



Medium Voltage Metal-Enclosed Power Capacitor Banks



General

Northeast Power System's (NEPSI's) medium voltage metal-enclosed power capacitor banks are an economic, compact, and easy to maintain source of reactive power for commercial, industrial, and utility power systems. Whether the need is to meet a utility interconnect requirement at a renewable power plant, or to meet a power factor penalty at an industrial facility, or to increase system capacity and reduce losses on a utility distribution system, NEPSI's metal-enclosed power capacitor banks are the best choice.

Our capacitor banks are custom built to your requirements, and are shipped fully tested, assembled, and ready for interconnection; containing all switching, all protection, and all control. When compared to an "open-rack" capacitor bank, they are easier to engineer, procure, install, commission, maintain, and take up less space. Combining this with NEPSI's "filter ready" design, the ability to quickly and easily convert a capacitor bank to a filter bank, the metal-enclosed capacitor bank is the most cost effective design.

Product Scope

- Voltage range: 2.4kV through 38kV (60kV BIL through 200 kV BIL)
- System frequency: 50 or 60 Hertz systems
- Reactive power rating: 0.5MVAR to 100 MVAR
- Single-step, multi-step (up to 15 steps), and fixed power capacitor banks
- "**Harmonic Filter Ready**" designs to incorporate high-pass, C-high-pass, and notch filter designs
- Equipped with all switching, all protection, all control
- Seismic, wind, and snow load certification
- Applicable industries: Solar, Wind, Electric Utility, General Industrial, Petroleum



Ratings

The **armorVAR™** is rated and configured to meet customer requirements for voltage, basic insulation level (BIL), available short circuit current, reactive power rating, and frequency. Internal components such as disconnect and grounding switches, circuit breakers, capacitors, capacitor switches, and capacitor fuses are chosen based on their ratings, costs, availability, and NEPSI's experience with the supplier's quality, service, and reliability.

Rating	Range of Available Ratings
Bank Configuration:	Single Step/Multiple Step/Fixed Step
"Filter Ready Designs"	Notch (Band-Pass), High-Pass, C-High-Pass, Multi-Tuned, Double-Tuned tuning point, reactor, current, type of harmonic filter determined at time of conversion
Operating Voltage (line-to-line):	2.4kV – 38kV
Operating Frequency:	50 Hertz 60 Hertz
Reactive power output:	0.5MVAR – 100 MVAR (500kvar – 100,000 kvar)
Short circuit (asymmetrical momentary):	16kA - 61kA
Impulse withstand voltage (Basic Insulation Level):	60kV – 200 KV (third party tested)
Short-time withstand voltage (1 minute 50/60 Hertz):	19kV – 80kV
Control voltages:	AC Volts: 110, 115, 120, 220, 50/60hz DC Volts: 24, 48, 110, 125, 220
Operating temperature range:	-50°C to +55°C -58°F to 131°F
Maximum altitude without de-rating:	1,000 Meters 3,300 Feet
Enclosure Rating:	(NEMA): 1, 3R, 4X, 12 (IEC): IP10, IP14, IP56, IP52 Arc Resistant Enclosure Designs: Type 1, Type 1D-SR-SL, Type 2 Hazardous Location: NEC Class 1 & 2 Div. II
Enclosure Materials:	Steel: 11 gauge Galvaneel, optional 12 gauge 409 or 316 steel. Paint: Salt Spray Rating: 5,500 Hr.
Seismic:	As specified - Prior certification to Zone 4
Wind	As specified - Prior certification to 190 mph (305.7 km/h)
Snow Load	As specified - Prior certification to 22.96 feet (7 meters)
Capacitor fusing:	Internally fused Externally fused
Standards Codes:	<ul style="list-style-type: none"> • IEEE Std. 1036-2010, <i>IEEE Guide for the Application of Shunt Power Capacitors</i> • IEEE Std. 18-2012, <i>IEEE Standard for Shunt Power Capacitors</i> • IEEE C37.99-2012, <i>IEEE Guide for the Protection of Shunt Capacitor Banks</i> • IEEE 519-2014, <i>Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems</i> • Standard IEC 61000-2-4:2002, <i>Environment— Compatibility levels in industrial plants for low-frequency conducted disturbances</i> • UL-347, <i>High Voltage Industrial Control Equipment</i> • UL-508, <i>Industrial Control Panels</i> • UL-50, <i>Standard for enclosures for Electrical Equipment</i> • ANSI C37.20.2, <i>IEEE Standard for Metal-Clad Switchgear</i>
NEPSI designs and builds their equipment to a hosts of national and international standards, including CSA, ANSI, and IEC. Consult with NEPSI for standards not listed.	



Equipment Configuration

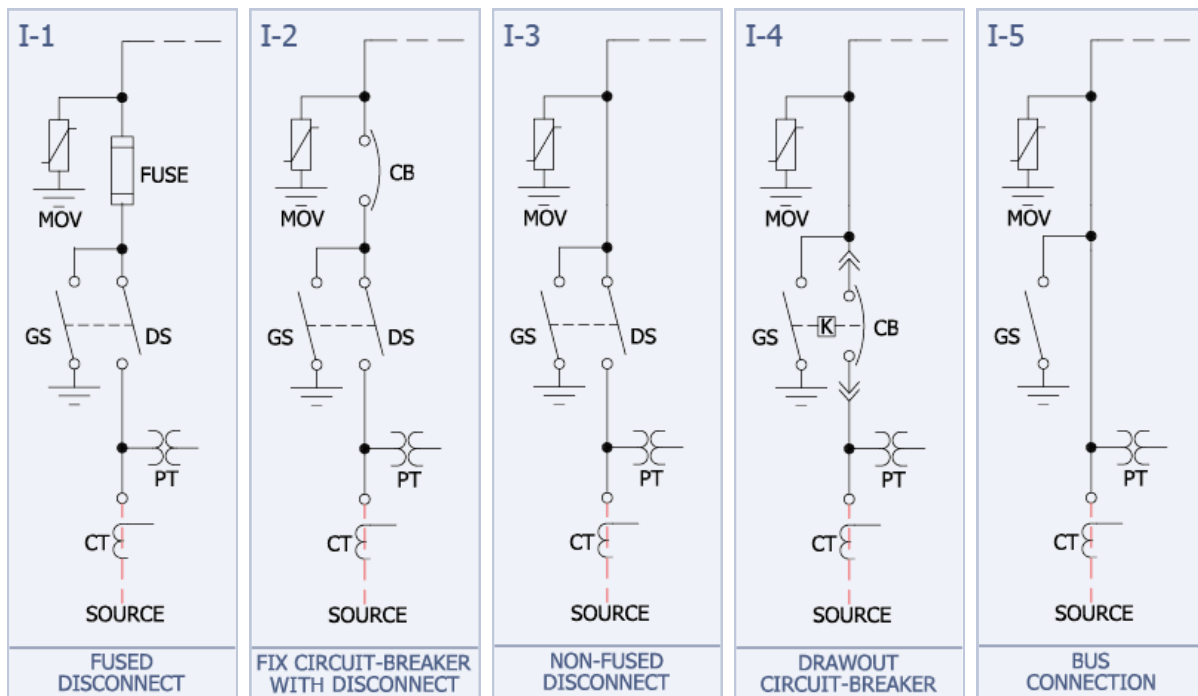
NEPSI's **armorVARs™** are custom designed to meet your requirements. From choice of incoming compartment to capacitor switching device, to type and rating of capacitor. NEPSI chooses components based on customer preference, suitability, cost, availability, and reliability.

Sections 1, and 2 that follow provide details on most of the available options.

1 Incoming Compartment Configuration Options

The incoming compartment of the armorVAR® is available with a range of options based on system ratings and customer preference. Generally, all capacitor banks should be equipped with a “visible break” and a grounding switch to allow for safe maintenance of the equipment. The “visible break” may be accomplished using a disconnect switch or a draw-out circuit breaker. Short circuit protection should also be provided and can be accomplished with main incoming fuses or a main incoming breaker. Only consider a bus connection when a visible break and short circuit protection are available on the capacitor bank feeder cables.

Incoming compartment configurations include the following:



Accessories For Incoming Compartment

The following items are available for placement in the incoming compartment. On simpler systems, CPT's or PT's can serve double duty as both protection/control signals and control power for the filter system. Roof bushings provide a simple means to connect to overhead bus in a substation yard. Key interlocks help ensure proper sequence of operation and safe entry into the enclosure. Lightning arresters provide transient voltage surge protection for the equipment in case of lightning strikes or breaker/switch restrike/prestrike.

PT	POTENTIAL TRANSFORMER	MOV	SURGE ARRESTER		ROOF BUSHING OVERHEAD BUS
CT	CURRENT TRANSFORMER	CPT	CONTROL POWER TRANSFORMER		KEY INTERLOCK

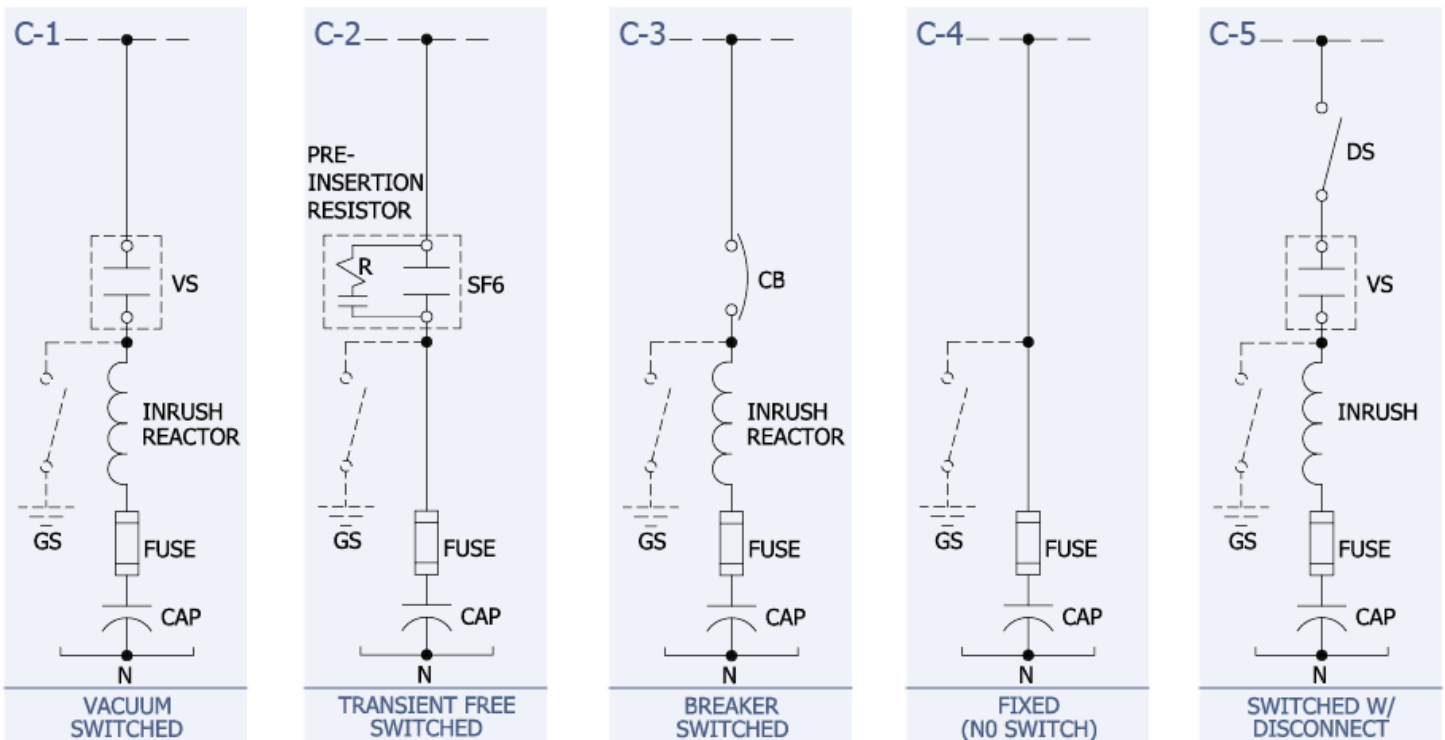


2 Capacitor Compartment Configuration Options

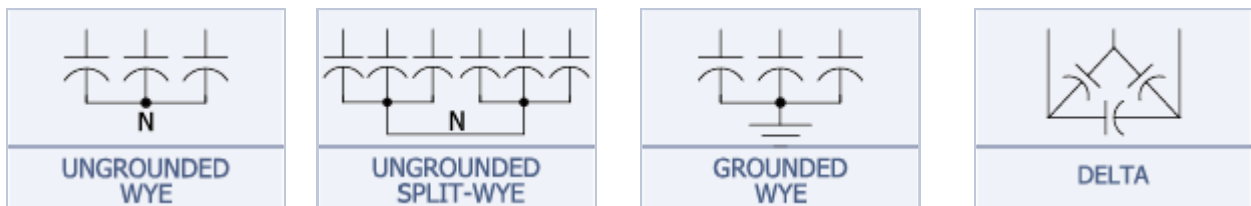
The capacitor compartment may consist of one capacitor bank or multiple capacitor stages. A capacitor bank or stage normally consists of the capacitors, capacitor fuses, and where applicable, a switching device and transient inrush reactors. Typical bank or stage configuration options are provided below. The capacitor bank/stage compartment is compartmentalized and isolated from the incoming compartment to allow for maintenance and repair.

For system voltages at or above 24.9kV, NEPSI recommends option (C-2), a Southern States CapSwitcher® or option (C-3) a vacuum or SF6 circuit breaker. Optional ground switches provide a secondary means of capacitor discharge and ensure capacitors are discharged should a capacitor discharge resistor fail.

Transient inrush reactors are not required for option C-2, but are required for all other systems involving back-to-back capacitor switching. Inrush reactor ratings are based on system voltage, stage reactive power rating, and switching device rating. Consult the resource page at NEPSI.com for further information.



The capacitor bank can be connected in a number of different ways depending upon bank rating and protection requirements. Typically, capacitor banks are provided with an ungrounded wye or ungrounded split-wye connection, but a grounded wye and Delta connection are also available.





Control Options

NEPSI's **armorVAR™** can be furnished with a fully integrated control and protection system that can form an integral part of the equipment or be remotely mounted in the E-house. In either case, your control system will be fully assembled, tested, and calibrated at the factory, relieving your contractors of costly onsite setup and commissioning cost.

Capacitor Bank Control Options

- Power Factor Control
- Voltage Control
- Harmonic Voltage / Current Distortion Control
- Remote / SCADA Control
- Remote control by plant DCS / EMS system

Typical Control Features

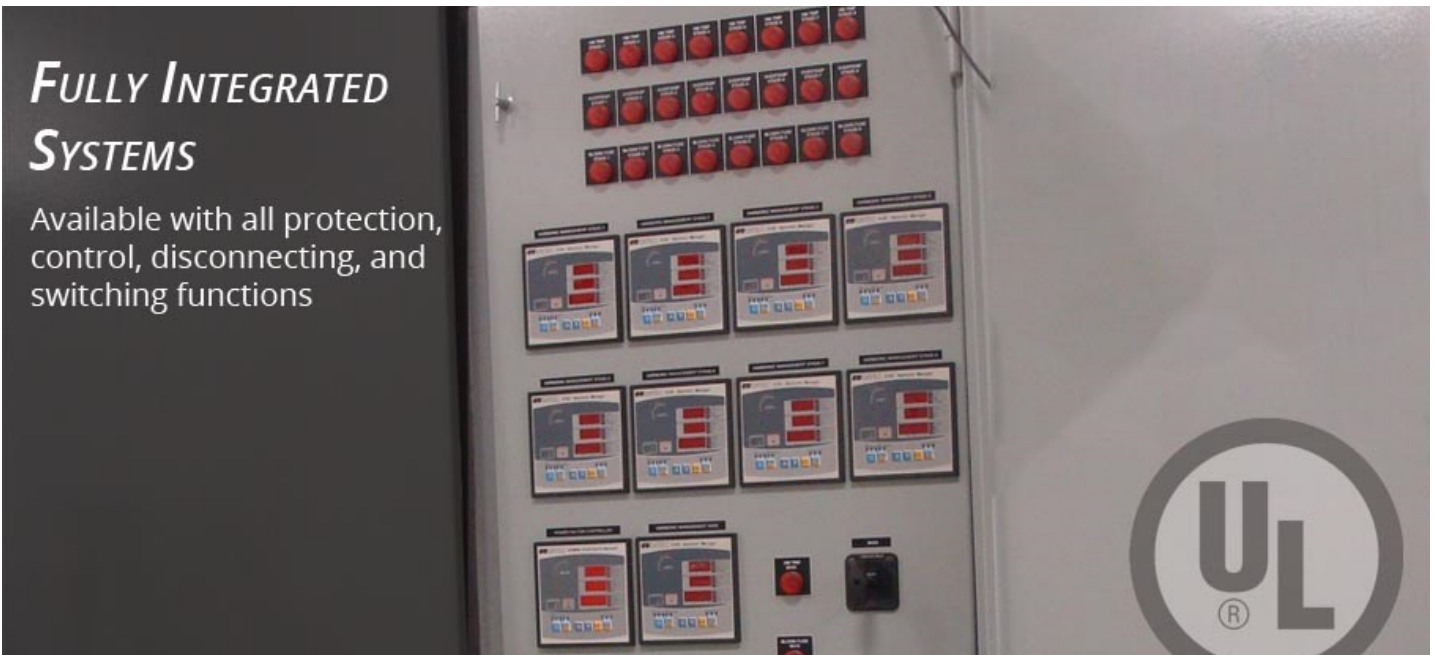
- On | OFF | Auto & Local | Remote Controls
- Stage status indication
- Circuit Breaker Control Switches
- Power quality meters on all main or on all filter branches/stages
- Control power circuit breakers for all branch circuits, lights, strip heaters, thermostatically controlled fans
- 5-Minute Discharge | re-energization timers
- Key interlocks to dictate sequence of operation and safe entry into enclosure
- PT/CT test and short switches

Protection Options

The **armorVAR™** is furnished with host of protection options to keep your system up and running with minimum down-time.

All stages are protected against short circuit, overload, over-voltage, harmonic over-current, harmonic over-voltage, over-temperature, and unbalance operation from blown capacitor fuses. Protective relays and ancillary protective devices are chosen based on function, cost, reliability, and customer preference.

The Table on the following page summarizes the protection device numbers that are typically provided with NEPSI's **armorVAR™**.

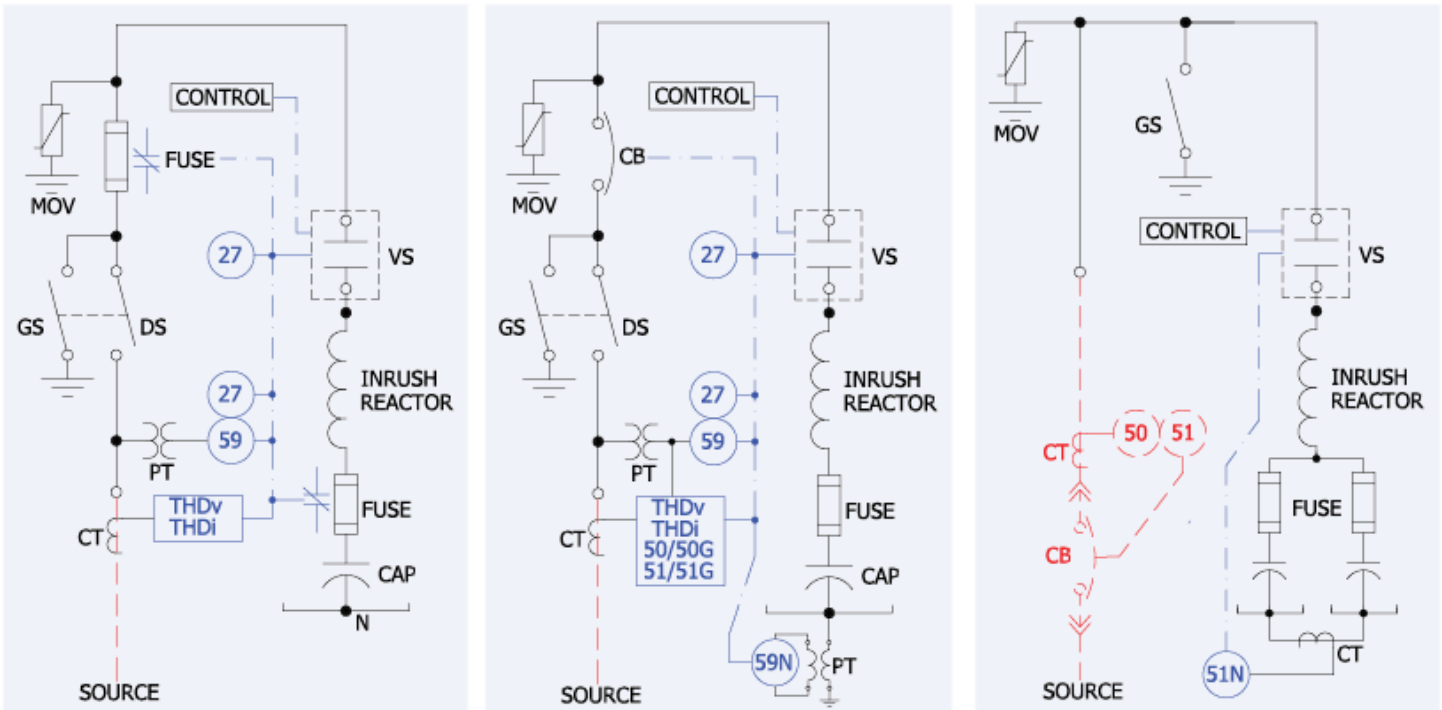




Protection Type	Designation	Description
Short Circuit and Overcurrent Protection	50/51 50/51G	Phase and Ground Short Circuit Protection
Over-Voltage/ Under Voltage	59/27	Over-voltage and Under Voltage Protection
Neutral Unbalance (Blown Fuse Detection)	59N or 51N or 51G or Direct	Relay or direct fuse sensing to detect a capacitor fuse operation. This is critical since a blown fuse condition will change filter de-tuning, lower var output, lower performance, and possibly create system resonance.
Over-Load	49	Over-load protection of the high-pass resistors (if provided), iron-core reactors, and thyristor valves. Relay is sensitive to RMS current associated with the filter's fundamental current and harmonic current.
Harmonic Voltage & Current Distortion	I_{THD} , V_{THD}	Protection against harmonic resonance, high voltage & current distortion, and harmonic overload
Over-Temperature	26	Protection for the thyristor valves, capacitors, and iron-core reactors. Also protects against fan failure.
Arc Flash Detection & Mitigation	Arc Flash	Arc flash detection relays as well as the ABB UFES system for fast detection and clearing of arcing faults.

Typical Protection System

Typical relay protection diagram for the **amorVAR™**. Protection systems are custom designed based on customer preference, customer relay platform, budget, and cost of equipment.





armoVAR® Ordering Guide

The **armorVAR®** is custom built to meet your requirements. Feel free to contact NEPSI for a quote or to discuss your specific application.

Additionally, visit our webpage at www.nepsi.com and follow the product page link to metal-enclosed harmonic filter banks. There you will find additional information, including:

- Guide form specifications
- Component Cut Sheets and Instruction Manuals
- Pictures of Equipment and Components
- Technical Resources, including spread sheet design tools, relay settings tools, and design calculators

Power System Studies

NEPSI performs power system studies to evaluate the expected performance of our metal-enclosed products. Studies offered by NEPSI include:

- Stability
- Motor Starting
- Load flow
- Reactive Power / Var Flow Studies
- Coordination
- Voltage Drop | Voltage Rise Analysis
- Harmonic Analysis
- Short Circuit
- Protective Coordination

Our Power System Studies are tailored to your needs and project requirements.



armorVAR™ - Project Showcase



MEETING THE DEMAND OF THE SOLAR INDUSTRY

Sunpower, California Valley Solar Ranch, California
Metal-enclosed capacitor bank, 34.5kV, 150kV BIL, 60MVAR, 5 Stages of 12 MVAR



SMALL INDUSTRIAL AUTOMATIC FILTER APPLICATION

Johns Manville, Ohio
13.8kV, 60HZ, 110kV BIL, 2 MVAR, 6 Step Automatic Harmonic Filter Bank



READY FOR INTERCONNECTION AND OPERATION

Quality Wind, Tumbler Ridge, B.C. Canada
NEPSI metal-enclosed filter banks and capacitor banks are shipped fully assembled, tested, and ready for operation