JSC “ELektrichesky Upravlyayemy Reactory”(ELUR/CERC) was established in 2000

Key companies working with ELUR/CERC for controllable reactors are:

- **Transformer factory (ZTR), OJSC, Zaporozhye, Ukraine**
- **Electro-technical factory, OJSC, Ramenskoye, Moscow Region, Russia**
- **All-Russian electro-technical institute, State Enterprise, Moscow, Russia**
- **Expending Edge LLC, San Anselmo, California, USA**

ELUR/CERC is a laureate of Russian government award for science and technology in 2003 (development, manufacture and maintenance arrangement of controllable electric reactors).

Range of products:

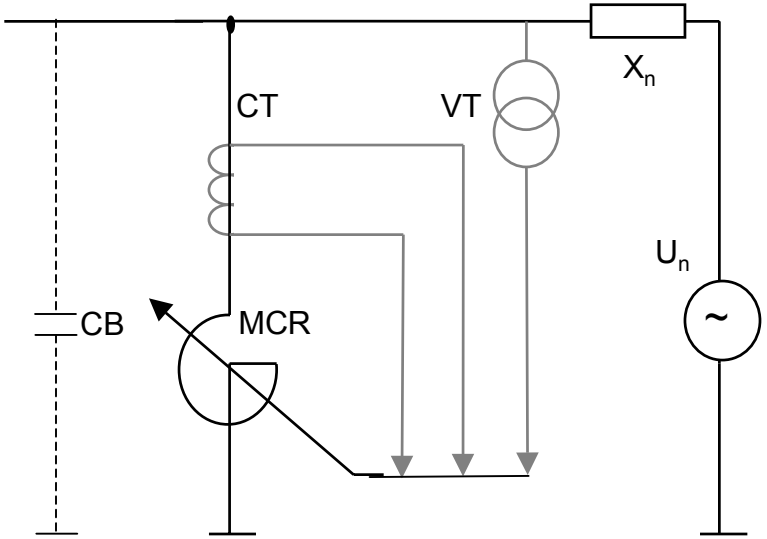
- Controllable shunt reactors (MCR):	**RTU**	**110…500 kV;**
- Controllable shunt reactors (MCR):	**RTU**	**6…35 kV;**
- Controllable arc-extinguishing (neutral) reactors (MCR):	**RUOM (ROU)**	**6…35 kV.**

1. MCRs are smoothly adjustable inductive resistances controlled by changing the magnetic circuit saturation.

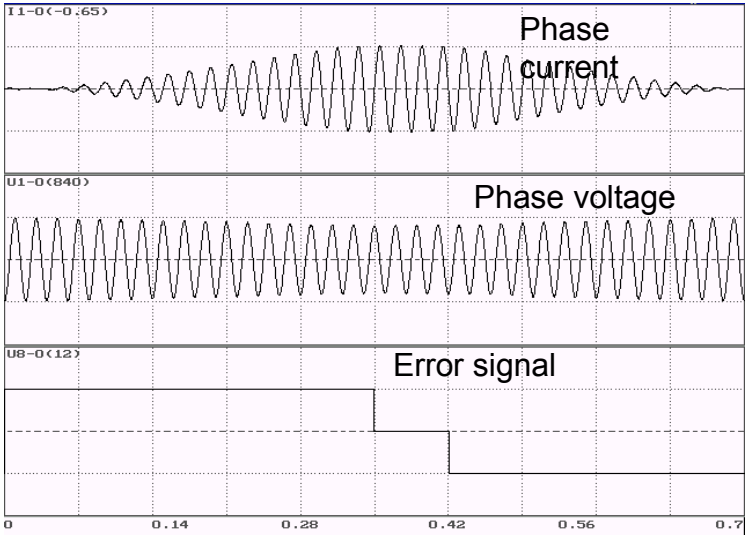
2. Application of MCRs instead of non-adjustable and stepwise adjustable reactors is expedient in electric networks mains with a variable load shedule.

3. MCRs combined with condenser bank capacitors act as synchronous and static thyristor compensators.

4. Structural diagram:

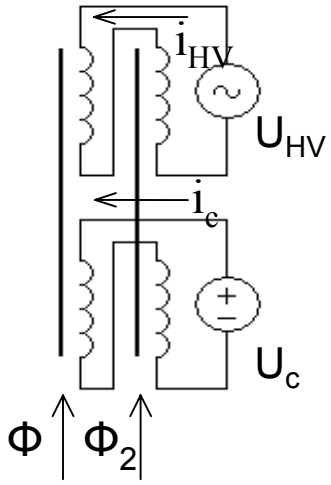


5. The main adjustment characteristics:



Principle of operation

Schematic diagram of the phase:

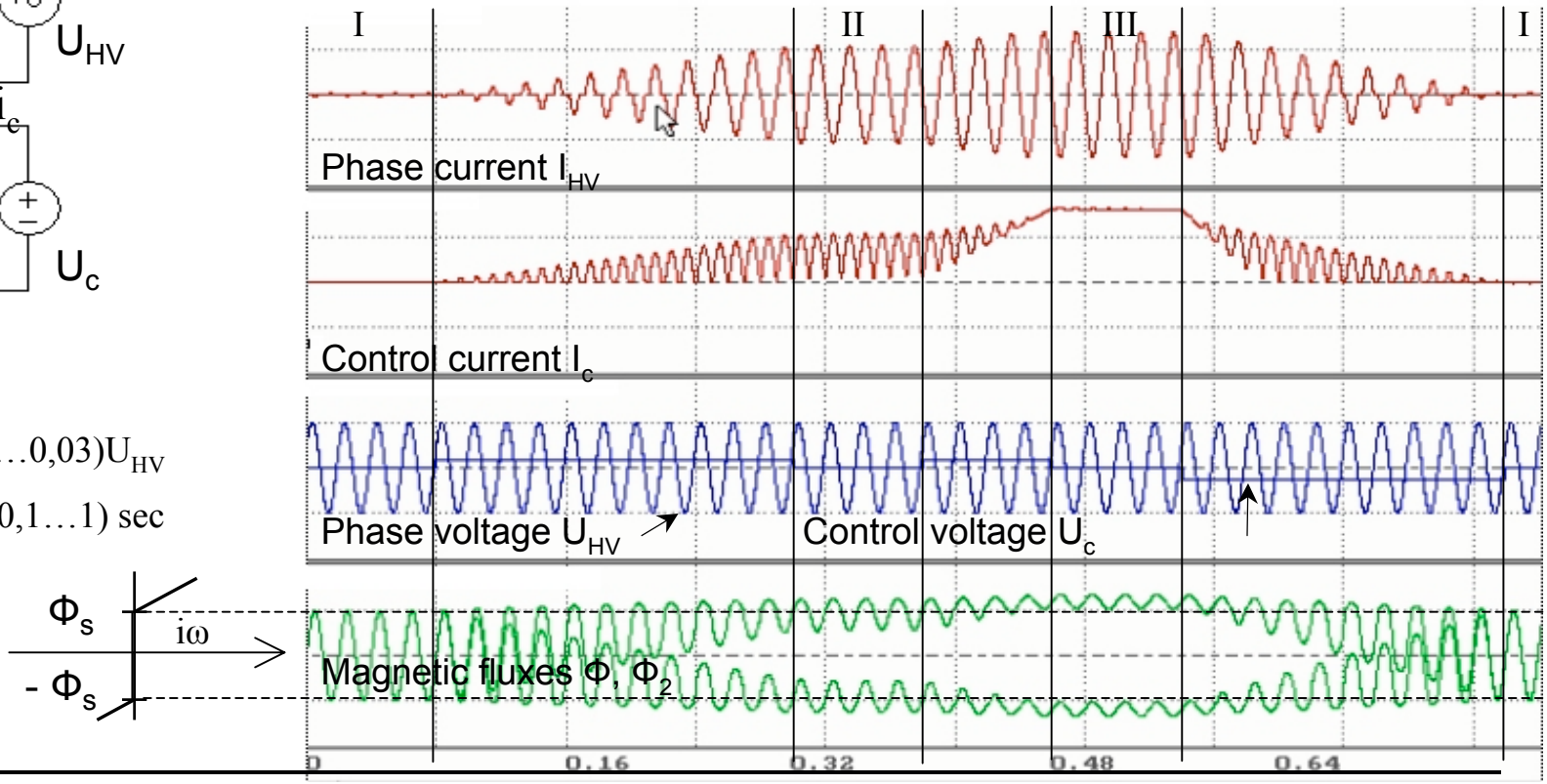


$U_c = (0{,}01 \ldots 0{,}03) U_{HV}$

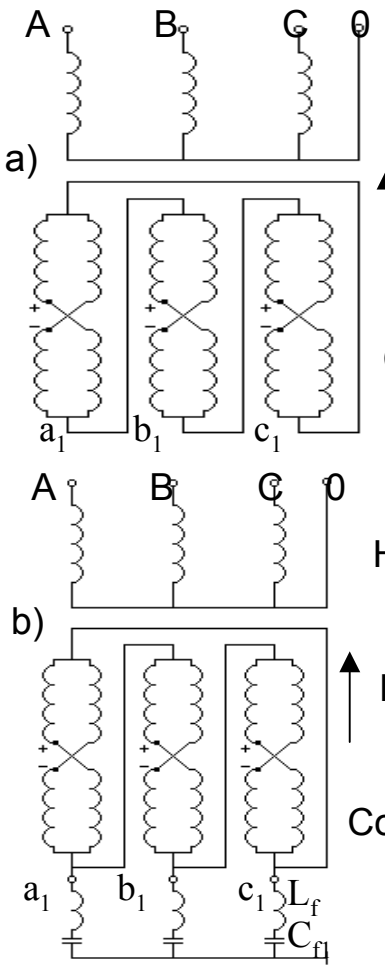
$\tau = (0{,}1 \ldots 1)$ sec

Typical modes

I. No-load operation (non-saturated mode)	II. Nominal mode (semiperiodic saturation)	III. Maximum mode (full-period saturation)
$I_{HV} = I_c \approx 0$	$I_{HV} = I_c = I_n$	$I_{HV} = 1{,}3I_n$; $I_c \approx 2I_n$



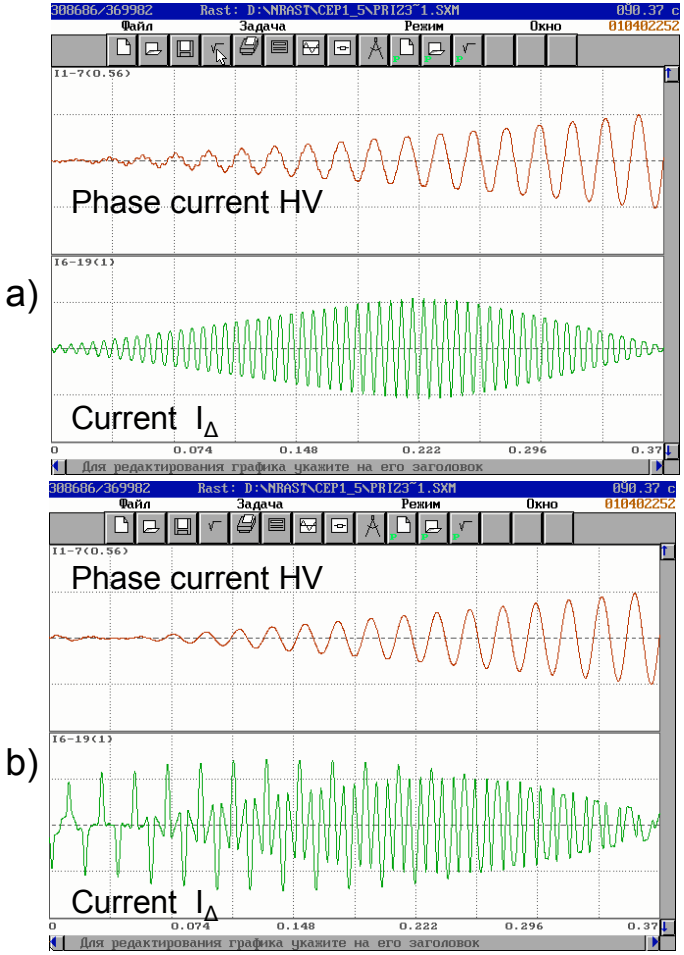
Schematic diagram of MCR



a) $I_{distortion} \le 0.04 I_n$

b) $Q_{ph} = (0.03 \ldots 0.05) Q_n$;

$I_{distortion} \le 0.02 I_n$



A phase of the controllable reactor RODTsU-60/525/√3 mounted in 1989 on the "Bely Rust" substation, Russian Federation

Purpose:
Network tests (adjustment, dynamic, vibration and noise tests, current nonlinear distortion, resonance events).

Basic technical specifications:

1. Rated voltage	525/√3 kV
2. Rated power	60 MVAr
3. Power variation range	0.2…81 MVAr
4. Time of power change	0.3 sec
5. Losses:	
-no-load loss	90 kW
-nominal loss	465 kW
6. Control power	1.8 MVA
7.Total weight	138 tons

Customer's (*"Dalny elektroperedachi"*) conclusion is,

"The sample has successfully passed the tests and can be accepted as a base for a pilot model."

3-phase controllable reactor 25 MVAr, 110 kV mounted on "Kudymkar" substation, Russian Federation, 1999

Purpose:

Being coupled with Shunt Condenser Bank (SCB) of 42 MVAr it provides voltage stabilization in connection point, optimization of reactive power flows in the adjacent network.

Basic technical specifications:

- Rated voltage 121 kV
- Rated power 25 MVAr
- Power variation range 0.25…30 MVAr
- Time of power change 2.0 sec
- Losses:

no-load loss 25 kW
nominal loss 200 kW
6.Control power 160 KVA
7.Upper harmonics in current < 4%
8.Total weight 69 tons

Customer's (UES of Russia) conclussion (on results of panel discussion at the reacrtor installation site) is that:

1.Voltage deviations are limited by ±1.5%.
2. On peak load the power loss in the adjoining network is reduced to 2.5 MW.
3. Due to the increased transmission capacity the projecting of additional 220 kV power transmission line for this region can be postponed.

3-phase controllable reactor 100 MVAr, 220 kV mounted on the "Chita" substation, Russian Federation, 2002

Purpose:
Voltage stabilization in the connection point, generator relief from the reactive power.

Basic technical specifications:

• Rated voltage	220 kV
• Rated power	100 MVAr
• Power variation range	-2.5…113 MVAr
• Time of power change	0.4 sec
• Losses:	
no-load loss	87.7 kW
nominal loss	558 kW
6. Control power	1 MVA
7. Upper harmonics in current	<2%
8. Total weight	183 tons

Customer's (UES of Russia) conclusion (of scientific and technical council, clause 2, of December 29, 2003) is,
"To recommend Federal Network Company of Unified Energy System, JSC using the similar controllable shunt reactors (MCR) in 110—330 kV networks".

3-phase controllable reactor 180 MVAr, 330 kV mounted on the "Baranovichi" substation, Belarus, 2003

Purpose:

Voltage stabilization, generator relief from the reactive power.

Basic technical specifications:

• Rated voltage	347 kV
• Rated power	180 MVAr
• Power variation range	-5…195 MVAr
• Time of power change	0.7 sec
• Losses:	
-no-load loss	138 kW
-nominal loss	753 kW
6.Control power	1 MVA
7.Upper harmonics in current	<2%
8.Total weight	320 tons

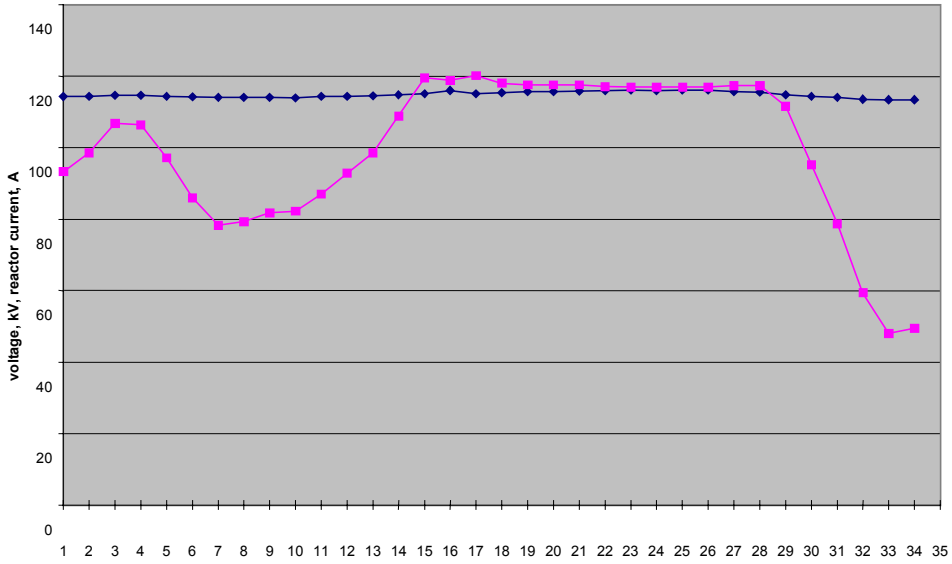
Preliminary conclusion of the customer (technical board of "Belenergoproekt") is,

"To recommend "Belenergo" using only MCR in 330 kV networks".

Measurement sheet of MCR operation

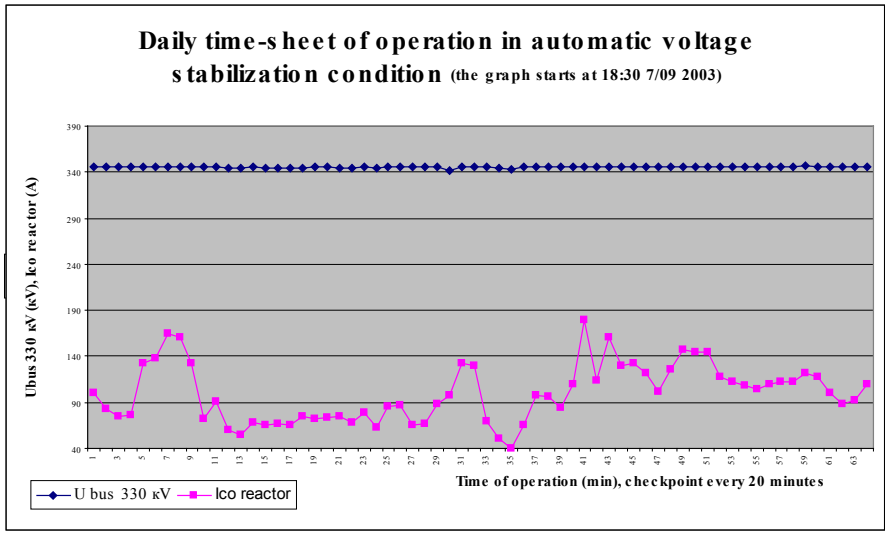
25/110 MCR "*Kudymkar*" substation

Bus voltage and RTU current graph for automatic operation of the reactor

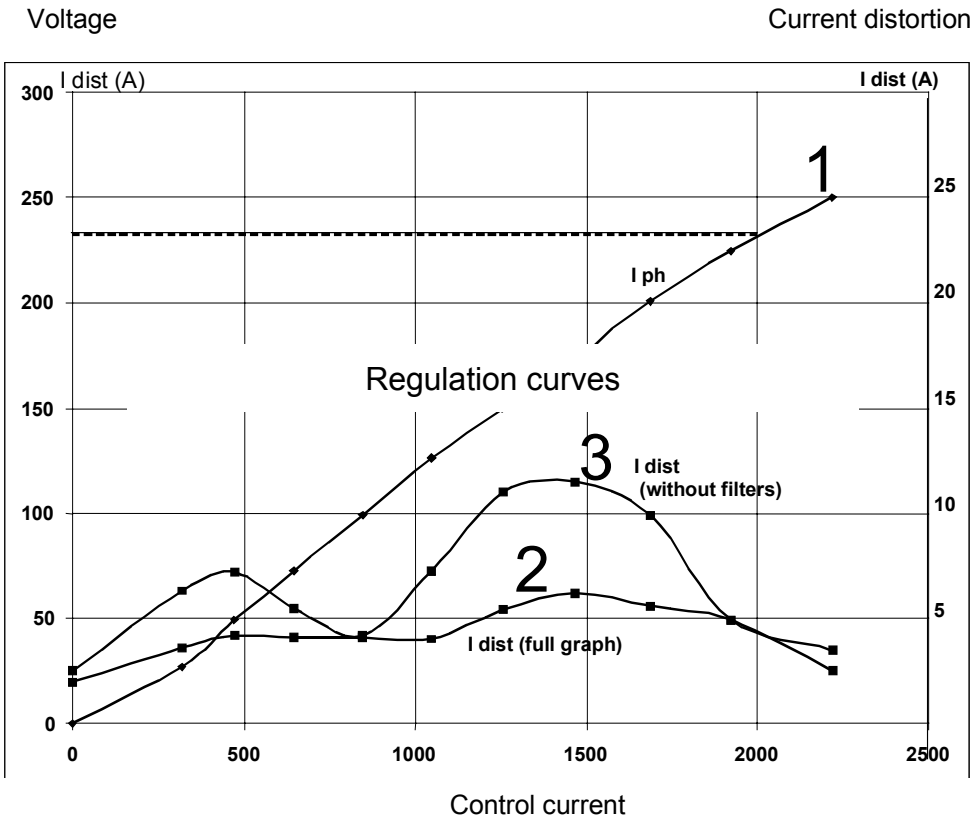


Voltage

180/330 MCR "*Baranovichi*" substation



Current



110/220 MCR, «Chita» substation

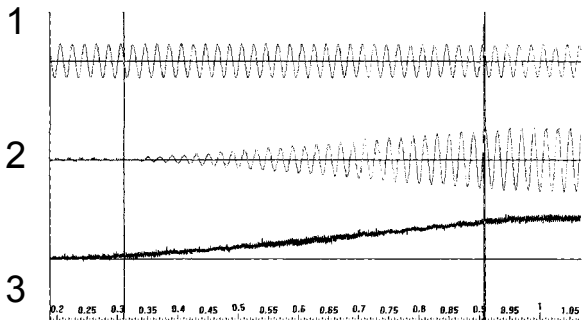
1 – phase effective current

2 – phase distortion current

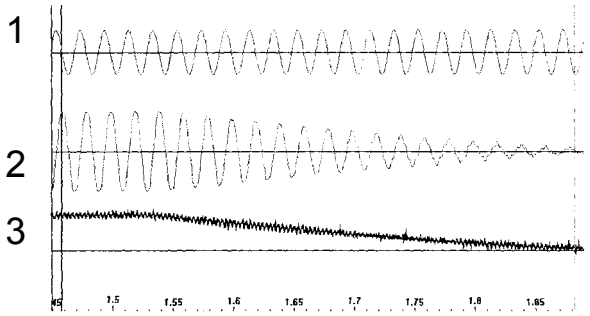
3 – phase distortion current, filters switched off

Dynamic performance

The maximum rate of current change in normal mode, 110/220 MCR “Chita” substation

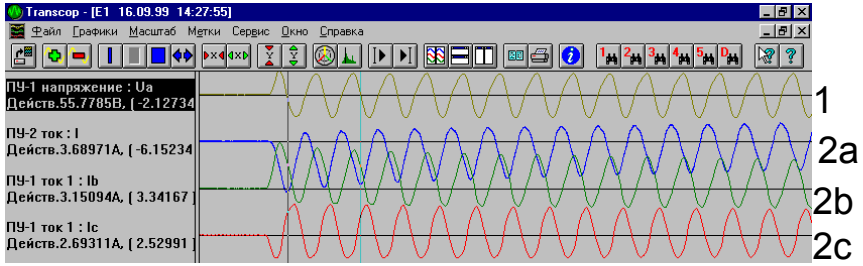


а)



б)

Phase currents of the 25/110 MCR “Kudymkar” substation when connected to the network

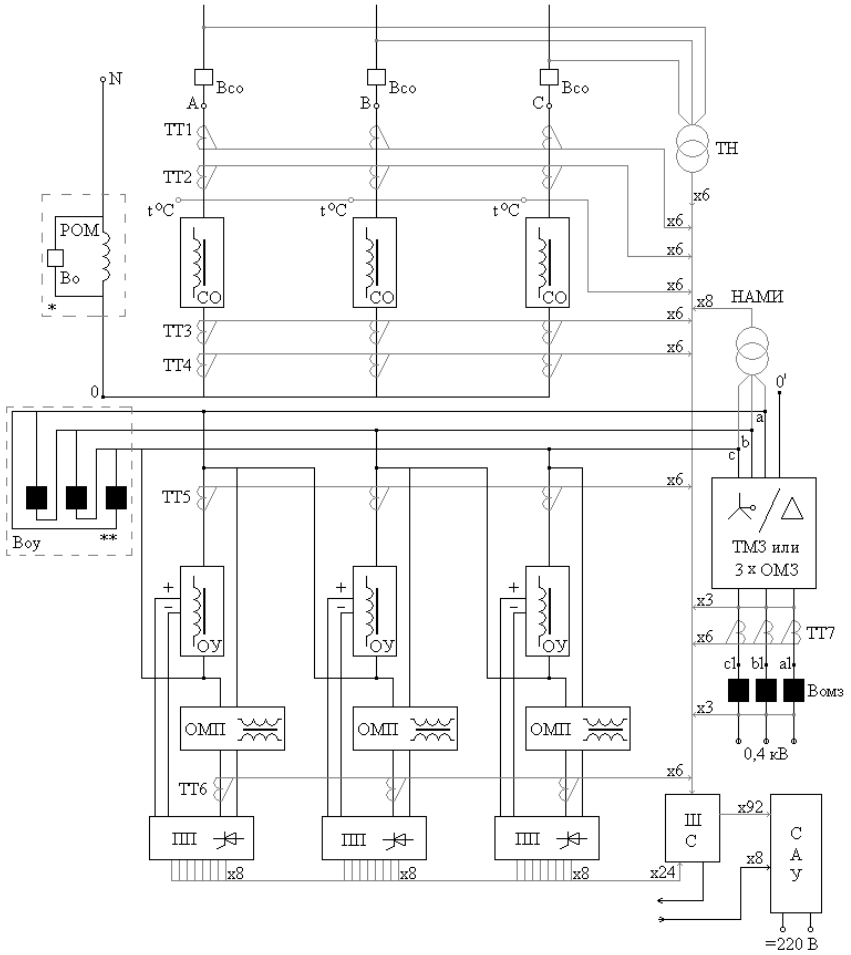


1 – network voltage

2 – phase currents

3 – control current

Principal electric diagram:



Equipment configuration:

Main equipment:

-MCR phases equipped with a semiconductor converter;

-system of automatic control (САУ).

Supplementary equipment:

-switches;

-voltage and current transformers (ТТ`x and ТН, НАМИ);

-neutral reactor (ТМ3).

Properties of MCR110-500* series:

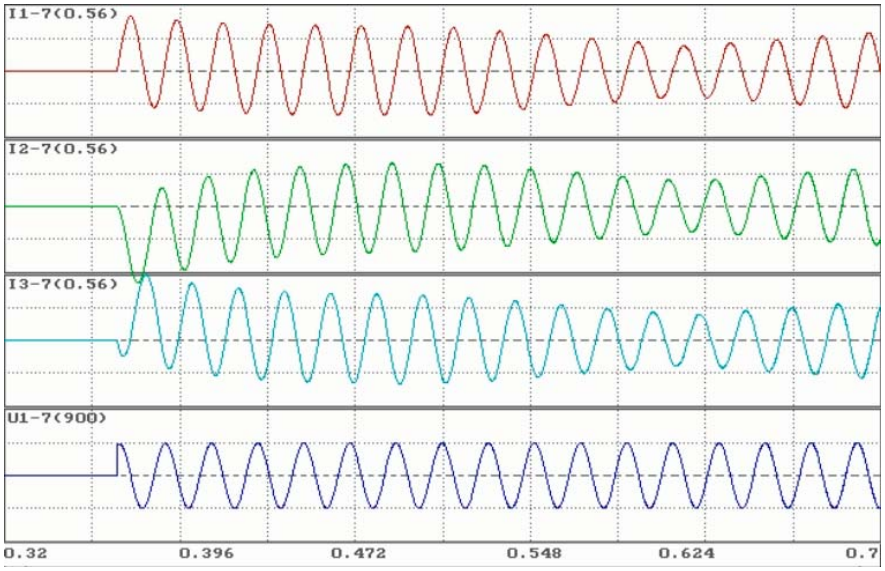
Power, MVA: 32, 63, 100, 180

Voltage, kV: 110, 220, 330, 500

*- any combinations of power and voltage are available.

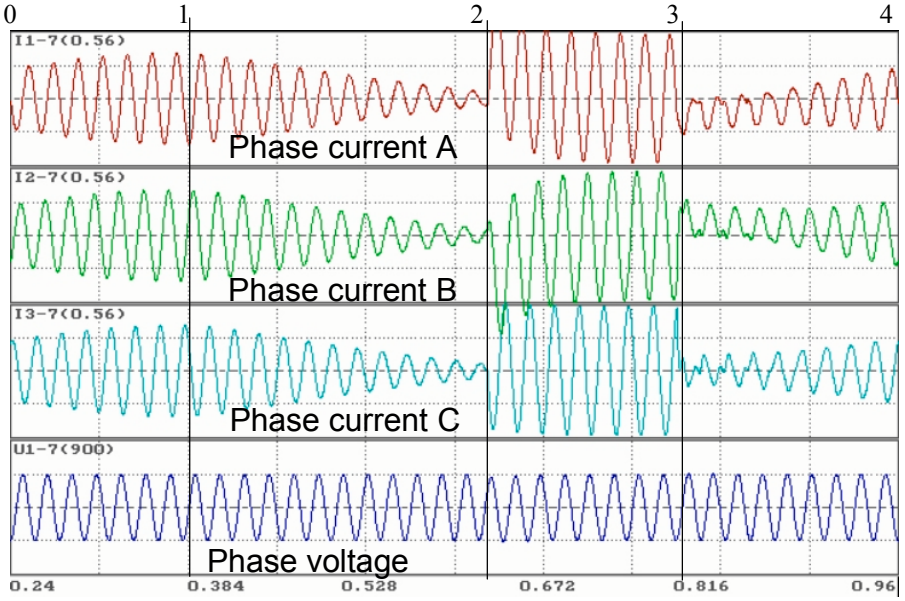
Typical modes of MCR operation

The connection of the reactor to a high-voltage network with the simultaneous adjustment of power consumption:



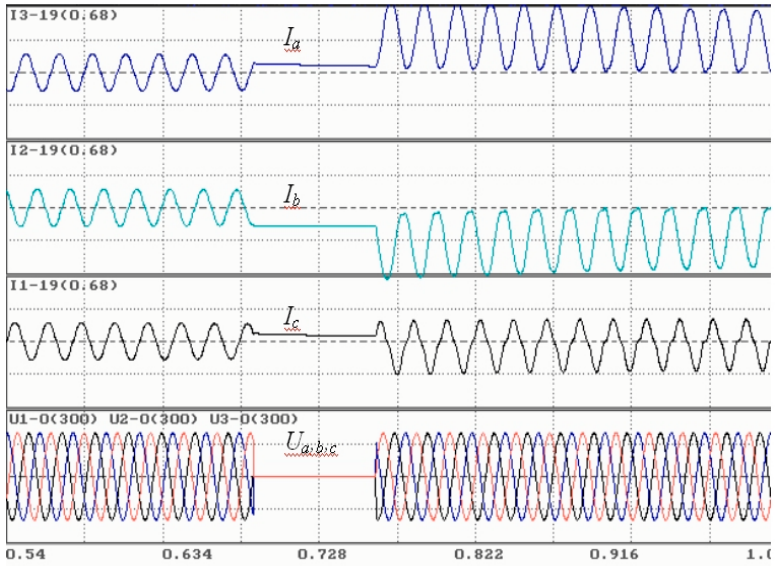
Transient processes in normal symmetrical modes:

0—1. Power rise from nominal to maximum level; 1—2 Power drop; 2—3 Double power forcing; 3—4 Changeover to nominal mode

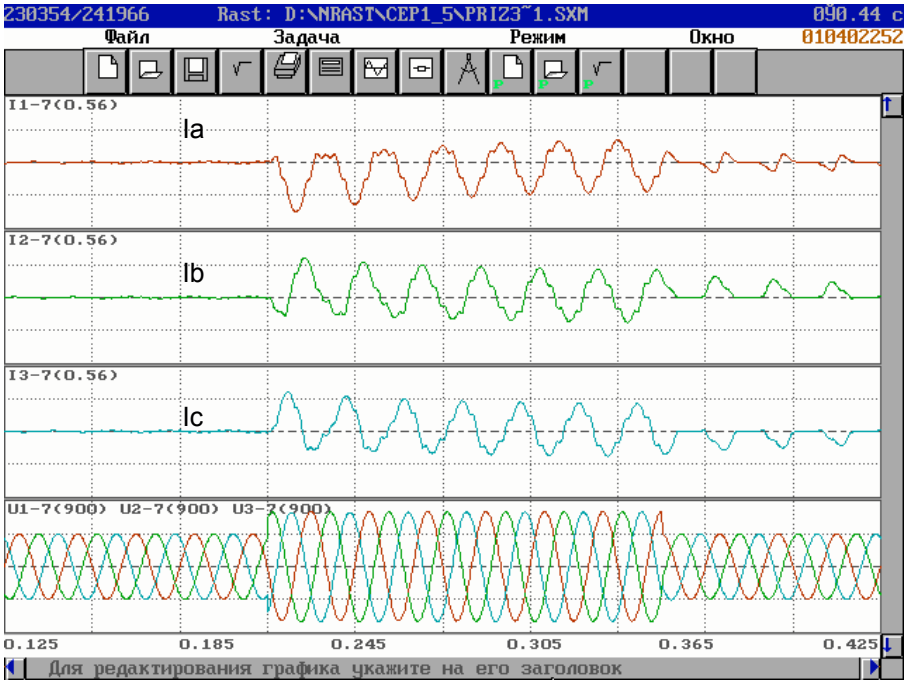


Transient processes of a MCR when:

Voltage drops



Voltage rises



Technical requirements for 110—550 kV MCRs (*UES of Russia*)

BASIC:

- The level of consumed power shall be adjusted automatically or manually within the range of 0.01 up to 1.2 of the rated power with unlimited number of possible changes.
- Guaranteed rate of smooth power change from one steady-state value to another shall be 0.3 to 0.5 sec.
- The effective value of distortion current consumed from the network shall be no more than 5 % of the nominal current of the major harmonics within the full adjustment range.
- Nominal mode shall be started faster than 0.02 seconds after the reactor has been connected to HV power network.

ADDITIONAL:

5. MCRs shall provide operability in asymmetrical mode and single-phase conditions.
6. MCRs shall have the following properties: fast-response (bellow 0.02 seconds), changeover of an effective power value to the mode of increased power consumption with consequent return to initial state.
7. Reactors shall provide enhancement of the consumed current shape with distortion current reduced to 2% of the major harmonic rated value.
8. MCRs shall provide power take-off at the LV side.

1. Basic technical and economic features for 110—500 kV CSRs of RTU series:
   - Weight index: 1.5—3 kg/kVAr
   - Power loss index:
   at no-load mode 0.5—1.0 W/kVAr;
   at rated mode 4—8 W/kVAr.
2. Performance:
   - fully automatic operation (without switching operation);
   - operation and maintenance costs, reliability are similar to those of conventional shunt reactors.
3. Multifunctional capabilities:
   - MCR can functionally substitute for conventional shunt reactors, stepwise adjustable reactors and thyristor reactor groups;
   - MCR combined with bank work as synchronous or thyristor compensators.
   - MCRs do not require switching of circuit breakers.

Backlog of orders for MCR in Russia

A phase of the controllable reactor RODTsU-60/525/√3 installed at "Bely Rust" substation, Russian Federation

1. MCRs types which have already been installed or are being manufactured:

25 (32) MVAr/110 kV — 4 units;

63 MVAr/110 kV — 1 unit;

100 MVAr/220 kV — 2 units;

180 MVAr/330 (500) kV — 2 units.

2. Backlog of future orders:

On estimation of UES of Russia, RJSC roughly each one in three reactors for 110-550 kV networks shall be of controllable type.