel area requirements.
- Panel/base and door mounting options.
- Operating handles with ON/OFF and I/O symbols can be padlocked in the "OFF" position with up to three padlocks for extra safety.
- Door interlock feature allows entry in the OFF position.
- Select operating handles include a concealed "defeater mechanism" that must be operated with a tool, allowing entry when the switch is in the ON position.




Products may vary from picture.

*For more information on UL 98 Non-Fused Disconnect Switches including technical specifications, CAD drawings, and product certifications, contact your c3controls sales representative.*

# DC Miniature Circuit Breakers

*Designed and manufactured to meet all expectations in renewable energy.*

COMING SOON



Products may vary from picture.

## APPLICATIONS

Our DC MCBs cover a wide range of applications such as:

1. Photovoltaic (Solar) Systems
2. Energy Storage Systems
3. Relay Protection
4. Control and Interlocking for Power Transmission and Distribution (switchgear and substations)

c3controls knows the importance of clean energy in ensuring a more sustainable future. That's why we're proud to introduce **DC MCBs (Miniature Circuit Breakers)** to support and protect the transition to renewable energy and mission critical applications.

- Only 17.5mm wide per pole.
- Available one, two, three, and four pole constructions.
- Includes both magnetic and thermal elements for overload and short circuit protection.
- Rated 250V DC per pole for up to 1000V DC with current ratings from 0.5A to 63A.
- 10kA @ 480Y/277V short circuit current rating on all multi-pole constructions — the highest interruption rating in the market.
- Available in C and D trip curves with an operating temperature range of -20°C to 50°C.
- Holding the operating handle in the ON position will not prevent the MCB from tripping.
- Captive screws make it impossible to lose screws when wiring and our box lug design terminals will accept a wide range of copper wire sizes. Line/load wiring is reversible for ease of use.
- Series 1110 DC MCBs are listed per UL489B, the standard for DC photovoltaic systems.

*For more information on DC MCBs including technical specifications, CAD drawings, and product certifications, contact your c3controls sales representative.*



# DC Isolators

*Specifically designed for the photovoltaic (solar) market.*

UPCOMING



Products may vary from picture.

## APPLICATIONS

Our DC Isolators cover a wide range of applications such as:

1. Photovoltaic (Solar) Systems
2. Inverter Applications
3. Isolator - DC Applications
4. PV Rapid Shutdown
5. ESS Emergency Shutdown

c3controls' **Series DCI** non-fused DC Isolators are designed to provide superior performance in the most demanding DC applications. They are available in various constructions providing installation flexibility and reliable switching up to 1,000VDC.

- Ensures disconnection from load circuits, suppressing any electrical arc.
- Installations are available for both door mount and panel/base mount.
- Our industry leading design saves space, reducing the size of your control panels.
- Operating handles with ON/OFF and international I/O symbols, can be padlocked OFF with up to three padlocks to meet U.S. and global installation codes and standards requirements.
- Switches are factory assembled with operating handles for Just-In-Time (JIT) manufacturing and reduced inventory.
- Panel/Base mount switches snap on to 35mm DIN Rail or secure to the panel with two fixing screws and feature dual terminal markings, suitable for combiner boxes.
- Two sets of jumpers provided, allowing multiple switching configurations with the same switch.

*For more information on DC Isolators including technical specifications, CAD drawings, and product certifications, contact your c3controls sales representative.*

# Product Portfolio

*Our 17 million+ product configurations deliver durability and reliability—even in the most punishing environments—meeting and exceeding global standards for quality and safety.*

series DS

DISCONNECT SWITCHES
NON-FUSED & ENCLOSED

series 1100 series 1110

MINIATURE CIRCUIT BREAKERS

series 300 non-reversing series 310 reversing

CONTACTORS & CONTROL RELAYS

series 320

OVERLOAD RELAYS

series 620

DIRECT-ON-LINE STARTERS
CONTACTOR + OVERLOAD RELAY

series E620

ENCLOSED DIRECT-ON-LINE STARTERS
CONTACTOR + OVERLOAD RELAY

series 330 series E330

MOTOR PROTECTION CIRCUIT BREAKERS
OPEN & ENCLOSED

series 630

DIRECT-ON-LINE STARTERS
MOTOR PROTECTION CIRCUIT BREAKER + CONTACTOR

series E630

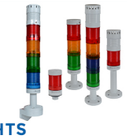
ENCLOSED DIRECT-ON-LINE STARTERS
MOTOR PROTECTION CIRCUIT BREAKER + CONTACTOR

series 30 industrial series 30 hazardous

30MM PILOT DEVICES
FOR INDUSTRIAL & HAZARDOUS LOCATION

series 22 iec series 22 nema

22MM PILOT DEVICES
IEC & NEMA

series WTL

WORLD TOWER LIGHTS

series CS

CAM SWITCHES

series 16

16MM PILOT LIGHTS

series 13

13MM PILOT LIGHTS

series EC

CONTROL STATION ENCLOSURES

series ECP 300

ENCLOSED UL508A COMBINATION MOTOR STARTERS

series EPS

ENCLOSED POWER SUPPLIES

series ECP BP

VFD BYPASS PANELS

series IPS

INDUSTRIAL POWER SUPPLIES

series CCT

CONTROL CIRCUIT TRANSFORMERS

series CPT

CONTROL POWER TRANSFORMERS

series TB

TERMINAL BLOCKS

series TBR

TERMINAL BLOCK RELAYS

series ETR

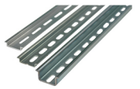
ELECTRONIC TIMING RELAYS

series 200 series 210

GENERAL PURPOSE RELAYS

series WD

WIRING DUCT

series DIN

DIN RAIL



# White Papers

*Product professionals AND subject experts! Check out c3controls' extensive library of white papers:*




### Solar Energy - New Trends in Technology

It makes perfect sense that we are turning to the Sun to help fulfill our energy needs. We have finally evolved our technology to be able to capture the Sun's energy, store and distribute it. Find out all about that in our latest paper on Solar Energy Trends in Technology.

READ WHITEPAPER




### Understanding Renewable Energy Infrastructure - New Trends in Technology

Renewable energy has been a topic of discussion for quite some time. We have been using renewable energy since long before there was electricity! To find out the latest trends, check out our paper.

READ WHITEPAPER




### The Smart Grid & Grid Modernization - New Trends in Technology

The increasing demand for electric power continues to accelerate. Read our paper for an overview of what is needed to strengthen the Smart Grid and ensure that the future electricity needs for the US are fulfilled.

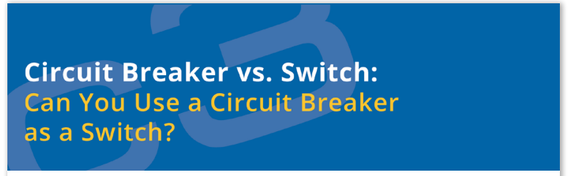
READ WHITEPAPER




### Understanding Energy Storage Systems - New Trends in Technology

In this issue, learn how Energy Storage could help the US power grid operate more efficiently, reduce brownouts during peak demand, and allow for more renewable resources to be used, becoming net-zero carbon emissions by 2035.

READ WHITEPAPER




### Circuit Breaker vs. Disconnect Switch

Can a circuit breaker be used as a disconnect switch? Should you use it as a switch and when shouldn't you? Here's what you need to know about the swap.

READ WHITEPAPER




### Circuit Breaker or Fuse? What's the difference?

Do you know which type of circuit protection is better? Click here to understand the differences and when to choose a circuit breaker over a fuse.

READ WHITEPAPER

# Why choose c3controls



## Integrated Manufacturing

*Vertical integration is the cornerstone of c3controls as it places innovation, development, design, manufacturing, testing, and shipping all within our control. With Everything Under Control, we can ensure the highest quality and customer satisfaction.*

## Innovation



*Product innovation is in our DNA. We approach our products as solutions. Unlike our competition, our business model allows us to provide customers with premium controls without the premium price.*




## Same-Day Shipping

*Reduce inventory. Improve cash-flow. Save money. Our customers enjoy peace of mind knowing they'll get what they need, when they need it. Our promise, guaranteed!*

## 36-Month Warranty



*With total control over engineering and manufacturing, we are able to guarantee the highest quality products on the market—products free of defects in material, workmanship, and design.*



## Advantage Pricing

*Total control means lower overhead and direct sales. For our customers, this translates to savings of up to 40+% on c3controls premium products.*

## Customer First



*Commitment to the success of our customers is a core value and the driving force behind all we do. We promise concierge style service that makes doing business easy, personalized, and responsive.*

# Notes

724.775.7926
c3controls.com





c3controls®
*Everything under control.*