CURRENT LIMITING CIRCUIT-BREAKERS FOR HOUSEHOLDS

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A new tariff scheme for electricity sale has been adopted in Slovenia. This scheme is supported by regulations that introduce current limiting circuit-breakers in low voltage wiring systems. The tasks of these device are limitation of the peak demand and protection of consumers against overloading and short circuit faults. The recent developments of communication systems have also given a possibility of remote control of current limiting circuit-breakers and thus indirectly of the consumers' behaviour. The paper describes various types of low voltage current limiting circuit-breakers, methods of their selection and installation, as well as possibilities of the remote control.

Key words: **low voltage current limiting circuit-breakers, short circuit capacity, selectivity, remote control.**

1. INTRODUCTION

The global process of world liberalisation and deregulation on the electricity market, as well as the accelerated development of communication and information technologies require constant system adjustment and searching for new solutions in the fields of organisation, technical equipment and offering of various services. The legislation and regulations also adapt to these challenges. Together with the tariff scheme for the sale of electricity (Official Gazette of the Republic of Slovenia No. 84/98) in 1998 Slovenia also adopted regulations that require an increased electricity price for consumers who do not rationally consume electricity. The purpose of these regulations is to achieve an optimal exploitation of the electric power system. This means especially peak demand reduction and more constant electricity consumption throughout the day [1]. Articles 31 and 35 require that for household consumers and consumers of the 2nd tariff level in the category "Other consumption" the peak demand is not metered but determined by a device for limiting the maximum electric current and thus also maximum power demand. Such devices are also current limiting circuit-breakers. The use of current limiting circuit-breakers offers new possibilities for controlling the electric power system at the level of electricity distribution. The device enables, if adequately upgraded, a possibility of direct control over the household consumers (switching them on and off) from the control centre of the electricity distributor.

On the Slovenian market there are several manufacturers of current limiting circuit-breakers already present, and the installation of these devices has become very attractive in recent years. According to the available data, similar systems as that currently being introduced in Slovenia are present in France and Croatia [2], [3]. On the Slovenian market there are presently no current limiting circuit-breakers with the possibility of remote control. Nevertheless, it is quite possible that the development will eventually go in this direction.

The paper presents the design and the characteristics of current limiting circuit-breakers. Given and described are some well-known schemes of their installation. The area of technical regulations and standards in Slovenia has not yet been satisfactorily settled. A special attention has been paid to the possibility of remote controlling of current limiting circuit-breakers.

2. CURRENT LIMITING CIRCUIT-BREAKERS

2.1. Construction of current limiting circuit-breakers

Current limiting circuit-breakers are switching devices for the limitation of current flowing to a consumer, which at the same time protect low voltage cables and devices, connected to them against short-circuit faults and overloading.

Current limiting circuit-breakers are in principle similar to conventional low voltage circuit-breakers.

Current limiting circuit-breakers are manufactured as single- and three-pole circuit-breakers (Figure 1), as well as two- or four-pole circuit-breakers (Figure 2). The mechanism ensures closing of neutral conductor against phase contacts during switching on, and opposite during switching off [4].

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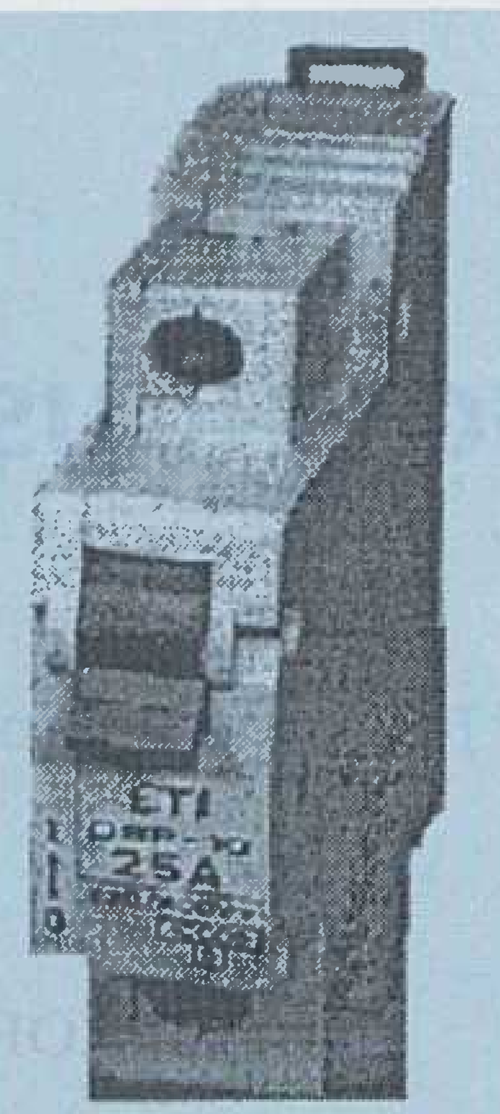


Figure 1. Single-pole current limiting circuit-breaker

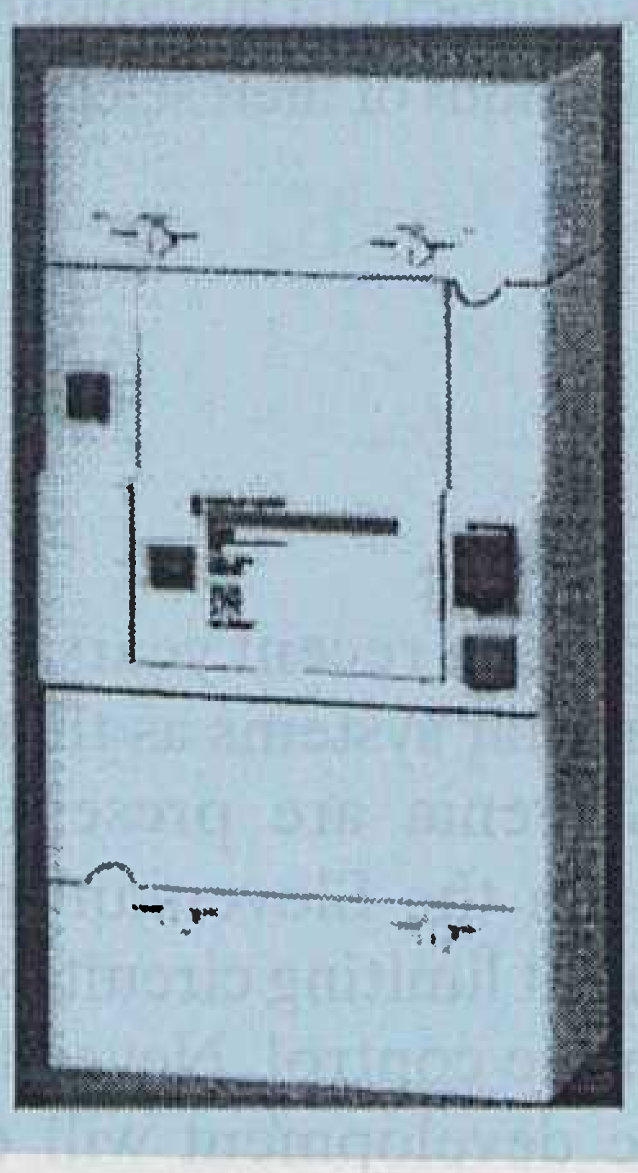


Figure 2. Two- and four-pole current limiting circuit-breaker

Figure 1 shows a single-pole current limiting circuit-breaker, which can also be made as a three-pole circuit-breaker. Figure 2 shows another type of current limiting circuit-breakers. The circuit-breakers of this type are either two- or four pole devices, suitable for the use in outdoor power panels, with a possibility of reclosing without opening the power panel's door.

Current limiting circuit-breakers have for each pole the following elements:

1. Thermal overload releases, working on the principle of bimetal wire that bends while heated and thus opens the circuit. Their operation is inversely delayed and depends upon the thermal effecting of current flowing through the release (Figure 3 - *I-t* characteristic). Thermal overload releases play, beside the current limiting role, also the role of protection against overloading.
2. Magnetic short circuit releases are also over-current releases, the operation of which depends upon the force, caused by the current of the main circuit that supplies the electromagnet's coil. If the case of sufficiently high current (multiple of the rated current) the opening of the circuit is instantaneous - $t < 0.1$ (Figure 3). Their task is to protect against short-circuit currents.
3. Some current limiting circuit-breakers have also optionally built-in a current protecting switch (FI switch).

Some current limiting circuit-breakers also enable setting of maximum permitted permanent current. After such setting it is required to seal the device in order to protect against unauthorised resetting.

2.2. *I-t* characteristic of current limiting circuit-breakers

I-t characteristic of a circuit-breaker describes the operating time as a function of expected current. The standards SIST EN 60898 and IEC 60898 prescribe operating time in dependence of the expected current (Table 1).

Table 1. Required I-t characteristic for a standard low voltage circuit-breaker

Testing current	Operating time	Expected operation
$I_1=1.13\,I_n$	t>3600 s	Doesn't break
$I_2=1.45\,I_n$	t<3600 s	Does break
$I_3=2.55\,I_n$	1 s<t<60 s 1 s<t<120 s (In>32A)	Does break

Croatian and French regulations require that current limiting circuit-breakers have slightly faster operation in the area of overloading than standard low-voltage circuit-breakers, as shown in Table 2 [2], [3].

Table 2. Required I-t characteristic for a current limiting circuit-breaker in France and Croatia

Testing current	Operating time	Expected operation
$I_1=1.1\,I_n$	t>900 s	Doesn't break
$I_2=1.4\,I_n$	2<t<900 s	Does break
$I_3=2.5\,I_n$	0.5 s<t<60 s	Does break

Table 3 shows the results of the test, performed by the Croatian Institute for Electricity and Energy Industry (Institut za elektroprivredu i energetiku Hrvatske) on a single-pole 25 A current limiting circuit-breaker (Figure 1).

Table 3. Operating times after overloading of current limiting circuit-breaker

Testing current	Operating time
$I_1=1.1\ I_n=27.5$ A	t>900 s, doesn't break
$I_2=1.4\ I_n=35$ A	between 75 s and 87.7 s, does break
$I_3=2.5\ I_n=62.5$ A	between 13.7 and 17.6 s, does break

Fugure 3 shows the *I-t* characterristic of a four-pole current limiting circuit-breaker. Single-pole current limiting circuit-breakers (Figure 1) have similar characteristics. The only difference is that the *I-t* characteristic of the latter in the short-circuit area have the same shape as the characteristic of a standard low voltage circuit-breaker [4].

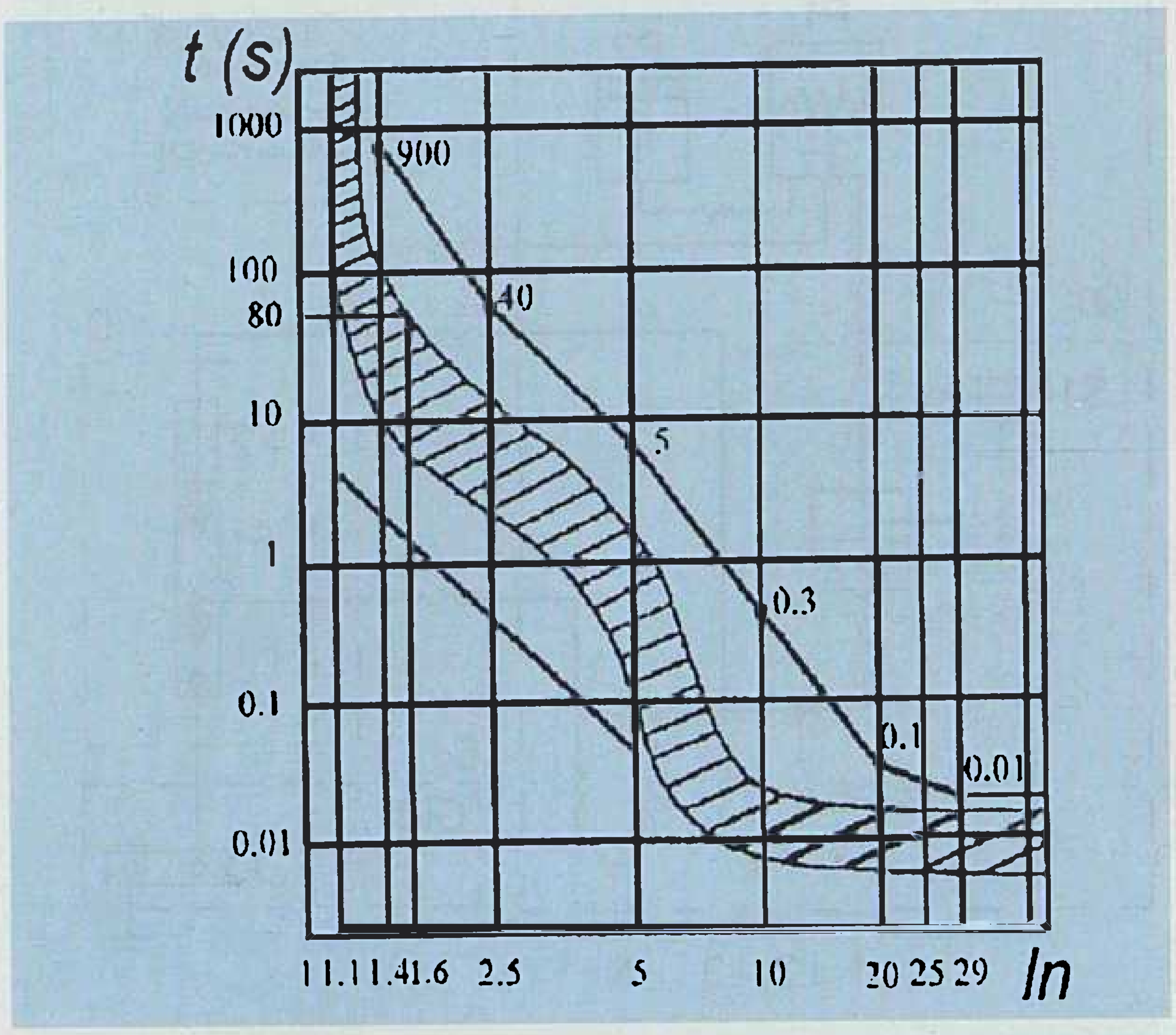


Figure 3. *I-t* characteristic of a four-pole current limiting circuit-breaker

2.3. Short-circuit capacity

Each current limiting circuit-breaker is designed for a certain nominal power, and consequently for a corresponding nominal current. Short circuit current can cause severe problems to a current limiting circuit-breaker, due to excessive heat and consequently temperature rise which may damage the device.

The magnitude of short-circuit fault current in low voltage networks depends mostly on:

- Supply transformer with its reactance and resistance (important data for them are short-circuit voltage and nominal capacity);
- Impedance of the cables and overhead lines that lead to the consumer's location (impedance of high voltage network can in most cases be neglected) [5].

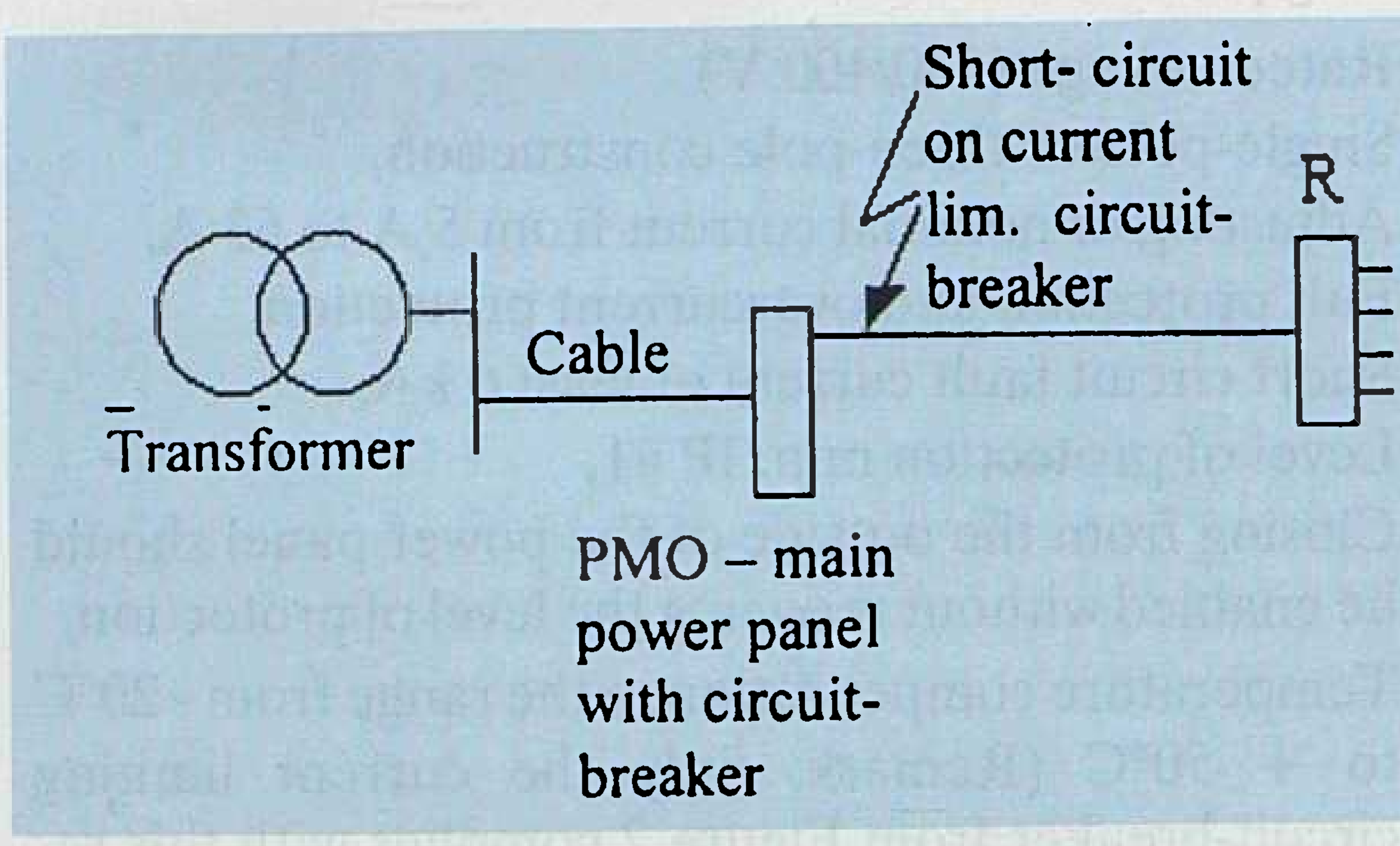


Figure 4. Typical low voltage network

Figure 4 shows a typical low voltage network. Three-pole short circuit fault occurs immediately after the current limiting circuit-breaker. Below is a procedure of calculating the fault current for this case.

The overall resistance between the transformer and the point of failure is:

$$R = R_{\mathrm{trf}} + R_{\mathrm{k}}, \tag{1}$$

and the overall reactance between the transformer and the point of failure amounts to:

$$X = X_{\mathrm{trf}} + X_{\mathrm{k}}, \tag{2}$$

where:

X_{trf} - transformer's reactance,
X_{k} - cable's reactance
R_{trf} - transformer's resistance,
R_{k} - cable' resistance.

Impedance of a low voltage network therefore amounts to:

$$Z = \sqrt{R^2 + X^2} \tag{3}$$

The magnitude of three-pole symmetrical short-circuit current at the moment of fault's appearance is:

$$I_{\mathrm{k}} = \frac{1{,}1U}{\sqrt{3}Z} \tag{4}$$

where U is phase-to-phase voltage.

If the current limiting circuit-breaker is installed in the distribution panel, the short circuit current will be significantly lower due to relatively high impedance of the cable between the main power panel and the distribution panel.

The short circuit fault current should be known since every circuit-breaker has its maximum short circuit breaking capacity that in most cases amounts to 6,000 A (sometimes also 10,000 A). If the expected short circuit fault currents are above the circuit-breaker's breaking capacity, it is necessary to install adequate fuses in the circuit [4], [5].

2.4. Selectivity of protection

Joule's integral gives the value of squared current in a certain time interval (I^2t) and represents a measure for energy that flows through the fuse or current limiting circuit-breaker (known as clearing). The protection is in the case of short circuit fault selective, if only the part of installation where the fault occurred is turned off. This is important when there is a fuse in the circuit before the current limiting circuit-breaker.

For such combinations it is very important that the *I-t* characteristics of the fuse and the current limiting circuit-breaker have no common points or intersections. The characteristic of the current limiting circuit-breaker should lie below the characteristic of the fuse. Selectivity in the case of a short circuit fault will be achieved, if I_k^2t clearing of the current limiting circuit-breaker is lower that the fuse's clearing.

The manufactures of current limiting circuit-breakers usually give maximum permitted magnitudes of expected short circuit currents. The selectivity between fuses (NV, D0, D) and the current limiting circuit-breaker is ensured, if the fault current is below the maximum permitted value.

Example: Before a 25 A current limiting circuit-breaker there is a 35 A D-type fuse. The maximum expected short circuit currents is 1,120 A. When fault currents do not exceed this value, the fuse has higher I^2t clearing than the current limiting circuit-breaker. This means that in all short circuit faults with fault currents below 1,120 A only the current limiting circuit-breaker will be activated, while in the cases with fault current exceeding, 1,120 A, both the circuit-breaker and the fuse will interrupt the circuit [4], [5].

2.5. Comparison of fuse's and circuit-breaker's interruption of circuit at overloading

It is interesting to compare the present situation, where main fuses are in most cases used for current limiting, and the future one, when this role will be performed by current limiting circuit-breakers. Let us take for the comparison the fuse type D0-25 A and the four-pole circuit-breaker - 25 A. We assume that there is an overloading in the amount of 1.6 x I_n. Melting current (current that should in 1 hour activate the fuse) for the 25 A fuse is exactly 1.6-times higher than rated current (IEC 60269-1). This means that the fuse can conduct 1.6 x I_n, i.e. 25 A x 1.6 = 40 A of current in one hour.

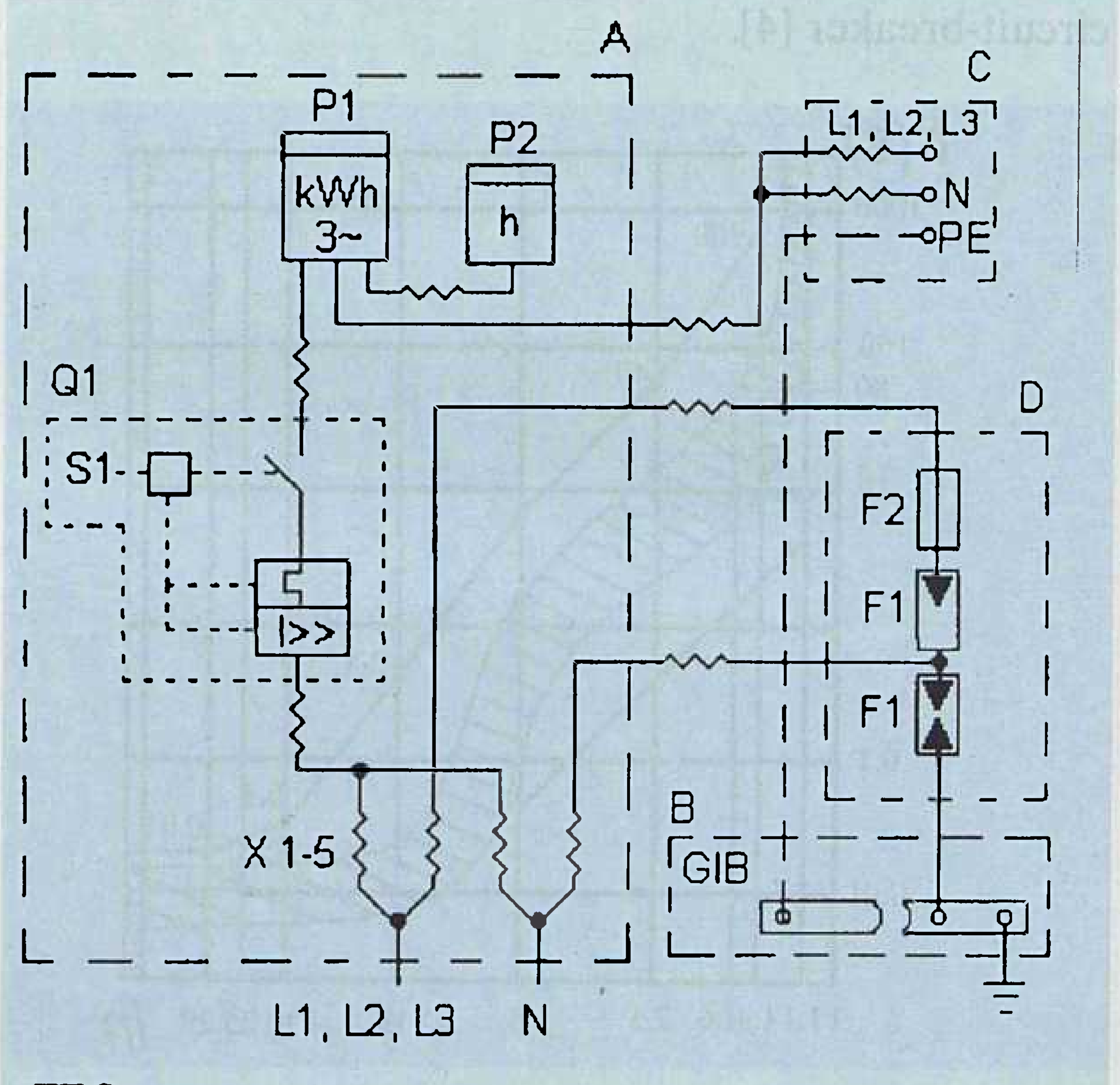
From Figure 3. which shows *I-t* characteristic of the current limiting circuit-breaker, it is evident that 40 A current (1,6xI_n) will be interrupted in about 80 s, that is much earlier than by the fuse.

The latter is quite unfavourable for a consumer, since the current limiting circuit-breaker at any time allows the consumption to be only equal to or lower than the consumer's "billing power" (maximum consumption allowed by current limiting device, used as a basis for calculating the fixed part of the consumer's electricity bill). On the other hand current circuit-breakers enable, the consumer to adapt the consumption to the circuit-breaker's capacity and then turn it on again.

3. PROPOSALS FOR INSTALLATION OF CURRENT LIMITING CIRCUIT-BREAKERS

3.1. Proposal of electricity distribution companies

At the symposium on electric power engineering and modern wiring systems in Radenci in 1999 [7] a proposal of all five Slovenian electrictiy distribution companies about the typification of low voltage power panels with current limiting circuit-breakers instead of fuses was given. The panels are intended to be used by a wide range of consumers in the sectors of households and small trade (max. 63 A), i. e. the consumers that according to the new tariff scheme have to be equipped with current limiting devices. Figure 5 shows the scheme and constituent parts of a power panel for a TT distribution system [7]:



TT System

A	connection compartment for metering and protection
B	potential levelling compartment
C	main distribution panel
D	surge arrester compartment
X1-5	wire connecting clamps
Q1	current limiting circuit-breaker
S1	push-button for closing the circuit-breaker
F1	surge arresters
F2	rated current of the fuse should be chosen in line with manufacturer's instructions
P1	electric meter
P2	tariff switching clock
GIB	main busbar for potential levelling

Figure 5. Scheme of the power panel

Current limiting circuit-breakers should have the following parameters:

- Rated voltage (230/400 V),
- Single-pole or three-pole construction,
- Adjusting of nominal current from 5 A to 63 A,
- Fult protection and overcurrent protection,
- Short circuit fault current at least 6 kA,
- Level of protection min. IP 41,
- Closing from the outside of the power panel should be enabled without reducing the level of protection,
- Temperature compensation in the range from - 20°C to + 50°C (Remark: only the current limiting circuit-breaker from Figure 2 complies with this requirement).

3.2. Proposal of experts

Two Slovenian companies have presented their joint proposal for the installation of current limiting circuit-breakers. The installation of these devices in accordance with this proposal would be substantially cheaper for the users that the installation in line with the distributors' proposal:

- Current limiting circuit-breaker should be installed on or in the immediate vicinity of the consumer's distribution panel,
- Current limiting circuit-breaker should be installed outside of the power panel that contains main fuses and electric meter [8].

The scheme for this proposal is shown in Figure 6.

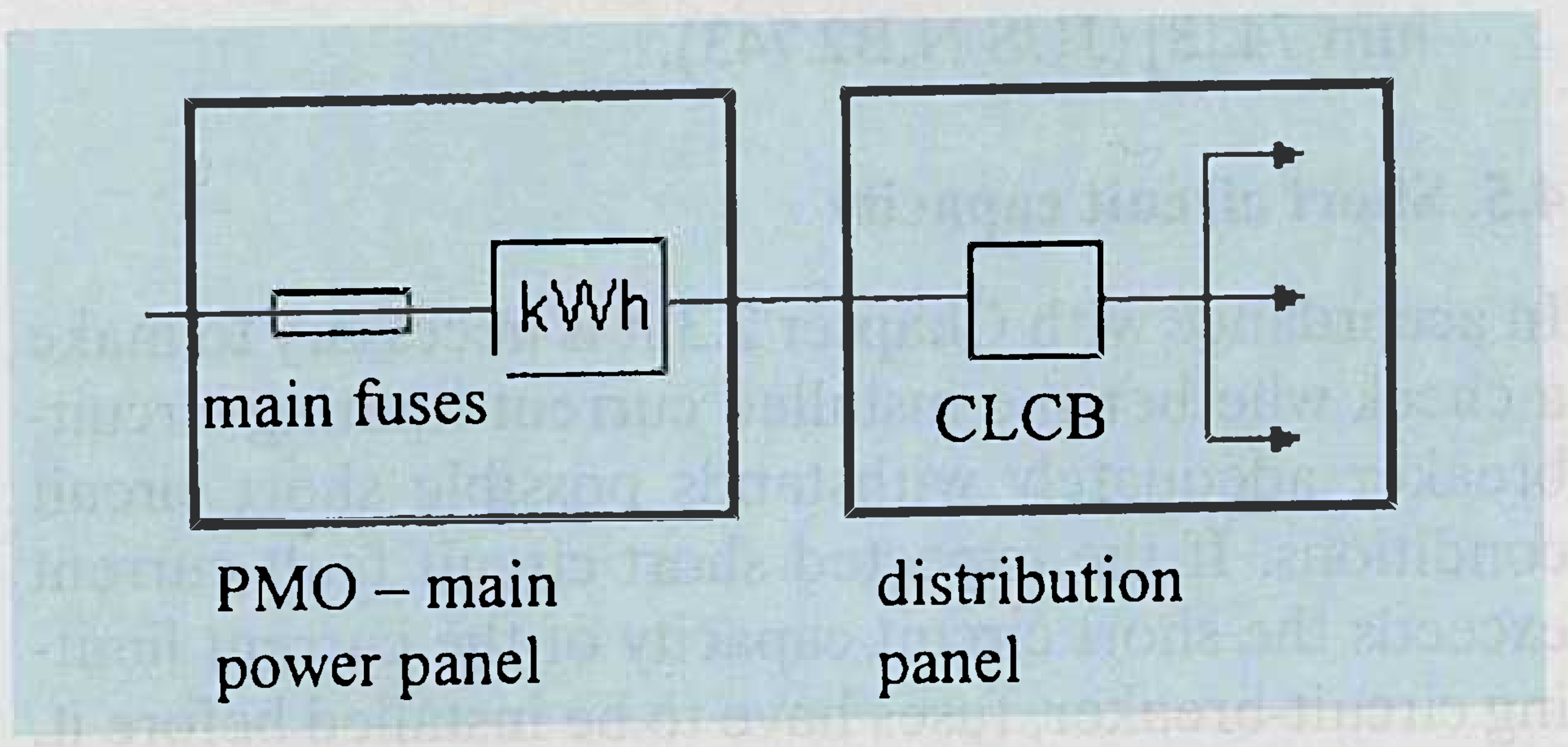


Figure 6. Connection scheme of current limiting circuit-breaker (CLCB) according to the proposal of experts

3.3. Current limiting circuit-breakers in other countries

Current limiting circuit-breakers are massively used in France. They are also being introduced in Croatian distribution systems. Both Croatian and French electricity suppliers require from the current limiting circuit-breakers used in their systems slightly faster response in the case of overloading that it is the case with standard low voltage circuit-breakers. This is shown in Table 2 and Figure 3 [2], [3]. The *I-t* characteristic of current limiting circuit-breakers used in Croatia has to be, according to the requirements of Croatian elekctricity company HEP, compliant with the norm N.220.01 klas. br. 4, 12/93 [3]. The values from Figure 3 are also treated by the French standard NFC 62.411. Current limiting circuit-breakers are in Croatia in most cases connected in the way proposed by the Slovenian experts (Figure 6).

4. TECHNICAL REGULATIONS AND STANDARDS

4.1. General

The main power panel that should contain the current limiting circuit-breaker (according to the distributors' proposal) is the connecting point between the distribution network and the house's wiring. Therefore the designer of elekctric wiring has to make all necessary calculations about the adequacy of the device that protects the conductor. He or she should also take into account all regulations and standards covering the field of electric wiring. They are generally more stringent than those covering electric networks. In the case when there are no fuses in the main power panel this protective device is current limiting circuit-breaker. In the next chapters, some of the most important checks the designer should do to prove the needlessness of the installation of fuses before the current limiting circuit-breaker in the main power panel are described. In the field of electric wiring in Slovenia still the Yugoslav (JUS) standards are in force. No major changes are expected after Slovenia adopt the European standards since the JUS standards have been prepared on the basis of the IEC standards [4].

4.2. Overcurrent protection (JUS N.B2.752)

Sizing and selection of conductors, as well as all overcurrent protection measures have to be done in line with the TP - 2/89 regulations and the JUS N.B2.752 standard (continuous current ratings). The conductors have to be adequately sized to continuously withstand rated currents. Here it is necessary to consider the JUS N.B2.752 standard. According to the JUS N.B2.743 standard it is necessary to perform a test of the overcurrent protection.

The working characteristic of the device protecting the conductors against overcurrent has to fulfil two conditions:

$$I_b < I_n < I_z \quad (5)$$

$$I_2 < 1.45 * I_z \text{ oz.} I_n < 1.45 * I_z / k, \quad (6)$$

where:

I_n (A) rated current of the protective device,
I_z (A) withstand current of cable, defined by JUS N.B2.752 - continuous currents,
I_b (A) design current of the circuit,
I_2 (A) current interrupted by the protective device after a certain period - conditional melting current.

The *k* factor for standard low voltage circuit-breakers amounts to 1,45; the same value can be assumed for current limiting circuit-breakers.

4.3. Protection against electric shock (JUS N.B2.741)

If a TN system is to be protected against indirect touch with automatic interruption of supply by overcurrent elements (in our case current limiting circuit-breaker), it is necessary to check whether the chosen device interrupts the circuit in the required time.

The principal condition of protection with automatic Supply interruption in TN systems is: the protective device characteristic (in our case current limiting circuit-breaker) and impedance of the circuit have to be properly chosen to enable, within a certain time interval, an automatic Supply interruption in the case of any contacts between phase conductors and ground conductors, as well as in the case of any contacts between phase conductors and non-insulated conductive parts anywhere in the wiring system. With other words: impedance of the fault circuit has to be low enough to enable the sufficient current for activating the current limiting circuit-breaker within the prescribed time interval. This requirements is fulfilled with the following condition:

$$Z_S \times I_a \leq U_0, \quad (7)$$

where:

Z_S - impedance of the fault circuit that encompasses the voltage source (low voltage transformer winding), the phase conductor up to the point of failure and the ground conductor between the point of failure and the voltage source,

I_a - current that enables activation of the protective device for automatic interruption within the prescribed time interval after the fault's occurrence (e. g. for socket circuits current it should be interrupted in 0.4 seconds, while for supplying circuits it should be interrupted in 5 seconds) if phase-to-neutral voltage is 220 V and phase-to-phase voltage 380 V,

U_0 - rated phase-to-neutral voltage (e.g. 220 or 230 V).

For our case it is necessary to calculate the impedance of fault circuit Z_s, e. g. up to the metal internal distributor, which includes impedance of secondary transformer winding, impedance of the fault circuit between transfomer substation and main power panel (where the current limiting circuit-breaker is installed) and impedance of the fault circuit between main power panel and point of failure (see Figure 6). The calculated value of Z_s has to be lower than the maximum permitted fault circuit impedance Z_{dop}, which means that the magnitude of electric current in the case of an indirect contact (phase conductor and metal housing of the distributor panel) has to be sufficiently high to trigger the activation of the current limiting circuit-breaker in less than 5 seconds (because the fault is in the supply circuit).

4.4. Protection of conductors against short circuit fault current - thermal sizing (JUS N.B2.743)

It is necessary to check whether the selected conductor is sufficiently sized to withstand the short circuit current that can appear in the case of a fault. For this purpose the short circuit impedance Z_k has to be calculated. Three-pole short circuit is considered in the calculations as the worst case possible. After the short circuit impedance is calculated, the short circuit current can be calculated using the equation (4). The short circuit impedance is the impedance between transformer substation and internal distribution panel.

The operating time in which the current limiting circuit-breaker will interrupt the circuit can be determined from the I-t characteristic of the circuit-breaker after short circuit current has been calculated. On the basis of the calculated short circuit current the minimum cross-section of conductor S_{min} can be calculated. This is done with the assumption that in the time from failure's occurrence to the activation of the circuit-breaker t_{odk} the conductor temperature does not rise above the maximum permitted temperature (70 °C for PVC insulation). Actual cross-section of the conductor has to be higher or equal to S_{min}.

$$S_{min} = \frac{1}{k} \cdot I_k \cdot \sqrt{t_{odk}} \quad (8)$$

where:

k.... coefficient of conductor material (PVC insulation); for copper it amounts to 115 and for aluminium 74 [8] (JUS N.B2.743).

4.5. Short circuit capacity

In accordance with Chapter 2.3 it is necessary to make a check whether the installed current limiting circuit-breaker adequately withstands possible short circuit conditions. If the expected short circuit fault current exceeds the short circuit capacity of the current limiting circuit-breaker, fuses have to be installed before it. In such a case it is necessary to check the selectivity as described in Chapter 2.4.

5. REMOTE CONTROL OF CURRENT LIMITING CIRCUIT-BREAKERS

5.1. Remote control systems

Various communication systems that are used for monitoring and control of electric power systems have been recently integrated in unified systems for monitoring and control through LON Works Technology (LON-Local Operating Networks) [9]. This gives a possibility of connecting the existing DA/DSM (Distribution Automation/Demand Side Management) hardware and software with the modern software, intended for contol, selection, processing and transfer of data on all levels in quasi-real time (AMR - Automatic Meter Reading) [10].

5.2. Communication structures, data transfer

The structure of AMR systems is divided in the following areas:

- Place of measurement that enables local sorting, as well as pre-processing and storing of collected data. It is at the same time the point of connection with existing or foreseen house automation system (house computer);
- Transfer of data, directly or indirectly, towards the remote control centre (distribution process centre). The selection of communication paths is based on quantity and frequency of data transfer. The later is

especially problematic on the household level, where there are many consumers with relatively low energy consumption. Advantages and disadvantages of the applied solutions are shown in Table 4 and 5 [11].

Table 4. Data transfer speed for various data transfer technologies

Technology	data rate (bps)
PSTN - V22.bis	2.4k/9.6k*
PSTN - ISDN	64k (128k**/256k*)
GSM II.	9.6k
CaTv modem	10 M⇒
CaTv modem (Iskraemeco)	⇒115k
DLC	⇒10k
DLT	500k⇒ (?)
LEO (satellitecommunication)	⇒2.4k (?)
RF_{lp}	⇒2.4k

* compression, ** joint B channel

The predominant communication method on the level of households in Europe and America is low power radio-frequency communication. Other less frequent ways of communication are telephone lines, electric power networks and coaxial cables. The communication via low voltage networks (DLC) has been for some years used in Sweden, as well as in Slovenia [11], [12]. The selection of communication path is any case a difficult task, but factors, such as ownership of communications, level of difficulty in maintenance, need for a permanent connection, geographical coverage, etc., call for the use of narrowband or broadband communications, such as:

a.) DLC (communication via low voltage network)

DLC communications represent a method of two-way data transfer via the existing low voltage network. They are very suitable for the implementation of specific DA/DSM functions, such as remote reading and remote control. The facts, such as ownership of the communication medium, relatively low price, and presence of the communication medium in every building, very positively affect the attractiveness of the use of electric networks as a primary communication medium. Due to the specificities of the data transfer via electric networks, i.e. relatively short transfer distance and impos-

Table 5. Advantages and disadvantages of various data transfer technologies

	PSTN
+	good geographical coverage (globality)
+	robust, tested in many applications
+	use of existing wire pairs
+	size of installed database
+	wide choice of appliances
+	simple installation and use
+	relatively high price efficacy
-	relatively slow speed of transfer
-	use on demand
	ISDN
+	robust, tested in many applications
+	use of existing wire pairs
+	widespread use
+	high speed
-	expensive for households
-	use on demand
	Ca Tv modem
+	excellent technical characteristics
+	permanent connection possible
-	limited geographical coverage
-	presently only in limited quantities
-	modifications of CaTv network necessary
-	quantity dependent performances
	GSM II (IMT - 2000)
+	good heographical coverage (globality)
+	high speed
+	size of installed database
-	limited choice of appliances
-	relatively small speed (for GSM III)
-	geographical dependent BER
-	use on demand
	DLC
+	good geographical coverage
+	permanent connection possible
-	relatively small speed
-	small installed database
-	limited distance of transfer
-	possible problems in divided electrical network

sibility to transfer the data through transformers, the data are collected in data concentrators, from where they are conveyed via some other communication medium to control centres.

There are still some unsolved problems in data transfer via electric networks. This is mostly due to the fact that the networks are predominantly intended for the transmission of energy in the 50(60) Hz frequency band, and not for transfer of data in the frequency band from 3(9) kHz to 99 kHz. Beside the frequency band, the CENELEC standard EN-50065 (1 - 4) specifies the maximum signal levels, wich for the narrowband modulation lie in the range from 34 dB/μV (95 kHz). For the broadband modulation the maximum signal level amounts to 134 dB/mV throughout the entire frequency band (in the so called A band, designed for the use of electricity distribution companies) [13].

The principal problems in data transfer are:

- high signal rejection ratio (40 - 100 dB/km),
- network impedance is indeterminably changing over time (depends on connected consumers),
- numerous interferences that cause white noise, impulsive noise and broadband noise (their sources are appliances connected to the network),
- network topology (multipath effect),
- type and location of power cables (underground, overhead).

DLC communications are theoretically sufficient for offering the required telecommunication services. Unfortunately experience shows that it is possible to achieve only transfer speeds of up to 10 kb/s, and the achieved transfer distances highly depend on cable types, network topology and the connecting function of the network. The technology is therefore satisfactory and enables implementation of AMR systems, although there is a high dependence on the communication technology applied.

The results of testing installations of the manufacturer Iskraemeco d.d.:

Results of the data transfer are satisfactory. Relative successfulness of data reading with regard to the current time interval is about 95%, and observed in the whole day even 100%. The average transfer speed is 1,200 bps, and with periodical deviations to 400 bps it reaches up to 3,200 bps. [10].

b.) CaTv (communication via cable television network)

CaTv systems are, due to the application of coaxial cables in older and optical conductors in newer systems, very capable and their maximum capacity is still to be fully exploited. In order to use a cable TV network, as a two-way communication channel, it is necessary to adapt it with installation of two-way amplifiers that can amplify the signals going in both directions. The standardisation in this field has not yet been completed (DOCSIS in America, DAVIC in Europe), although the frequency band for these communications has already been defined. For the communications from the cable operator's centre to customers the frequency band from about 82 MHz to 862 MHz is used (download band), while for the communications in the opposite direction the band from 5 to 65 MHz is used (upload band). The capacity of communication channel is very high and with the modern modulation shemes reaches more than 30 Mb/s in the 6 MHz wide download band, and up to 10 Mb/s in the upload band.

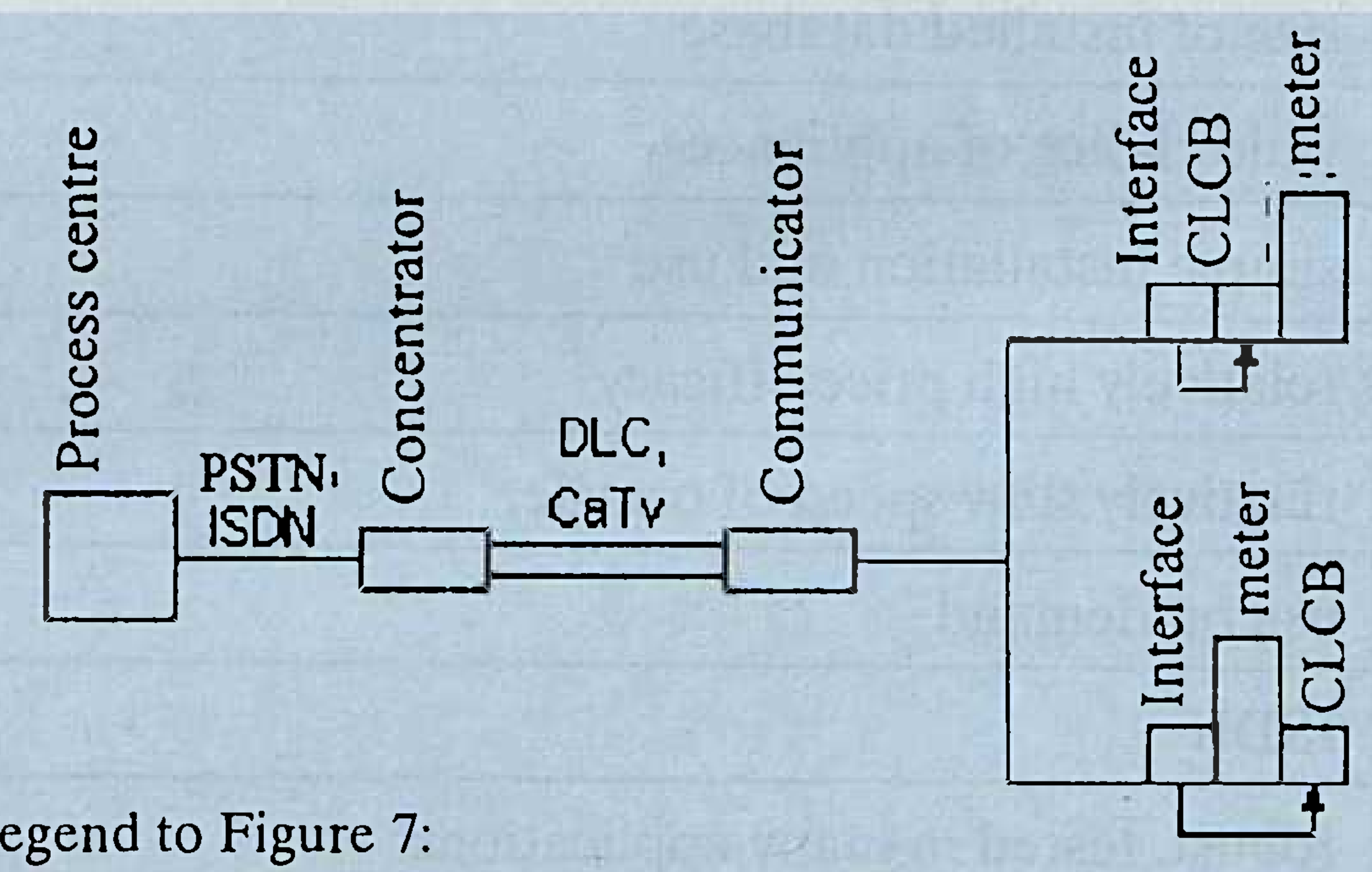
The results of testing installations of the manufacturer Iskraemeco d.d.:

Results of the testing installations show that broadband CaTv networks are very suitable for AMR systems. The communication itself is very reliable and robust [10].

The described testing installations show that it is possible to obtain a relatively reliable system of remote data selection, data transfer and other services by means of communication technologies that are especially interesting for electricity distribution companies. The above described two-way communication with individual electricity consumers and the possibility of remote switching of consumer's appliances with current limiting circuit-breaker can above all bring substantial savings of money.

5.3. Control of current limiting circuit-breakers

Figure 7 shows a scheme of remote switching of consumer's appliances with current limiting circuit-breaker. The program package in the form of executable computer program for performing this task is built of modules, where each module takes over the func-



Legend to Figure 7:

- process centre: computer with required hardware and software,
- PSTN, ISDN: communication channel (telephone network),
- concentrator: device this selects, processes and transfers high quantity of data, and controls the network,
- DLC, CaTv: communication via low voltage networks or coaxial cables,
- communicator: acquisition and transfer of data on the level of household consumers,
- interface: transformation of signal (if necessary),
- circuit-breaker: automatic device for limitation of consumer's current,
- meter: device for metering of electricity consumed.

Figure 7. Algorithm of signal conveyance from distribution control centre to current limiting circuit-breaker

tions of the entire package. The modules ensure working with various devices and enable integration in a unified system. This system has in fact already been built, it only has to be adapted to the requirements of each specific process.

The question how to design current limiting circuit-breakers with regard to remote switching on and off remains open. The development of this device will undoubtedly depend upon interests and needs of the market.

6. CONCLUSIONS

The paper gives the actual situation in the use of current limiting circuit-breakers in Slovenia. A wider use of these devices will first of all depend on an agreement and common interests among electrictiy distributors, manufacutrers and users. It will also be necessary to accelerate development of remote control and automation systems. With regard to the fact that the system of remote meter reading is already being introduced, it would be logical also to introduce a system of remote control of current limiting circuit-breakers.

As described in Chapter 4, if the proposal of electricity distribution companies is adopted, the designer of each wiring system will have to decide whether to install a fuse bifore the current limiting circuit-breaker or not. If the proposal of expert is adopted, there will be fewer problems with breaking capacity of current limiting circuit-breaker. A smaller cross-section of the cable between the power panel and the internal distribution panel in this case essentially reduces the magnitude of short circuit current. Our opinion is that the electricity distribution companies should also agree with the latter proposal. Namely, these companies can in their Technical Conditions for Obtaining the Permission for Connection to the Distribution Network require from the applicants to install a current limiting circuit-breaker in the main power panel.

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- JUS N.A9.001: klasifikacija električnih naprav gled na zaščito pred električnim udarom
- JUS N.B2.730: splošne karakteristike in razvrstitev,
- JUS N.B2.741: zaščita pred električnim udarom,
- JUS N.B2.743: zaščita pred prevelikimi toki,
- JUS N.B2.751: izbira in postavitev električne opreme v odvisnosti od zunanjih vplivov,
- JUS N.B2.757: trajno dovoljeni toki,
- JUS N.K5.503: nizkonapetostni stikalni bloki,
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OGRANIČIVAČI STRUJE POTROŠNJE

U Sloveniji je bio prihvaćen nov tarifni sustav za prodaju električne energije. Dio tog sustava je i pravilnik, koji u niskonaponske električne instalacije uvodi i tarifni prekidač ograničivač struje potrošnje, koji ima zadatak ograničenja vršne snage i osiguranje potrošača prema preopterećenju i kratkim spojevima. Razvojem komunikacijskih sustava ostvarena je i mogućnost daljinskog upravljanja.

DIE STROMVERBRAUCHSBEGRENZER

In Slowenien wurde ein neuer Verkaufspreissatz für Strom angenommen. Dieser Satz ist mit einer neuen Verordnung verknüpft. Diese Verordnung führt in elektrische Niederspannungsanlagen den Preissatzschalter, d.h. einen Stromverbrauchsbegrenzer, ein. Der Zweck dieses Schalters ist die Spitzenleistungsbegrenzung und die Verbrauchersicherung im Bezug auf Überlastungen und Kurzschlüsse. Die Entwicklung der Datenübermittlungsverfahren hat die Fernsteuerung dieser Schalter möglich gemacht.

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