MiCOM P9xx

Voltage & Frequency Management Relays

MiCOM P9xx voltage and frequency management relays provide an integrated solution for secure and efficient operation of the power system.

Their versatility of application and the association of protection functions with automation, control and measurement functions, provide an optimal and innovative solution for ensuring power system stability, as well as maintenance reduction.

The enhanced techniques employed, designed to operate under non-linear abnormalities and sub-oscillations, eliminate the risk of unwanted operation.

With up to 30 output contacts available for use, simple or complex load and generation management schemes can be created using the relay's logic capabilities. Integrated restoration facilities ensure that any disconnected loads are reconnected as soon as possible after system recovery to reduce the length of time that customers are disconnected from the network.

A choice of industry standard communication protocols are available on the relays, permitting easier integration into both new and existing network control systems.

Customer Benefits

- Improved power quality through the ability to maintain system stability
- Minimise customer disruption using automatic restoration facilities
- Cost-effective solutions to match application requirements
- Frequency measurement accuracy better than 0.01Hz

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APPLICATION

The MiCOM P9xx relays are suitable for all applications where voltage and/or frequency protection is required to provide load or generation shedding to ensure system stability.

The comprehensive voltage protection elements will detect unbalances and faults that can lead to significant damage on motors, generators and other voltage sensitive equipment.

The integration of various frequency protection elements ensures proper response for different contingencies. Conventional schemes using under or over frequency elements can be provided but where there is a rapid change in system frequency, these can be supplemented by rate of change of frequency elements.

With 6 stages of protection available, multiple stage load shedding schemes can be created thereby minimising customer disruption.

GLOBAL FUNCTIONS

The following functions are generally available in all devices:

> Under- and Over-voltage protection
> Metering
> Programmable scheme logic
> Communication facilities with a choice of standard protocols

Other protection, control and recording features are added to these generic features depending upon the particular relay model. An overview of the available features is shown in the table below.

Functions Overview						
ANSI	**FEATURE**	**P921**	**P922S**	**P923**	**P941**	**P943**
27	Undervoltage protection	3	3	3	2	2
59	Overvoltage protection	3	3	3	2	2
59N	Residual overvoltage protection (Neutral voltage displacement)	3	3	3	-	-
47	Negative Sequence overvoltage protection	-	2	2	-	-
27D	Positive Sequence undervoltage protection	-	2	2	-	-
81U/O	Under/over frequency protection	-	6	6	6	6
81R	Rate of Change of Frequency protection	-	-	6	6	6
81RF	Frequency supervised rate of change of frequency protection	-	-	-	6	6
81RAV	Average rate of change of frequency protection	-	-	-	6	6
	Automatic Frequency based Load Restoration	-	-	-	6	6
	User-settable undervoltage blocking	-	Yes	Yes	Yes	Yes
	Selectable averaging cycles for f and df/dt calculations	-	-	df/dt only	Yes	Yes
81AB	Generator Abnormal Protection	-	-	-	4	4
	Programmable Scheme Logic (AND Equation based)	2	2	4	-	-
	Programmable Scheme Logic (Graphical based gate logic)	-	-	-	Yes	Yes
86	Latching of Output contacts	Yes	Yes	Yes	Yes	Yes
	Number of alternate setting groups	1	2	2	4	4
	Front communication port (EIA(RS)232 9-pin)	Yes	Yes	Yes	Yes	Yes
	Rear communication port (EIA(RS)485 / K-Bus)	Yes	Yes	Yes	Yes	Yes
	Protocols supported on rear communications port	Courier,Modbus (RTU), IEC60870-5-103 DNP3 (Level 2)			Courier,Modbus (RTU), IEC60870-5-103, DNP3 (Level 2)	
	Fibre-optic communications (IEC60870-5-103 protocol only)	-	-	-	Option	Option
	IRIG-B Time Synchronization	-	-	-	Option	Option
	Event, Fault & Disturbance Recording	-	Yes	Yes	Yes	Yes
	Number of optically isolated (digital) inputs *	2	5	5	8 min., 16 max.	16 min., 32 max.
	Number of relay contacts *	4	8	8	7 min., 15 max.	14 min., 30 max.

* The maximum number of digital I/O is dependent upon I/O configuration. For example, with maximum digital inputs only the minimum number of digital outputs will be available.

MAIN PROTECTION FUNCTIONS

The main protection functions are autonomous and can be individually enabled or disabled to suit any particular application. Each protection function is available in each of the alternate setting groups which can also be individually enabled or disabled. Three phase tripping with faulted phase indication is provided for all protection functions.

VOLTAGE PROTECTION

> Under/ Over Voltage protection [27/59]

A minimum of two stages of under and over voltage protection are provided within the P9xx series and can be configured to operate from either phase-neutral or phase-phase voltages, from ANY PHASE variation (OR mode) or THREE PHASE variation (AND mode). The first stage can be configured for either inverse or definite time operation, with all subsequent stages definite time only.

> Residual Overvoltage [59N]

Three stages of residual overvoltage (or Neutral Voltage Displacement) protection are provided within the P92x series of relays. Depending upon the VT configuration set on the relay, the protection will operate from either an internally calculated value or from a directly measured value of residual voltage. As for the other voltage elements, the first stage can be configured for either inverse or definite time operation, with all subsequent stages definite time only.

This element is particular useful for detecting earth faults on isolated or high impedance earthed systems whilst avoiding the installation of expensive core balanced CTs. This element is insensitive to 3rd harmonic voltages.

> Negative Sequence Overvoltage [47]

Two stages of negative sequence overvoltage protection are provided within the P922 and P923 relays. The first stage can be configured for either inverse or definite time operation, with all subsequent stages definite time only.

> Positive Sequence Undervoltage [27D]

Two stages of positive sequence undervoltage protection are provided within the P922 and P923 relays. The first stage can be configured for either inverse or definite time operation, with all subsequent stages definite time only.

Either negative sequence or positive sequence elements can be used for the detection of voltage unbalance and are often used on switchboards with a predominance of motor loading in which case, unbalance will quickly lead to overheating and damage.

FUNCTIONAL OVERVIEW

(Description of ANSI code nos. see Function Overview)
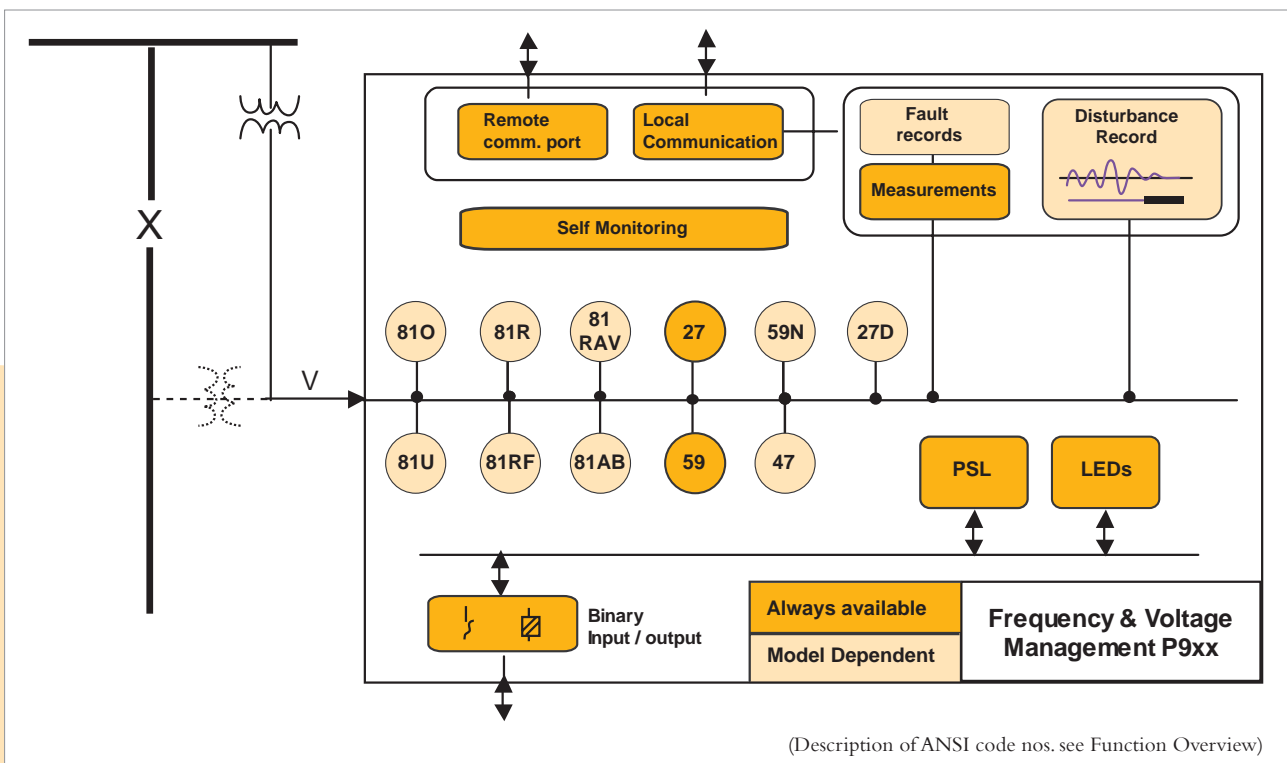
LOAD / GENERATION SHEDDING

The P9xx relays are provided with a variety of frequency based protection elements, a combination of which can detect all possible contingencies of generation - load imbalance.

A fall in system frequency may require that the system load be reduced, whereas a rise in frequency would call for a reduction in generation. The frequency elements of the P9xx relays can be programmed for both requirements.

Each protection element is provided with six independent stages. Combined with the logic capabilities, the relay can be programmed to ensure efficient and secure operation of any system.

> Under / Over Frequency [81U/O]

Time delayed under and over frequency protection provides the fundamental form of frequency protection and is available on all P94x relays, as well as the P922 and P923. When the measured frequency crosses the programmed threshold the element generates a start signal and after a user settable time delay, a trip signal is generated.
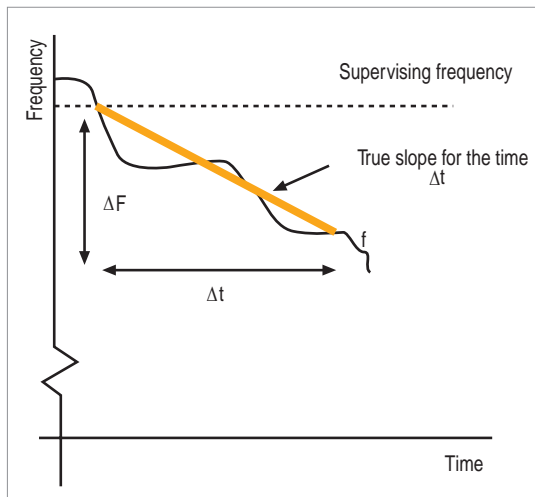
Average rate of change of frequency diagram.

> Rate of Change of Frequency [81R]

Time delayed rate of change of frequency protection is suitable for severe disturbances when shedding load in small steps may not be sufficient. This element can be used to accelerate load shedding during such system conditions. It can also compliment the generator control system to reduce or shed generation when the frequency rises above the nominal frequency at a high rate.

Rate of change of frequency protection is available on the P923 and all P94x relays.

> Frequency Supervised Rate of Change of Frequency [81RF]

For this element, the rate of change of frequency protection is supervised by an independent frequency element. This allows the relay to respond faster to severe system conditions and accelerate the recovery process by shedding more load than would have been done for a slow decay at the same frequency. This element is only available on the P94x relays.

> Frequency Supervised Average Rate of Change of Frequency [81RAV]

The frequency supervised average rate of change of frequency element provides a mechanism to measure the change in frequency over a user set time interval. This allows a more secure trip decision to be achieved by monitoring the trend in the change of frequency. This is particularly useful during transient system disturbances such as power swings, where instantaneous measurement can lead to an erroneous decision. The element starts a timer when the system exceeds the user set start threshold and at the end of the time delay, a second measurement of frequency is made. A calculation of average rate of change of frequency is then made and compared with the user setting to arrive at the tripping decision.

This element is only available on the P94x relays.

LOAD RESTORATION

The P94x relays provide up to six stages of automatic load restoration. This process can only start when the system frequency has recovered to a value above the load restoration frequency, following a load shedding operation by one or more of the protection elements associated with that stage. Minor frequency excursions during the restoration time delay are ignored by means of a cumulative timer which suspends if the system frequency falls between the restoration frequency and the load shedding frequency (holding band).

GENERATOR ABNORMAL PROTECTION [81AB]

P94x relays have this element to protect the turbine blade from potential damage due to prolonged under/over frequency operation of generators. Up to four frequency bands can be programmed, each having an integrating timer to record the time spent within the band. The time in each band is stored in battery backed memory so that loss of auxiliary supply to the relay does not lead to a loss of the recorded time. When the time within a band has reached the user set limit, an alarm can be raised to initiate investigation and maintenance.

ELEMENT BLOCKING & AVERAGING

In addition to the under/over voltage protection elements, a user-settable undervoltage blocking facility is provided that will prevent operation of all the frequency based protection elements. Similarly, if the system frequency falls outside of the tracking range of the relay all the frequency elements (except the under/over frequency [81U/O]) are blocked.
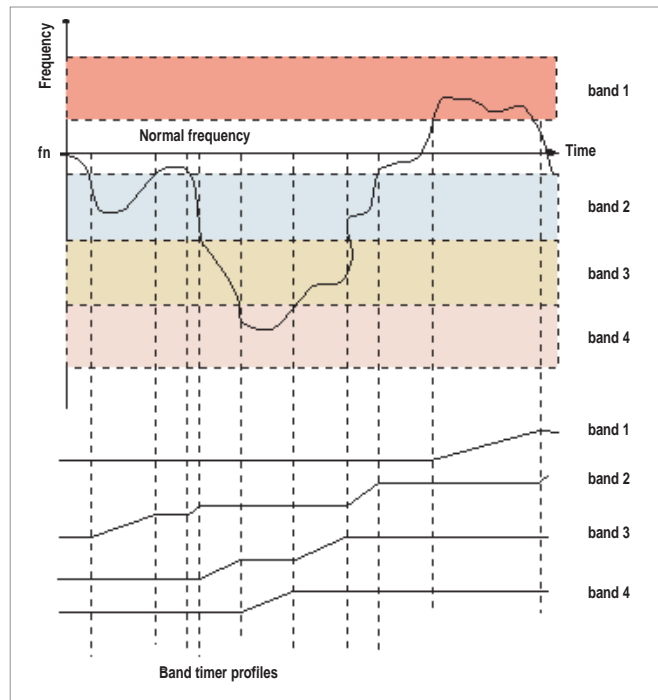
Generator abnormal frequency protection

To help stabilize the calculation of frequency and rate of change of frequency during oscillatory conditions, the P94x relays give the user the ability to select the number of cycles over which the measurement is averaged. The averaging uses a "rolling" window method to ensure that two new measurements are available for the protection elements every cycle. A similar facility is provided on the P923 for the rate of change of frequency element only.
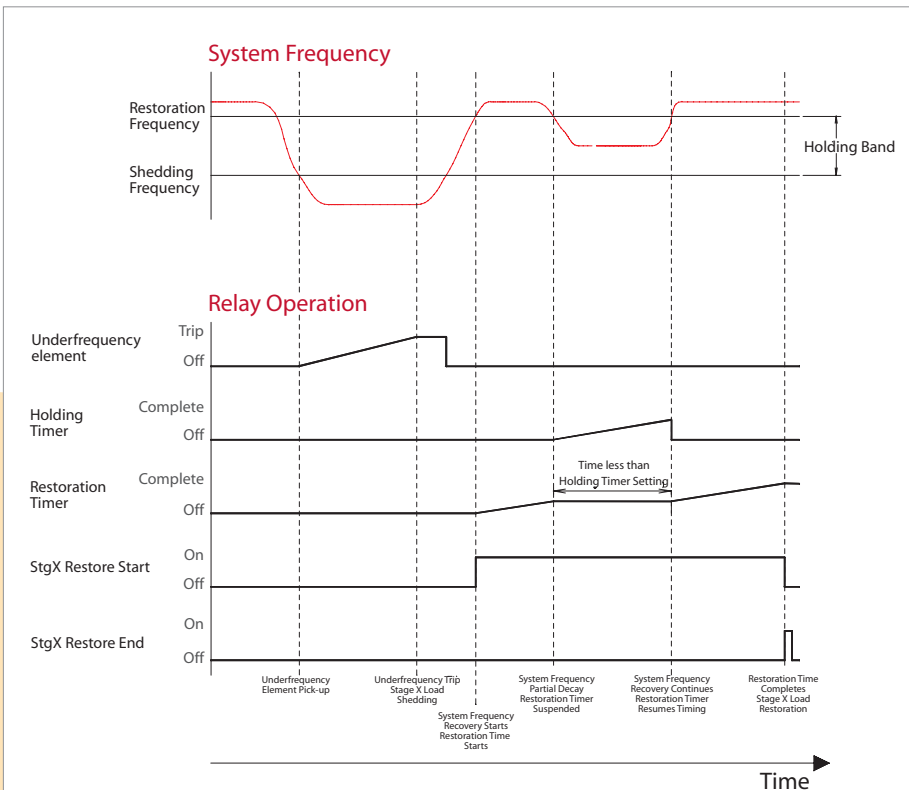
Load restoration diagram

CONTROL

> **Programmable Scheme Logic**

The P92x relays use simple AND logic equations to provide scheme flexibility. Each equation has two timers associated with it to control the delay on pick-up and the delay on drop-off of the logic. This logic is independent of the programming facilities of the digital inputs, output contacts and LED's and is additional to dedicated blocking facilities.

The programmable scheme logic (PSL) in the P94x relays is a very powerful tool for the protection engineer giving a high level of flexibility. Even complex load shedding schemes can be easily programmed using the graphical, Windows based MiCOM S1 support software. The gate logic of the PSL includes OR, AND and majority gate functions with the ability to invert and provide feedback. The system is optimised (event driven) to ensure that the protection outputs are not delayed by the PSL operation.

The PSL has found extensive use in providing control and supervision features such as trip circuit supervision, auto-changeover and busbar blocking schemes.

The PSL of the P94x relays is used to programme the functionality of the digital inputs, relay outputs and LED's.

> **Control Inputs**

The ON / OFF status of 32 control inputs can be changed locally or remotely to provide user defined control functions within the P94x PSL.

> **Latched Output Contacts [86]**

Each relay output contact can be individually programmed to be latched. Once in the latched state, the contact can be reset either locally or remotely, or via the PSL in the P94x relays.

In addition to the ability to latch output contacts, on the P94x relays each of the contacts can be individually conditioned by a timer to give pulse, dwell, delay on pick-up or delay on drop-off operation.
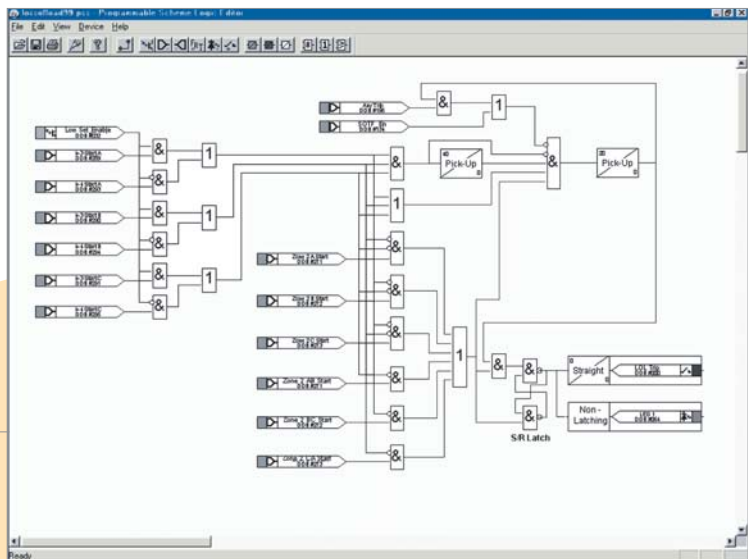
MEASUREMENTS & POST FAULT ANALYSIS

The P9xx relays are capable of measuring and storing a number of quantities. All events, faults and disturbance records are time tagged to a resolution of 1ms using an internal real time clock. On the P94x relays an optional IRIG-B port is also available to maintain the accuracy of the real time clock. A supervised and easily accessed lithium battery ensures that the real time clock and records are maintained during auxiliary supply interruptions.

> **Power System Measurements**

The measurements provided will depend upon the application and model of the relay. Where appropriate the measurements may be viewed in primary or secondary terms and can be viewed locally or remotely. Measurements include:

• Phase / line voltages (true RMS)
• Sequence voltages
• Phase angles
• System frequency

> **Stage Statistics**

On P94x relays, the number of protection starts and trips generated by each element of each of the six stages may be viewed. In addition, the date and time of any setting change is also recorded for traceability.

> **Event Recording**

The P922 and P923 can store up to 75 event records for viewing via the local and remote communication ports using MiCOM S1.

The P94x relays can store up to 250 event records for viewing locally on the LCD, or extraction via the communication ports.

PSL Editor (MiCOM S1)

> Fault Recording

All P9xx relays (except P921) store the last 5 faults records, typically containing:

- Date and time
- Protection operation
- Active setting group
- Fault voltages, frequency, etc..

> Disturbance Recording

All P9xx relays (except P921) have an internal waveform capture facility with user programmable trigger point. The P922 and P923 can record five disturbances, each with a duration of 2.5 seconds at a sampling rate of 32 samples per cycle. The P94x relays use a compression algorithm to increase the number of records that can be stored, but typically this can be up to 20 records, each of 10.5 second duration. All disturbance records capture both analogue and digital information and when extracted via the communication ports, are stored in Comtrade format. These records can be examined using MiCOM S1 or any other suitable software programme.

> Frequency Recording

The P923 has the ability to record one 20 second record in addition to the normal disturbance recording facilities. This frequency record uses a sampling rate of 1 sample per cycle and only records the measured frequency.

INFORMATION INTERFACES

Information exchange is performed via the LCD, the local PC interface or via the rear communications interface.

> Local Communication

The front EIA(RS)232 port has been designed for use with MiCOM S1, providing the ability to programme the settings (on or off-line), configure the PSL, extract and view records, view the measurement information dynamically and perform control functions.

> Remote communication

The rear communication port is based upon EIA(RS)485 voltage levels and is designed for permanent connection to network control and data acquisition systems. Any of the four protocols listed below can be selected at the time of order:

- Courier / K-Bus
- Modbus
- IEC 60870-5-103
- DNP3

> Password protection

To prevent unauthorised setting changes, all relays have password facilities. On the P92x one level of password control is available, whereas the P94x provide two password levels.

Disturbance record analysis using MiCOM S1
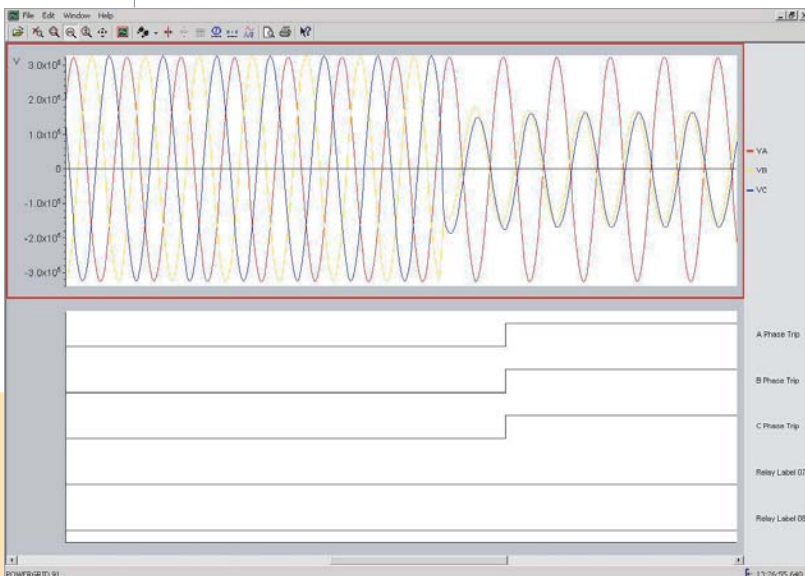
EMC COMPLIANCE

C E 89/336/EEC: Compliance with the European Commission Directive on EMC

PRODUCT SAFETY

C E 73/23/EEC : Compliance with the European Commission Low voltage directive

P94X THIRD PARTY COMPLIANCE

c(UL)us File Number : E202519
Original Issue Date :
05-10-2002
(Complies with Canadian and US requirements)

Certificate Number :
105 Issue 1
Assessment Date :
19-02-2003

AREVA TRACK RECORD - FREQUENCY PROTECTION

>> **MFVU:** First digital frequency protection relays, first released in 1986. Over 8500 devices installed.

>> **KVFG/MX3VI:** First numerical relays combining voltage and frequency protection features.
Over 3500 devices installed since 1996.

>> **RFS3000:** First relay produced by AREVA with rate of change of frequency elements. Over 400 devices installed since 1997.

>> **MiCOM P92x:** Combined numerical voltage and frequency relay. More than 2000 devices installed since 2000.

>> **MiCOM P94x:** Designed for all frequency based load applications. More than 1100 units installed since 1999.

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