



Medium Voltage Metal-Enclosed Harmonic Filter Systems



General

NEPSI's **armorVAR™**, medium voltage metal-enclosed harmonic filter banks are custom designed for application on industrial, commercial, and utility power systems that require medium voltage power factor correction, var and voltage support, and mitigation from harmonic resonance or harmonic distortion. NEPSI's filter systems are equipped with all switching, all protection, and all control. They come fully assembled and ready for interconnection. They are well suited for applications that are remote, require a high level of reliability, are at high-altitude, where footprint comes at a premium, and at high altitude and wind/snow load locations.

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
- Filter types: C-high-pass (damped filters), high-pass, notch (band pass), double-tuned, and multi-tuned
- Single-step, multi-step, and fixed filter banks
- Equipped with all switching, all protection, all control
- Seismic, wind, and snow load certification
- Applicable industries: Mining, Chemical, Petroleum, Commercial, General Industrial, Wind & Solar



Ratings

The **armorVAR™** is rated and configured to meet customer requirements for voltage, basic insulation level (BIL), available short circuit current, reactive power rating, frequency, and filter performance. 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 Multi-tuned/Single-Tuned
Filter Types:	Notch (Band-Pass), High-Pass, C-High-Pass, Multi-Tuned, Double-Tuned
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)
Tune frequency (Hz)	85 Hz 2100 Hz (1.4th Harmonic – 35th harmonic)
High-Pass (damping) resistor rating:	1 Ohm to 1000 Ohms 10kW/Phase - 200kW/Phase
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:	(NEMA): 1, 3R, 4X, 12 (IEC): IP10, IP14, IP56, IP52 Arc Resistant Enclosure Designs NEC Class 1 & 2 Div. II
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

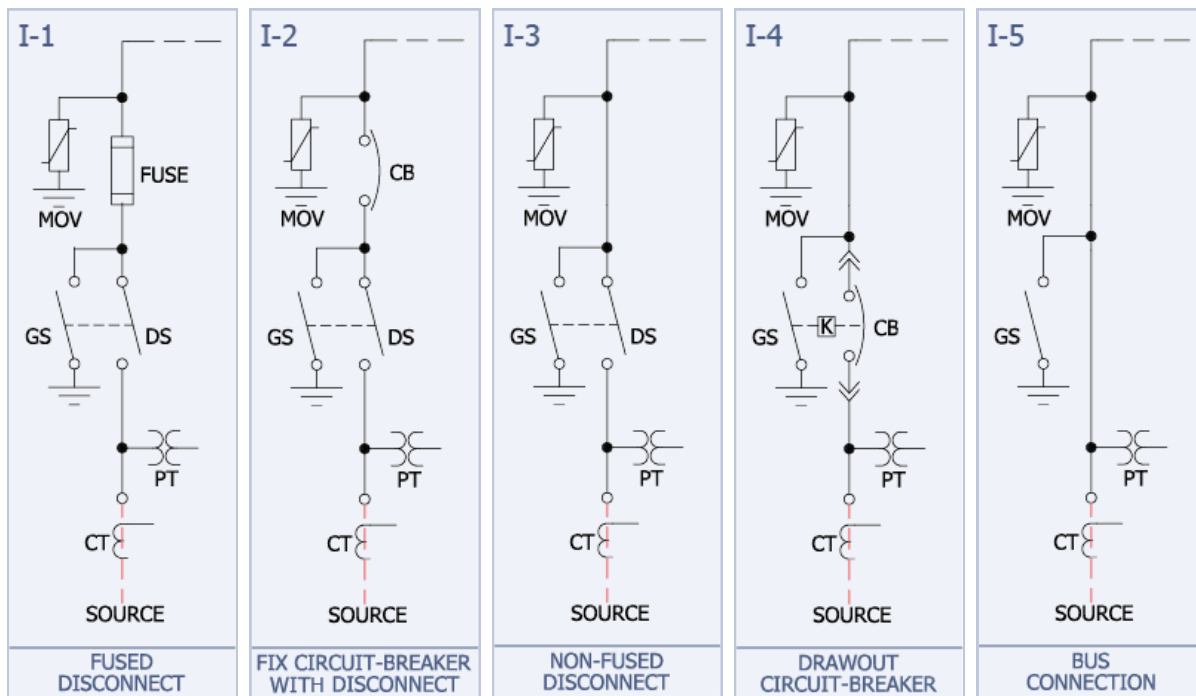
NEPSI's armorVARs™ are custom designed, configured, and rated to mitigate site-specific harmonic voltage, harmonic current, and system power factor. They may be equipped with or without switching and disconnecting means as required by the customer and can come in a variety of configurations based on customer site requirements and preferences.

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 filter systems 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 filter 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.



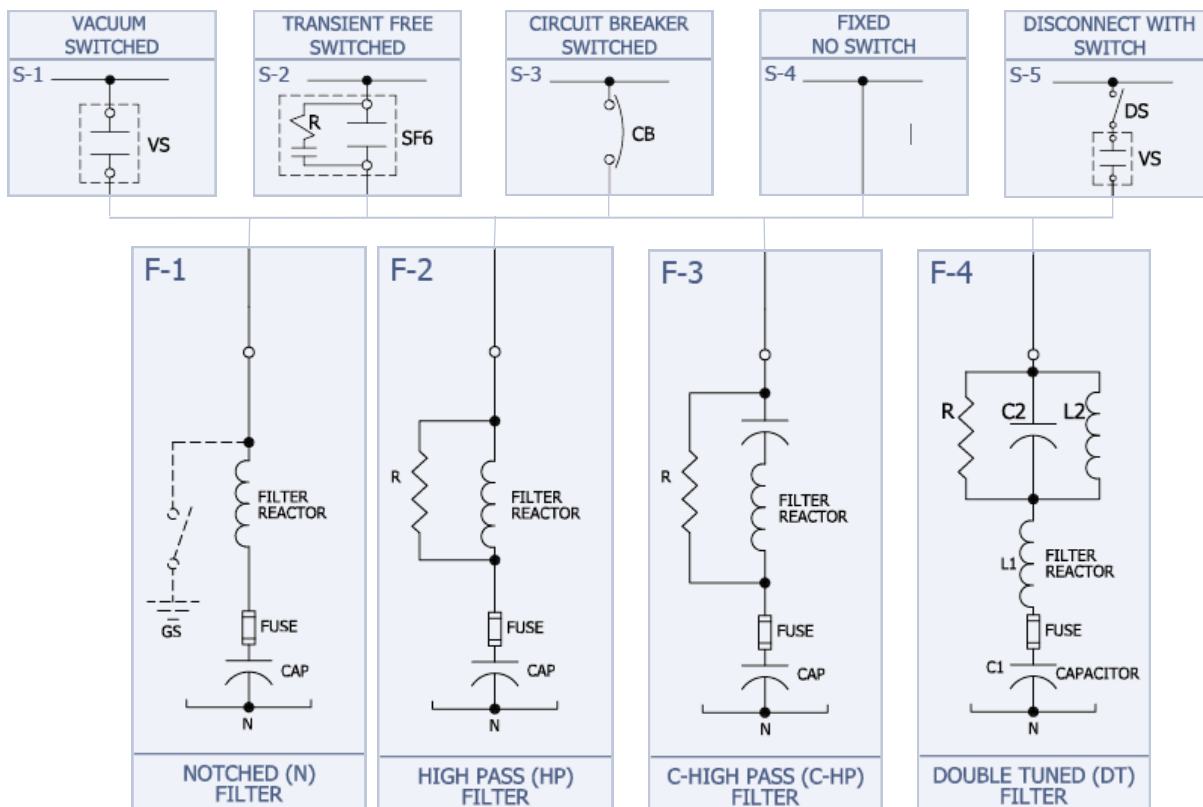


2 Stage | Filter Branch Options

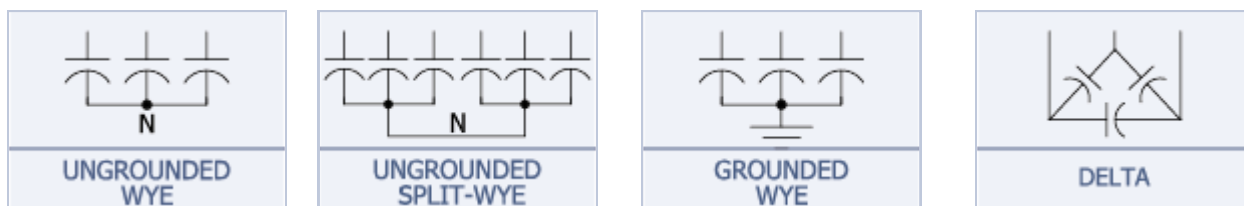
Each filter stage or filter branch can be switched by a number of different types of devices, depending on ratings; devices include vacuum contactors, vacuum switches, and SF6/vacuum circuit breakers. The individual branches/stages may also be equipped with an isolation switch or draw-out device to facilitate partial shutdown and maintenance of the filter system. Choose the technology that suits your application (S-1 through S-6) and work with NEPSI to determine the correct rating and best manufacturer.

A number of filter configurations are available. Notch filters (F-1) provides the best filtering at their tune frequency but are more susceptible to non-characteristic harmonic resonance and resonance due to stray capacitance. High-pass filters (F-2) help dampen these concerns but have high losses, especially at low tuning frequencies. In such cases, consider a C-HP filter where such losses are high or where a significant amount of dampening is required.

Work with NEPSI to determine what filter works best on your system.



The harmonic filter can be connected in a number of different ways depending upon bank rating and protection requirements. Typically, harmonic filters 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.

Filter Bank Control Options	Typical Control Features
<ul style="list-style-type: none"> Power Factor Control 	<ul style="list-style-type: none"> On OFF Auto & Local Remote Controls Stage status indication Circuit Breaker Control Switches
<ul style="list-style-type: none"> Voltage Control 	<ul style="list-style-type: none"> Power quality meters on all main or on all filter branches/stages
<ul style="list-style-type: none"> Harmonic Voltage / Current Distortion Control 	<ul style="list-style-type: none"> Control power circuit breakers for all branch circuits, lights, strip heaters, thermostatically controlled fans
<ul style="list-style-type: none"> Remote / SCADA Control 	<ul style="list-style-type: none"> 5-Minute Discharge re-energization timers Key interlocks to dictate sequence of operation and safe entry into enclosure
<ul style="list-style-type: none"> Remote control by plant DCS / EMS system 	<ul style="list-style-type: none"> 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 downtime.

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™.



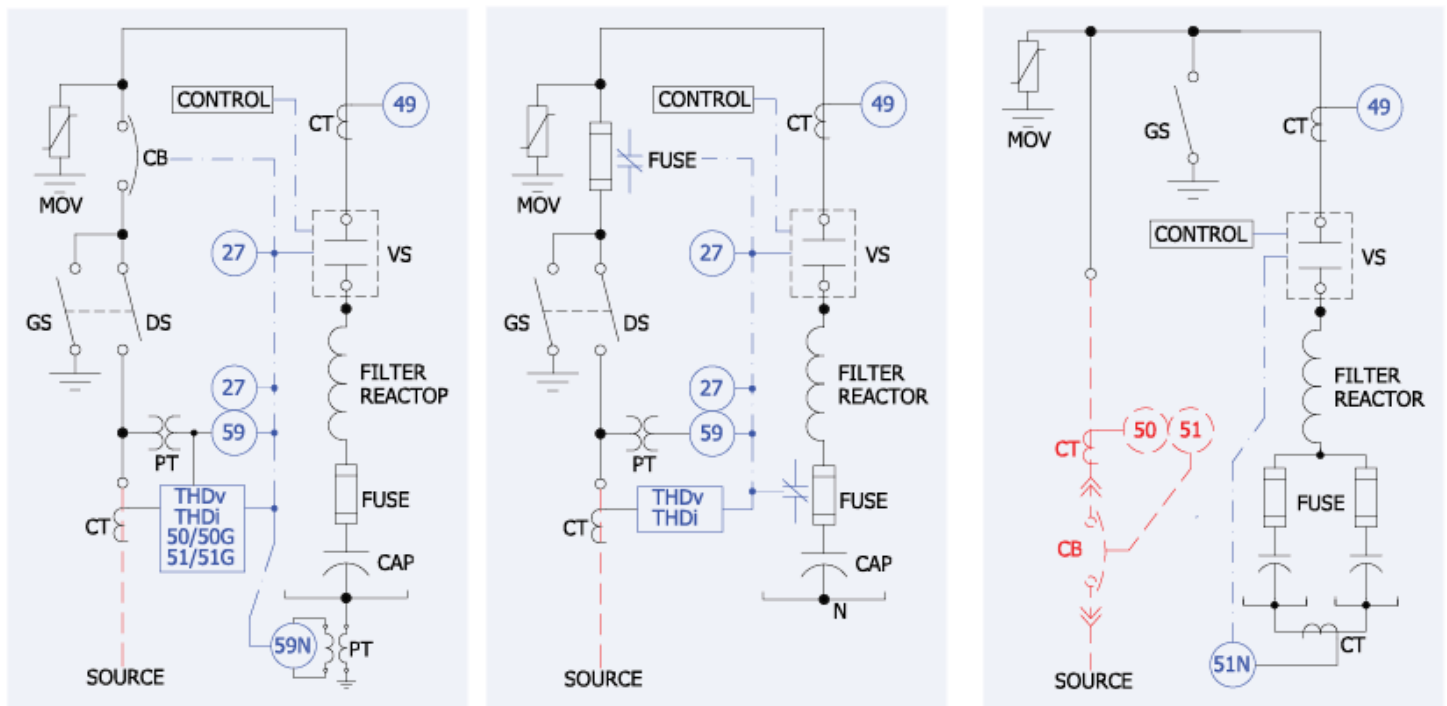
FULL FEATURED FILTER BANK CONTROL AND PROTECTION SYSTEMS
 Protection & Control for all size systems
 Design | Build | Program | Commission



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

The below filter system supplies reactive power and harmonic filtering to Red Chris Mine's 30,000-tonne-per-day mill, which includes two 9,000 HP variable frequency drives. This all-inclusive design encompassed all protection, control, switching, disconnecting, and interlocking requirements.

This metal-enclosed system was chosen instead of an open-rack filter system due to the remoteness of the mine and its harsh arctic environment, which sits at the tree line at an elevation of 1,500 meters with temperatures that vary from average lows of -21°C (-6°F) in January to average highs of 9°C (48°F) in July with extremes ranging from -50°C (-58°F) to 30°C (86°F).



RED CHRIS MINE - BRITISH COLUMBIA
 C-High Pass, High Pass, and Notch Filter Branches
 23 MVAR, 24.9 kV, 5-Stage, All-Inclusive Harmonic Filter System

