DLT / LEDOTRON –
New Digital Standard for the Control of LED Lamps

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Summary

Within the framework of the European ban on incandescent lamps [1], in future millions of installed dimmers in existing buildings will be operated with replacement lamps whose trouble-free operation in combination with the dimmers is not guaranteed. Bad dimming quality (flickering, humming) and no reliable respect of the prescribed EMC-standards are some of the results causing problems for final customers and electricians.

The alternative is the new digital dimming process "LEDOTRON", which has been developed in cooperation between Insta and OSRAM. With LEDOTRON this described problems are solved, first control units and lamps can already be obtained in specialized trade and – which is the essential point - in future it will even bring an additional benefit in application by the options of controlling colour, colour temperature and lamp groups.

Why do we need a new process?

In Europe, since the 1970s dimmers have been installed in residential and commercial buildings. Today, their total stock is estimated at more than 100 million pieces and per year this number rises by about 5 million pieces [2]. In residential buildings they are normally installed in flush-mounted boxes and control incandescent lamps, halogen lamps but also electronic or inductive coiled transformers for low-voltage lighting. For the final customer as well as for the electrician it has always been a satisfying situation, for the devices offered a high dimming quality, could be installed easily and met all standards reliably.

With introduction of the European Eco Design Guideline [1] in 2005 and 2009 however, the situation has changed completely. The less efficient incandescent lamps were gradually banned from the market and were replaced by the more efficient compact fluorescent lamps (CFLi) and LED lamps. There is nothing wrong with it at the first glance. But if now an incandescent lamp at the dimmer fails, the final customer buys a replacement and screws a new lamp type into his luminaire which functionally does not reliably fit with the dimmer! (which makes me think of the green fuel ordinance for vehicles …). The final customer and the electrician partly may face the following problems:

- Flickering during setting and in operation
- No lamp start in lowest dimming position
- Unsteady dimming course
- High minimum brightness
- Small dimming range
- Noise development
- No reliable compliance to EMC requirements on limits for harmonic current emissions [3]
- No reliable compliance to EMC requirements on radio disturbances [4]

What can we do about it? Insta and OSRAM found out that a pragmatic resort out of this dilemma is not to optimize existing analogue dimming technologies acc. to the leading and trailing edge principle, because the dimming processes and above all the ballasts in the new lamps are not subject to any standard and develop rapidly and in many ways. Against this background a free combination of dimmers and lamps on the market which would guarantee system operation conforming to standards and functions is hardly achievable any longer.

Therefore Insta and OSRAM in cooperation developed the new digital dimming and control process „LEDOTRON" with the aim of achieving an international standardization and of granting interested companies licence-free access to this problem-solving technology.

The technical solution

Core-characteristics of LEDOTRON

In development of LEDOTRON the following system characteristics were defined and realized:

- For control unit and lamp the existing wiring structure of 2-wire-dimmers in flush-mounted boxes is sufficient, which makes renovation of existing buildings easy.
- Setting up of simplest installation processes to enable the final customer also in future to exchange lamps on his own. Thus addressing after installation of the devices is to be avoided.
- Compliance with highest quality standards in operation and dimming to achieve customer satisfaction.
- Undisturbed co-existence of several LEDOTRON circuits at one phase.
- Undisturbed co-existence with other digital services (Powerline etc.).
- Full compliance with all relevant standards.
- Safe conditions at any time, also if unsuitable dimmer-lamp combinations have been used by mistake.
- Additional benefit: option of controlling colour, colour temperature and grouping of suitable LED lamps and luminaires!

The LEDOTRON data transmission

In hitherto common dimming processes, the dimmer controls the electrical power given to the lamp by cutting the mains sinus either in leading- or trailing-edge of each half-wave. Thus in dimmed state the lamp and the integrated ballast in the lamp base receive only a fraction of the mains voltage.

LEDOTRON control units operate according to a completely different method: in operation, they let the mains sinus pass nearly fully to the lamp – independent of the desired brightness value of the lamp. (Only a small constant leading-edge cut provides that the control unit is able to power itself). The control unit contains an encoder which modulates information of the desired brightness and/or colour information as digital telegram on the mains sinus. A decoder in the ballast of the lamp evaluates the telegram on the mains sinus and transmits the information to the power electronics of the lamp which then operates the lamp with the desired values. This correlation is shown in fig. 1.

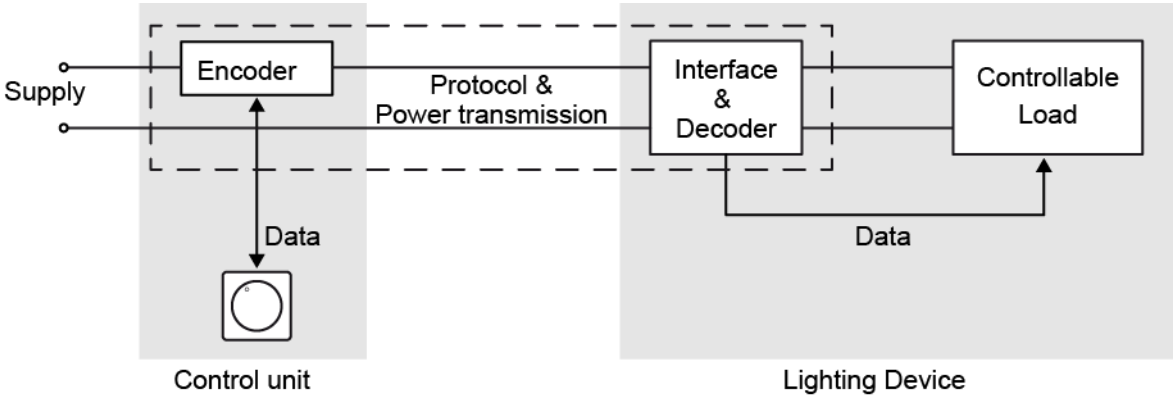

Fig. 1: Block diagram on data transmission of LEDOTRON control unit and lamp

Signal profile between control unit and lamp

Since the control unit is designed in 2-wire-technique it has no neutral terminal and therefore must supply itself by a low current via the lamp load. To this effect it generates a low constant leading-

edge cut. The digital telegram is coupled to the falling slope of the mains sinus and stretches over several half-waves. The resulting signal run between control unit and lamp is shown in fig. 2.

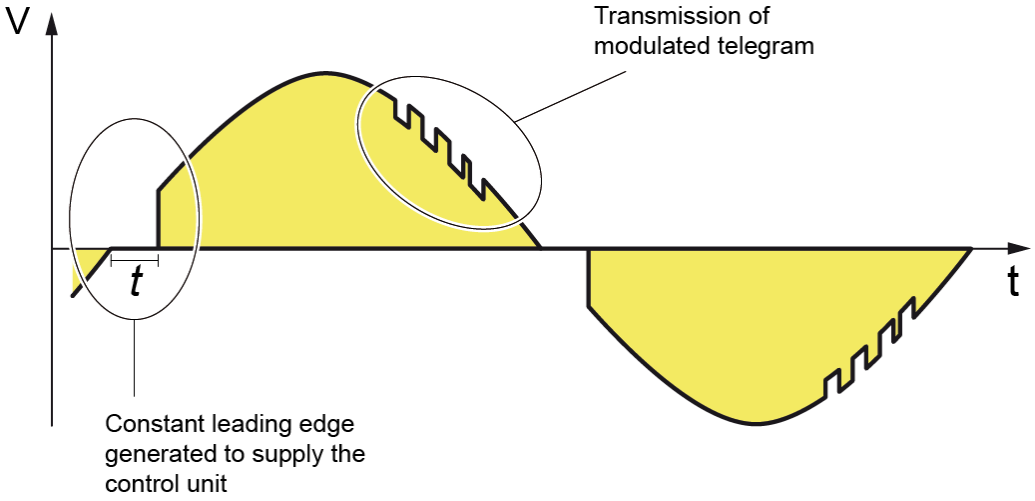

Fig. 2: Signal profile between control unit and lamp

Switchings and signal profiles compared

Comparing switchings and signal profiles it becomes clear that simply both control unit and lamp have to be exchanged to retrofit existing systems to the new process, see fig. 3.

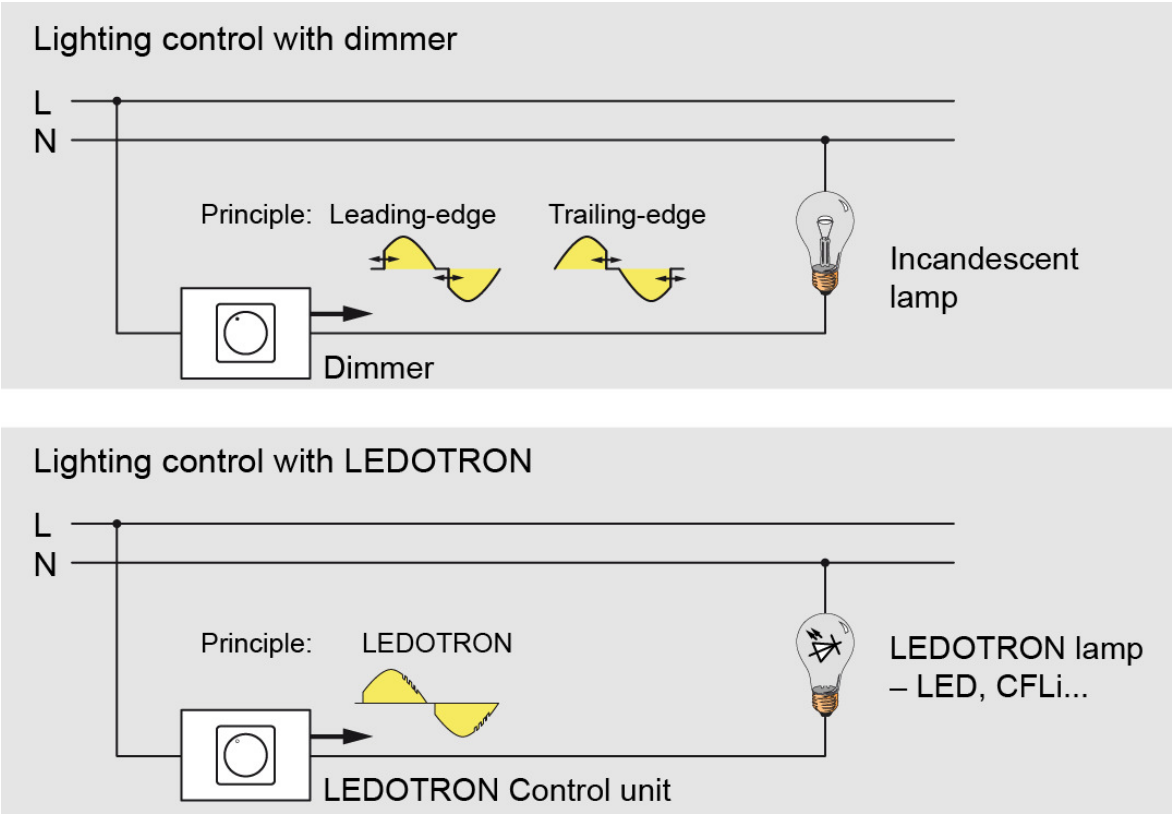

Fig. 3: Switchings compared

If, by mistake, a non-LEDOTRON-lamp is installed in a LEDOTRON-controlled luminaire, you will be able to switch it on and off without a problem, for the control unit passes on nearly full mains voltage. Dimming, however, is not possible, for the lamp cannot evaluate the telegrams.

Additional benefit through colour control

In LEDOTRON technology different operation modes are defined which enable control unit and lamp to interpret the transmitted value in different ways. Here, primarily, we talk about the possibility to be able to interprete the transmitted values as brightness value, as colour temperature value or as colour value for red, green or blue content on lamp side. To this effect the telegram contains 3 additional bit, defining an operation mode for control unit and lamp. With 3 bit up to 8 operation modes can be defined, but by cascading of the telegram structure the theoretical number of possible operation modes can be extended. Currently the following operation modes are defined for LEDOTRON:

Table 1: LEDOTRON operation modes

Nr.:	Mode	Suitable LEDOTRON lamp types
0	Brightness control	1-channel LED (monochrome)
1	Colour control	3-4-channel LED (e.g. RGB, RGBW)
2	Colour temperature control	2-4-channel LED (e.g. RGB)
3	Reserved	To be defined
4	Reserved	
5	Commissioning, group control	Lamps with grouping function
6	Manufacturer-specific telegrams	
7	Reserved for telegram extensions	

In case control unit and lamp do not have exactly the same operation modes, both components will automatically set to the possible common operation modes.

Examples:

- A control unit with only one rotary button for brightness is combined with an RGB LED lamp. Result: The RGB lamp can be operated in white light and can be dimmed.
- A control unit with RGB option is combined with a monochrome LED-lamp. Result: the lamp with its monochrome light can be dimmed without problems, but of course the colour cannot be changed.

In general, it is manufacturers' task to develop control units whose operation interface to the customer meets the many possibilities that become apparent here and which at the same time are operable conveniently and intuitively. Here, devices with colour sliders or touch displays are conceivable.

Control of lamp groups

For the typical application, in which one control unit controls one or several lamps, it was intentionally avoided to implement an addressing process. „Keep it simple!“ On the other hand it is of course interesting to be able to control several lamps in one control circuit independent of one another. To reach both targets at the same time, in the LEDOTRON telegram 2 bit were implemented as group address for lamp groups. If the group address is not used, for instance because the addresses of control unit and lamp are not assigned, address “0” is used automatically, to which all connected lamps react in the same way. If, however, an address

assignment is supported by control unit and lamp, the lamps connected at one circuit can also be operated in three individually controlled lamp groups. Table 2 shows this correlation.

Table 2: LEDOTRON group addresses

Address	Lamp group
0	Control of all lamps in the circuit (broadcast)
1	Control of lamp group 1
2	Control of lamp group 2
3	Control of lamp group 3

Technical data

Table 3: Technical data

System characteristics	Value
Transmission reach control unit – lamp	100 m
Data transmission speed	200 Bit/s
Transmission time for control commands	e.g. 80 ms for brightness control
Resolution of brightness information	255 steps
Resolution of colour information	x, y 4095 steps each
Number of possible lamp groups per circuit	3 lamp groups and broadcast
Co-existence with other mains services (Powerline etc.)	yes
Co-existence with phase-cut dimming technologies in neighbouring circuits	yes

Naming and identification

The described process bears the technical and manufacturer-neutral description „Digital Load Side Transmission Lighting Control“ or just DLT. Under this title currently all activities for international standardization of the process are summarized. In addition, the currently involved manufacturers had the trademark „LEDOTRON“ registered to have a shorter trademark name which is suitable for the market. In order to be able to make out the relation between control unit and lamp rapidly at the point of sale, additionally the following figurative mark was defined and registered:

Fig 4: Figurative mark LEDOTRON

If the customer recognizes the figurative mark on the control unit and on the lamp, he can be sure to hold a suitable pair of devices in his hands.

Note: DLT should not be mixed up with „Powerline“-transmission. It is true that both processes modulate telegrams to mains voltage, but the Powerline-transmission is related to the neutral conductor and extends to all circuits in the building. LEDOTRON does not. Therefore the processes are not comparable.

International standardization

The process to standardize DLT internationally is under way and corresponding activities are up and running in the relevant standardization committees.

Table 4: Standardization activities

Subject of standardization	Standardization committee
Transmission principle	IEC TC34 SC34C
Dimmer standards	IEC TC34 SC23B
Lamp standards	IEC TC34 SC34A

During these activities a CDV "Committee Draft for Voting" on the transmission principle with the standard description „IEC 62756-1" has been filed with the IEC [5]. A successful standardization of DLT can be expected for next year.

Positioning of LEDOTRON

It is true that LEDOTRON also operates a digital data transmission between transmitter and receiver, but it is apparent that LEDOTRON cannot be seen as replacement or competition for bus systems like DALI, KNX, instafunk etc.! LEDOTRON was specifically defined to allow standard-conform, high-quality and easily-installed dimming and controlling of CFLis and LEDs. So it is an adequate replacement for today’s leading and trailing edge dimmers. Nevertheless LEDOTRON can be integrated in higher-level radio or wired building system engineering e.g. KNX via intelligent couplings of the control units. Also remote controls, scene controls or central functions can be realized rapidly this way.

For the manifold simple installation situations, LEDOTRON has intentionally been designed without an addressing process between the devices, to allow the consumer to exchange lamps in his luminaires at his own discretion. Nevertheless, the option to control the lamps in groups for more complex applications is maintained.

Focus of application of LEDOTRON is on private buildings and small trade, on shop lighting and practices. Here, dimmers are normally installed flush and control retrofit lamps with lampholder types E27, E14, GU10 etc. Technical alternatives to LEDOTRON, which would also bring the advantage of standardization, cannot be found there.

Commercial buildings like administrations or shopping centres are normally equipped with building system engineering and systemically controlled luminaires e.g. with DALI interface, thus there is less demand for installing LEDOTRON.

LEDOTRON, however, is not limited to the control of retrofit lamps! So currently DLT is brought in as approach in the European promotion project "EnLight" focusing on research of energy-saving lighting systems beyond retrofit solutions. Target is to fit DLT optimally into future higher-level control systems.

Benefit of LEDOTRON

Using LEDOTRON brings different benefits for the target groups, the most important being listed in table 5:

Table 5: Benefit for the target groups

Target group	Benefit
Final customer	Convenience by high dimming and control quality
	Safety in the choice of lamps
	Reliable in future due to standardization
	Option of colour control
Electrician	Safety in compatibility of devices
	Safety in complying with standards
	Rapid and easy installation
	Colour control on offer
Energy supplier	Little system perturbation
Manufacturer	Low-risk development of long-life products, since tested against the standard

Participating companies

In the LEDOTRON pool, the following companies are currently working actively together:

Fig. 5: LEDOTRON partners (state: 2013)

Survey of products available on the market

Currently, the participating companies supply the following products to the specialized trade:

- LEDOTRON flush-mounted rotary control device (monochrome)
- LEDOTRON LED Classic 2500 K 12 W E27
- LEDOTRON LED PAR16 3000 K 9.5 W GU10
- LEDOTRON CFLi Stick 2700 K 18 W E27
- LEDOTRON CFLi Globe 2500 K 14 W E27
- LEDOTRON CFLi Classic 2500 K 11 W E27

Fig. 6: LEDOTRON products

Outlook

What can we expect with regard to LEDOTRON in the years to come?

- The manufacturers involved today will further expand their product portfolio
- Further interested manufacturers will be participating actively
- Control devices and lamps will be realized which also support colour temperature control and group control
- Manufacturers of semi-conductors will offer chips facilitating and supporting a realization of LEDOTRON products
- The international standardization of LEDOTRON will be finished as scheduled in 2014

LEDOTRON / DLT is seen by the participating companies as open standard. Interested companies are invited to get involved and to cooperate.

References:

[1] The European ban on incandescent lamps is defined in the eco design guideline EuP 2005/32/EG, replaced by ErP 2009/125/EG

[2] Frost & Sullivan: The European Market for Lighting Dimmers, Study of June 2011

[3] EN 61000-3-2: Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

[4] EN 55015: Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

[5] IEC 34C/1027/CD:2012: Project IEC 62756-1 Ed. 1.0: Digital load side transmission lighting control - Part 1: Basic requirements