TRAFFIC LIGHT REGULATOR

TECHNICAL AND FUNCTIONAL SPECIFICATIONS

Barcelona, May 2008

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

TABLE OF CONTENTS

1 INTRODUCTION.. 11

1.1 BACKGROUND.. 11

1.2 KEY FEATURES.. 11

1.3 OTHER CONSIDERATIONS.. 12

1.4 APPROVAL OF THE .... EQUIPMENT 12

2 SCOPE AND JUSTIFICATION OF THE SPECIFICATION.............................. 13

3 APPLICABLE REGULATIONS 16

3.1 SPECIFIC SPANISH REGULATIONS ON TRAFFIC SIGNALLING SYSTEMS... 16

3.2 EUROPEAN REGULATIONS. CE MARKING.. 16

4 MAIN COMPONENTS 18

4.1 WARDROBE... 18

4.2 REGULATOR ARCHITECTURE.. 19

4.3 CENTRAL UNIT.. 19

4.3.1 Watch-Dog... 19

4.3.2 Parameter memory.. 20

4.4 FOOD... 20

4.4.1 General aspects.. 20

4.4.2 Electrical connection 21

4.4.3 UPS (optional) ... 22

4.4.3.1 General aspects ... 22

4.4.3.2 Autonomy ... 23

4.4.3.3 Interface ... 23

4.5 GPS WATCH (OPTIONAL) ... 24

4.6 DCF77 WATCH (OPTIONAL) ... 24

4.7 DIGITAL INPUTS ... 24

4.7.1 Inputs for detectors and pushbuttons ... 24

4.7.2 Auxiliary inputs ... 25

4.8 GROUP CONTROL OUTPUTS ... 26

4.8.1 Output switch to optical drives ... 26

4.8.2 Exit steering circuits ... 26

4.8.3 Output check circuits ... 27

4.9 SYNCHRONISM (CABLE COORDINATION) ... 27

4.9.1 Synchronism Receiver ... 27

4.9.2 Synchronism Emitter ... 27

4.10 GUARD KEY ... 28

4.11 COMMUNICATIONS ... 30

4.12 MODULARITY ... 30

5 TRAFFIC CONTROL FUNCTIONS ... 32

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

5.1 OPERATING AND CONTROL MODES 32

5.2 CAPACITY AND PROGRAMMABLE ELEMENTS 33

5.2.1 Simplified data diagram 33

5.2.2 Types of output 33

5.2.2.1 Traffic light groups 33

5.2.2.2 Direct command groups 34

5.2.3 Color Coding 34

5.2.4 Stages 36

5.2.5 Phases 36

5.2.6 Transitions 37

5.2.7 Structures 39

5.2.8 Plans stored 39

5.2.9 External plan 42

5.2.10 Singular days of the year 42

5.2.11 Weekly 43

5.3 COORDINATION PROCEDURES 43

5.3.1 Relative Coordination or Synchronization 44

5.3.1.1 Synchronization Method 44

5.3.1.2 Synchronism loss and recovery 44

5.3.2 Absolute coordination with respect to a time reference 44

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

5.4 RESYNCHRONIZATION PROCEDURE.. 45

5.4.1 Introduction.. 45

5.4.2 Temporal components.. 45

5.4.3 Situation of change 46

5.4.4 Generic validity of the algorithm... 46

5.4.5 Particular cases.. 47

5.4.6 Algorithm in the Regulator: Abrupt Method... 47

5.5 TIME MANAGEMENT COMPONENTS IN THE REGULATOR.............................. 47

5.6 METHODS OF CONTROL BY THE ORIGIN OF ORDERS.................................. 49

5.7 TRAFFIC ACTION AND EXTERNAL DEMANDS 50

5.7.1 Types of phases defined.. 51

5.7.2 Plans implemented.. 51

5.7.3 Drive inputs.. 52

5.7.4 Priority Phase Sequence 52

5.8 ALARMS 53

5.8.1 Generation... 53

5.8.2 Transmission.. 53

5.8.3 Regulator reaction.. 53

5.9 PROCESSING OF OUTPUTS.. 54

5.9.1 General condition of departures.. 54

5.9.2 Change of status... 55

5.9.3 Dimming.. 55

5.9.4 Calibrating 56

5.9.5 Anomaly Detection.. 56

5.9.5.1 Optical Drive Failure.. 56

5.9.5.2 Incompatible movements.. 57

5.9.5.3 Absent Red.. 58

5.9.5.4 Difference in group outings.. 58

5.9.5.5 Group Differential Current Measurement (Optional) 58

5.10 PROCESSING DIGITAL INPUTS.. 59

5.10.1 Detector inputs... 59

5.10.2 Auxiliary inputs... 59

5.11 .... PROGRAMMING 59

5.12 PUBLIC TRANSPORT PRIORITY... 60

5.13 FIRE BRIGADE RUNNERS 60

5.14 COMPATIBILITY WITH EXISTING EQUIPMENT... 61

6 DEFINED INTERFACES.. 62

6.1 INTERFACE WITH THE TRAFFIC LIGHT... 62

6.2 INTERFACE WITH CONTROL CENTER AND HANDHELD DEVICE................... 62

ANNEX TO REGULATOR-TRAFFIC LIGHT INTERFACE.. 64

ANNEX B GLOSSARY AND ACRONYMS.. 68

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

B. 1 - GLOSSARY 68

B. 2 - ACRONYMS 73

ANNEX C REFERENCE REGULATIONS........ 74

ANNEX D COMMUNICATIONS PROTOCOL........ 80

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

TABLE OF CONTENTS

Table 1: Allocation of auxiliary inputs.. 25

Table 2: Modularity.. 31

Table 3: Active group departures 34

Table 4: Color Codes... 35

Table 5: Stages.. 36

Table 6: Phases.. 37

Table 7: Transitions.. 37

Table 8: Transitions (extended mode) 38

Table 9: Transients (extended mode).. 39

Table 10: Structures 39

Table 11: Plans stored 41

Table 12: External plan.. 42

Table 13: Singular days 43

Table 14: Weekly program 43

Table 15: Intermittency period... 48

Table 16: Types of phases.. 51

Table 17: Status of the departures 55

Table 18: Incompatible movements.. 57

Table 19: Steady-state operating conditions. Data at traffic lights................... 65

Table 20: Connection procedure (lighting). Data at traffic lights....................... 66

Table 21: Disconnection procedure. Data at traffic lights..................................... 67

Table 22: Glossary... 68

Table 23: Acronyms... 73

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

INDEX OF FIGURES

Figure 1: Traffic light regulator without UPS... 14

Figure 2. Traffic light regulator with UPS... 14

Figure 3. Traffic light regulator architecture.. 19

Figure 4. Resettable circuit breaker and differential protection.............................. 21

Figure 5. Protection of circuit breakers and resettable differentials in case of UPS installation.. 22

Figure 6. Normal guard key scheme... 29

Figure 7. Guard key diagram with manual phase control 29

Figure 8. Simplified data diagram.. 33

Figure 9. Example of resynchronization.. 46

Figure 10: Operation by source of the control.. 49

Figure 11. Change of status due to the presence of alarms... 54

Directorate of Mobility Services
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08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

1 Introduction

1.1 Background

In the city of Barcelona there are currently more than a thousand and a half traffic light crossings, with their local regulators. The reliability and communication requirements with the Control Centre, as well as its interoperability, make it necessary to define its basic characteristics and functionalities, as detailed in these Specifications.

Within the framework of the current European standardisation trend and taking into account the needs detected in the city's regulators, Barcelona City Council defines these technical specifications with the aim of incorporating new features and reviewing and standardising existing functionalities.

1.2 Main features

- LED technology. **LED spotlights are established as a standard for new installations, with a much lower consumption than incandescent lamps and a longer useful life. These spotlights will be powered by the regulator at 42V in alternating current.**

- Reduced brightness. **The regulators will have the possibility of dimming the light of the traffic lights they control to avoid glare and reduce energy consumption.**

- Uninterruptible power supply (optional). **The regulator may have a UPS to keep the crossing fully operational during power outages.**

- Time setting via GPS or DCF77 time transmitter (optional) **The controller will support the connection of a GPS or DCF77 receiver to keep the internal clock on time.**

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1.3 Other considerations

In addition, this document will serve to standardise the regulator's interfaces, both with the traffic light (see 6.1, Interface with the traffic light), defining the procedures for the use of optical units of different types and the detection of inactive units, and with the Control Centre (see ANNEX D, Communications Protocol)

1.4 Equipment approval

An open process of approval of the regulators will be implemented through an independent third party that will facilitate competition and give guarantees to the City Council on the equipment to be installed. The tests that will be necessary to obtain the certificate of approval are described in the document:

Traffic light regulator
Approval tests

At the same time, Barcelona City Council will issue a certificate that validates compliance with the functionalities detailed in this document in the new regulator, without exempting the provider from strictly complying with the specifications of this document. To this end, the necessary equipment must be presented to the City Council to be subjected to the functional tests that the administration considers necessary.

From that moment on, the only regulators that can be installed in Barcelona will be those that prove that they are approved by an independent laboratory, and that have a certificate from Barcelona City Council that validates compliance with the required functionalities.

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2 Scope and rationale for the specification

Recent advances in the fields of electronics and telecommunications, among others, have led to a worldwide review of the technologies used in both control systems and traffic signalling equipment.

Specifically, in Europe, CENELEC has worked on the adaptation of European regulations on LED traffic signs, taking as references the OCIT (Open Communication Interface for Road Traffic Control Systems) interface proposed by the German consortium ODG, and the one proposed by ASTRIN (Associations of Traffic Industries in the Netherlands) has defined for the Netherlands. This new regulation arises from the need to address specific technical characteristics of LED traffic lights that are not described in the currently available standards, and its main objective is to establish a minimum set of requirements that allows the independent verification of regulators and traffic lights. In this way, it will be possible to guarantee the interoperability of products that comply with the new regulations, even if they come from different suppliers.

The migration from current incandescent lamps to new spotlights based on LED technology is basically justified by the energy savings and the reduction in maintenance costs associated with the new technology. In addition, the reduction in energy consumption makes it possible for the regulator and traffic lights to be powered by a UPS for a certain period of time in the event of a power failure.

The following diagrams (Figure 1 and Figure 2) present the two planned installation variants, the first with the regulator working alone, while the second has the addition of a UPS, for live support in case of falls. Both situations will occur in the city, leaving the installation of SAI at the discretion of the City Council.

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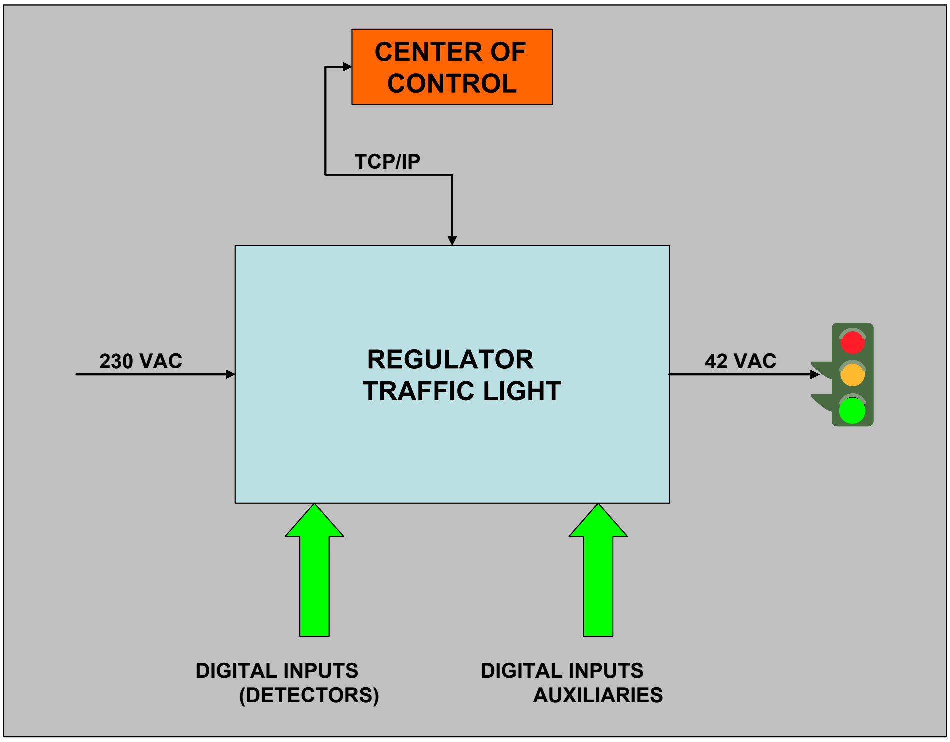

Figure 1: Traffic light regulator without UPS

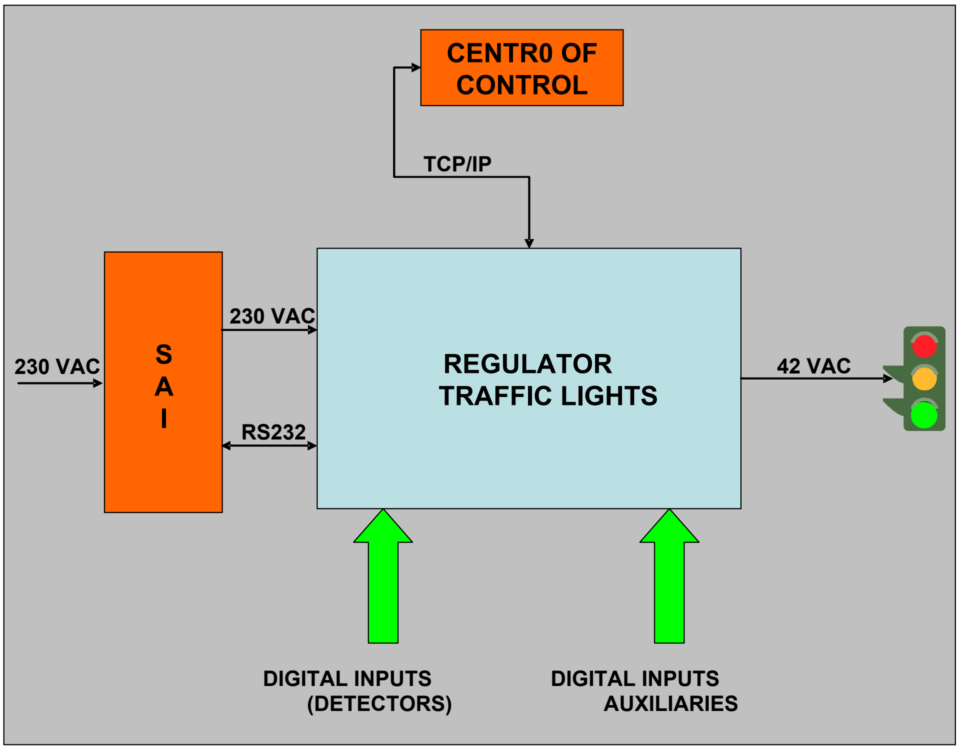

Figure 2. Traffic light regulator with UPS

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These specifications specify:

- The traffic light regulator
- The UPS
- The regulator's interfaces with traffic lights, the Control Center and the UPS
- The logic of processing the signals from the detectors
- The communications protocol between the regulator and the Control Centre

It is expressly not desired to determine:

- The functional specifications of traffic lights
- The behavior of the Control Center
- The specifications of the detectors (coil, microwave, infrared, etc.) and their corresponding interfaces, i.e. the set of physical and logical elements that transform the electrical signal generated by the detectors into digital signals that are directed to the regulator

Ajuntament de Barcelona

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3 Applicable regulations

3.1 Specific Spanish regulations on traffic signalling systems

The basic Spanish regulations are included in the UNE 135401 standards (Equipment for road signage – Traffic regulators) which include:

• UNE 135401-1 EX	Functional characteristics
• UNE 135401-2 EX	Test Methods
• UNE 135401-3	Electrical characteristics
• UNE 135401-5 IN	Communications Protocol, Type V
• UNE 135401-6	Electromagnetic Compatibility [1]

3.2 European regulations. CE marking

CE marking is mandatory, through compliance with directives 89/336/EC and 72/23/EC and the standards harmonized under these directives.

As applicable regulations we must point out:

• UNE-EN 60950-1:2003:	*Security Information of The Technology Equipment of*
• IEC 60950-22:2005	*Safety of outdoor equipment*
• UNE-EN 61000-3-2	*Harmonic emission limits*
• UNE-EN 61000-3-3 / A1	*Flicker Limits and Voltage Fluctuations*
• UNE-EN 50293:2001:	*Electromagnetic compatibility. Road traffic signalling systems. Product Standard*

[1] Adaptation of the European standard UNE-EN 50293

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In addition, the following regulations apply at European level:

- UNE-EN 12368:2000: *Traffic control equipment. Traffic light heads 2*
- UNE-EN 12675:2001: *Traffic lights. Functional safety requirements*

and the harmonization document:

- UNE-HD 638:2001: *Road traffic signalling systems*

which makes up the electrotechnical part of the EN 12368 and EN 12675 standards.

On the other hand, the traffic light regulator and all its optional components (UPS equipment, for example) must comply with the General Ordinance of the Urban Environment of 26 March 1999 and specifically the title referring to noise pollution.

A detailed list of applicable rules is presented in ANNEX C.

[2] To be overridden by PNE-prEN 12368

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4 Main components

4.1 Wardrobe

The regulator, and if applicable the optional UPS, will be supplied in a corrosion-resistant enclosure with a grey RAL 7001 exterior finish with anti-graffiti properties.

The assembly must pass the environmental resistance tests described in the UNE 135401-2 EX 3 standard and the electromagnetic compatibility tests prescribed by the EN 50293 4 product standard , with the degrees of severity determined by the Traffic Light Regulator document. Homologation tests.

The equipment must be fully operational in the outdoor temperature range between -10ºC and +55ºC, so it must have the necessary mechanisms, equipped with protection filters, so that the interior temperature does not exceed that tolerated by the components, as well as so that condensation does not occur.

The regulator will have a thermostat to control the temperature inside the cabinet. In the event that this exceeds that established by the thermostat, a temperature alarm will be sent to the Control Center and the optical units will be switched off.

The cabinet will have an open door detector that will be connected to an auxiliary entrance.

The cabinet will have a universal key lock for all regulators that will enable a more robust opening or closing system (handle), this not being a usual lock with an allen key, quad or triangle.

The interior will be conveniently compartmentalized to facilitate installation, connection and maintenance and will be mounted on a concrete base, no less than 30 cm high.

[3] Road signage equipment. Traffic regulators. Test Methods
[4] Electromagnetic compatibility. Road traffic signalling systems.

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4.2 Regulator architecture

The following figure presents a diagram of the architecture of the regulator.

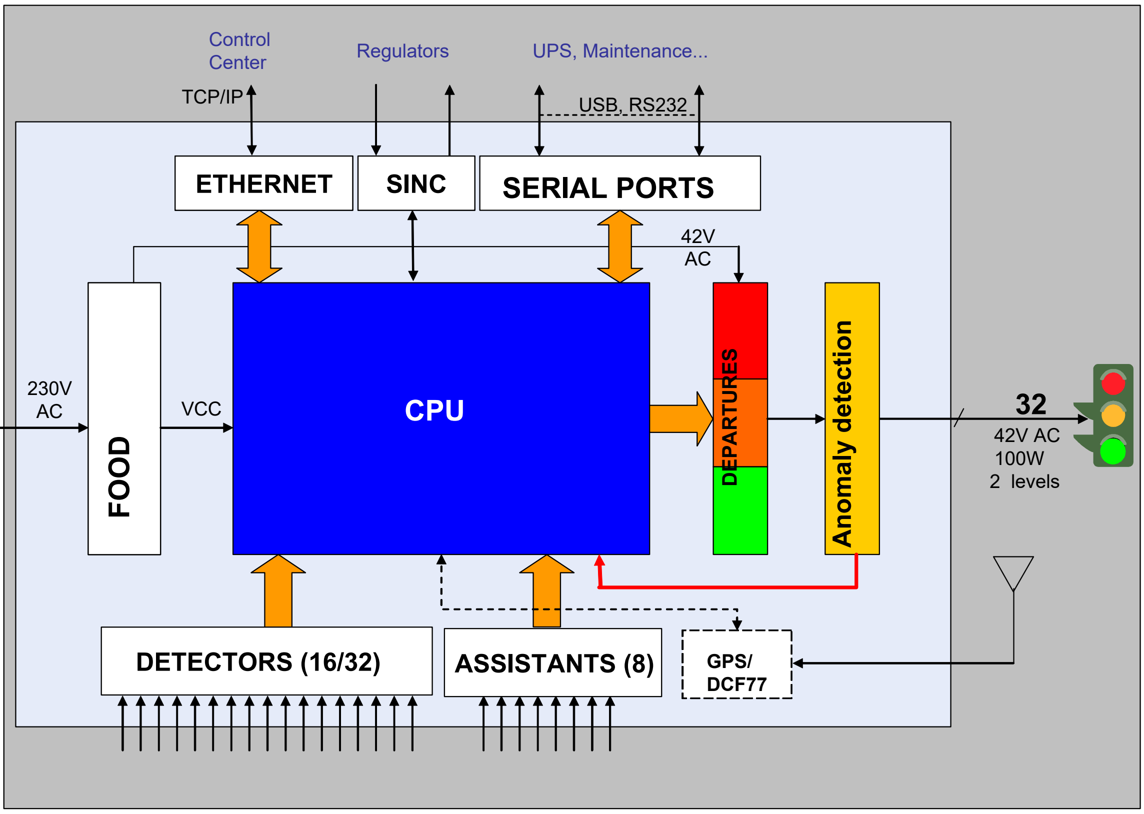

Figure 3. Traffic light regulator architecture

The characteristics of each module are described below.

4.3 Central Unit

4.3.1 Watch-Dog

The central unit of the regulator shall have a watch-dog timer monitoring system so that,

- Perform a Reset of the computer if it is not activated by the program for a while
- Send a reset alarm upon completion of the reboot due to your performance

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4.3.2 Parameter memory

The slider will store the parameters in non-volatile memory (e.g. Flash memory) and not easily removable.

The integrity of the parameters will be guaranteed by a CRC code. The failure of the CRC will cause an alarm and the shutdown of the crossing.

4.4 Feeding

4.4.1 General aspects

The regulator shall be supplied at the rated voltage of 230 VAC (directly from the electrical connection or via an optional UPS) and shall operate properly within the input voltage range of 184 VAC to 265 VAC (230 VAC, +15% - 20%). The manufacturer may choose to ensure proper operation within a wider range of voltages. The regulator's power supply will be responsible for supplying the voltages necessary for the operation of the electronics and the 42 VAC for the power supply of the traffic lights.

With regard to voltage microcuts, the system will be classified as Class E1, as specified by the UNE 135401-2 E standard. Therefore, micro-cuts with a duration of less than 50 ms should not affect the system's Control Mode, while in the event that the duration of the cut is greater than 300 ms, the system should turn off the traffic lights and start a start-up sequence.

If the supply voltage falls below the minimum operating voltage guaranteed by the manufacturer (which in no case may exceed 184 VAC), the regulator will send an alarm to the Control Centre and proceed to turn off the outputs. To ensure stable operation, the regulator will only re-enter service, starting a start-up sequence, when the supply voltage exceeds the threshold of 195 VAC (-15% 230VAC).

If the supply voltage is above the maximum operating voltage guaranteed by the manufacturer (at least 265 VAC), the equipment must not be unsafe signalled or damaged other than that relating to protective devices.

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The regulator shall have mechanisms for reading the voltage of the electrical connection. In the event that the control is outside a configurable range set by the Control Centre (which does not necessarily have to coincide with the permissible range), an alarm is sent to the control centre, indicating the current value of the supply voltage. The algorithm for generating incoming and outgoing warnings from the supply voltage alarm zone must take into account a certain hysteresis to avoid sending multiple warnings in short periods of time.

4.4.2 Electrical connection

The regulator must be resistant to the specified electrical situations.

It must incorporate magnetothermal and monobloc differential switches with automatic reset (See Figure 4).

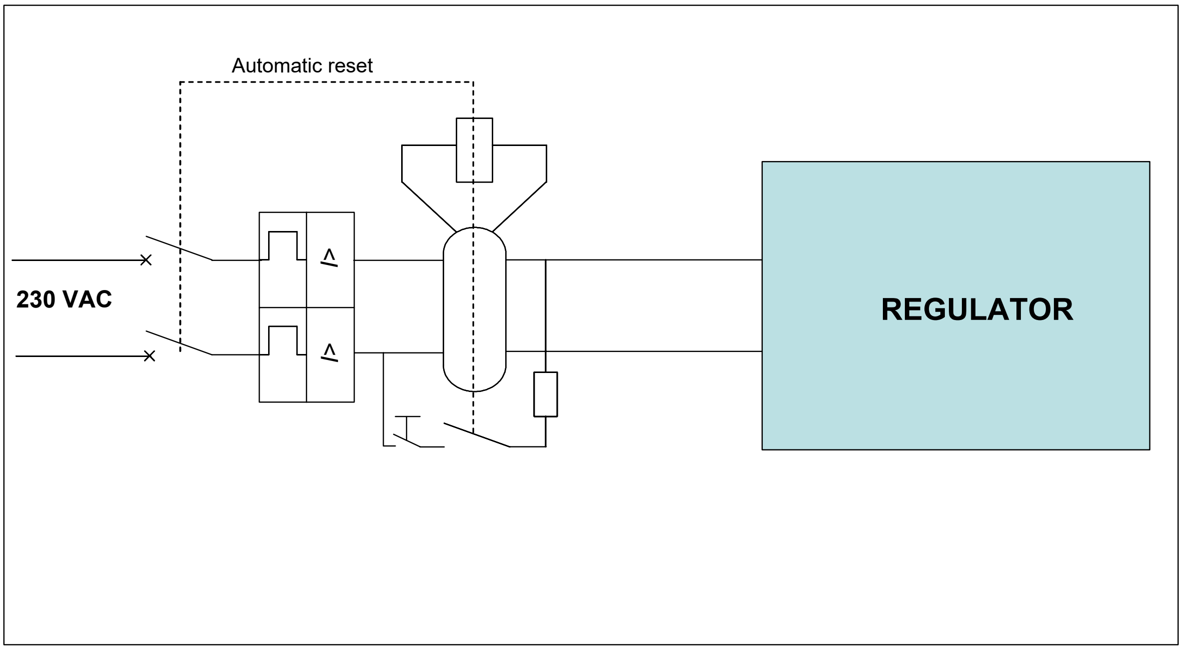

Figure 4. Resettable circuit breaker and differential protection

The specified resistance to electrical disturbances can be obtained,

- By Design
- using unloaders
- by an appropriate combination of the above methods When unloaders

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are used, they should have a potential-free contact indicating their availability, which should be connected to an auxiliary input of the regulator.

4.4.3 UPS (optional)

4.4.3.1 General aspects

The regulator may incorporate a UPS of the type called ON LINE or double conversion, connected in series between the electrical connection and the regulator. In this case, magnetothermal and monobloc differential switches with automatic reset must be provided between the UPS and the regulator, and between the electrical connection and the UPS, in order to guarantee safety at each stage of the power circuit. The latter switch will have a potential-free contact for connection to one of the regulator's auxiliary inputs. (See Figure 5).

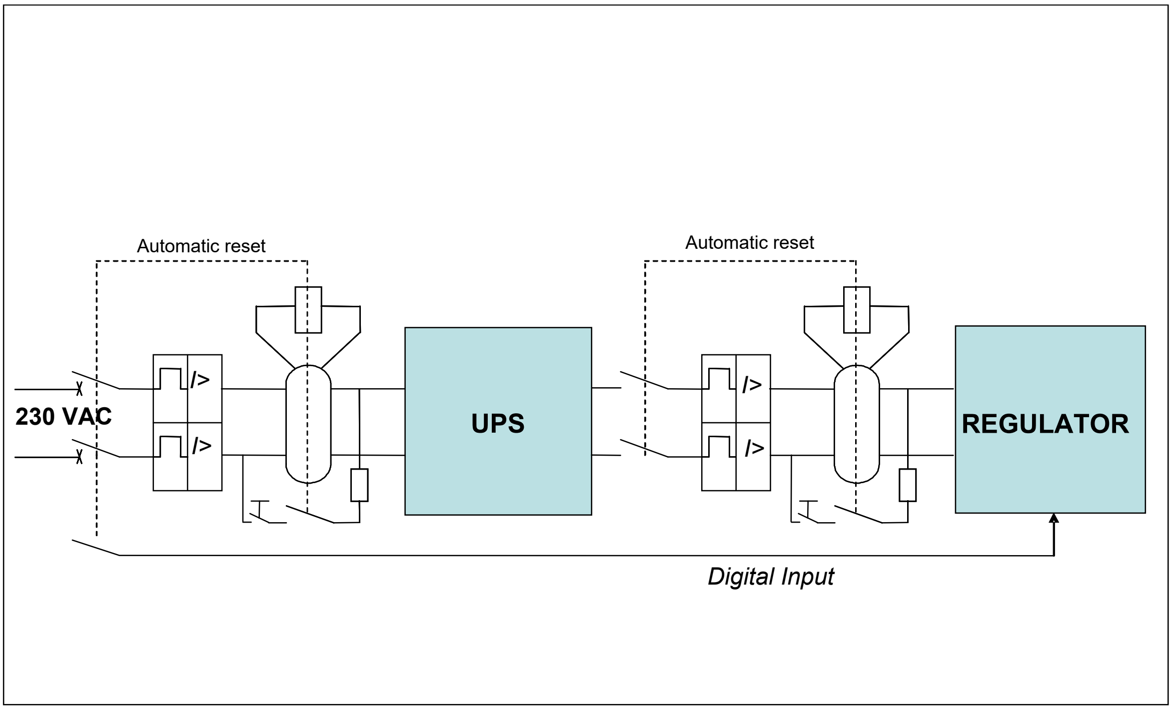

Figure 5. Protection of circuit breakers and resettable differentials in the event of UPS installation.

The UPS will have three modes of operation:

- Normal mode, **when there is a normal power supply. The regulator is powered via the rectifier/charger - inverter combination.**

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- Local mode, **when the power supply has fallen. The regulator is powered via the battery and inverter, until the supply is restored or until the battery charge level drops below a threshold, in which case the regulator will send an alarm to the Control Center**

- Bypass mode**. The regulator is powered directly from the power supply.**

4.4.3.2 Autonomy

The UPS must be capable of supplying the regulator-traffic light assembly, and optionally the detectors, in full operating conditions and at all times, throughout the life of the UPS, during:

- 2 hours in full brightness
- 3 hours in dimmed brightness

The supplier shall indicate the maximum power of the UPS that the regulator cabinet allows.

It shall be possible to extend the system by means of an add-on external module, in order to:

- Install a UPS with greater autonomy, in case the power of the internal UPS is insufficient for crossing.
- Install a larger capacity battery, in case the internal battery cannot guarantee the autonomy necessary for a certain crossing.

The most regulatory UPS complex in full operation must comply with the General Environmental Ordinance of the Barcelona City Council.

4.4.3.3 Interface

The regulator-UPS communication will be carried out via two potential-free contacts and optionally via an RS-232 port.

Through this port, the UPS will inform the regulator, and the regulator will inform the Control Centre, of:

- Failure and restoration of the power supply.
- Battery charge level below a certain threshold.

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4.5 GPS Watch (Optional)

Optionally, the internal clock of the regulator can be synchronized using a GPS clock. This is a physical component that provides GMT time 5 .

The GPS antenna must not be covered by absorbent material in the L-band (10.23Mhz).

4.6 DCF77 Watch (Optional)

Optionally, the internal clock of the regulator can be synchronized by a DCF77 receiver. It is a physical component, based on the transmission of legal time 6
carried out by the radio station DCF77.

The antenna shall be located so as to allow good reception in the 77.5 kHz band.

4.7 Digital Inputs

4.7.1 Inputs for detectors and pushbuttons

The regulator shall have at least 8 digital inputs for detectors and pushbuttons, activated by voltage-free contacts.

- Each entrance will have galvanic isolation. The manufacturer must declare the input impedance values, the high and low voltage thresholds (which must be within the limits defined by the Spanish standard 135401-2) and the maximum allowable overvoltage values.

- Each input can be used interchangeably for a detector or for a pushbutton.
- Inputs assigned to a detector will accumulate at least count and occupancy time.

- Any input - detector or push button - can be used in operated plans

[5] Strictly speaking, it provides the GPS time. The accuracy required in this application allows it to be assimilated to GMT time

[6] UTC(PTB)+1h or UTC(PTB)+2h. The broadcast is in charge of the PTB, Physikalisch-Technische Bundesanstalt, which has contracted the Mainflingen station until 2006. This contract has a good chance of being renewed.

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- Virtual detectors can be defined as logical combinations of physical and virtual detectors.

4.7.2 Auxiliary inputs

The regulator shall have at least 8 auxiliary inputs, activated by voltage-free contacts.

- Each entrance will have galvanic isolation. The manufacturer must declare the input impedance values, the high and low voltage thresholds (which must be within the limits defined by the Spanish standard 135401-2) and the maximum allowable overvoltage values.

- The controller will read the status of the auxiliary inputs once per second and treat status changes as alarms. (See 5.8)
- The status of auxiliary inputs can be consulted using the directives provided for in the protocol.

The auxiliary inputs initially assigned are:

Table 1: Allocation of auxiliary inputs		
ID	ENTRANCE	DESCRIPTION (logical value of the input: 1)
1	Circuit breaker monobloc	Open switch
2	Thermostat	Temperature alarm inside the cabinet
3	Open Door Cabinet	
4	Downloader	Drainer consumed (when the regulator use this component)
5	Synchronism	
6	Intermittent Guard Key	
7	Manual Guard Key	
8	<Unassigned>	

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4.8 Group Control Outputs

4.8.1 Output switch to optical drives

The regulator will have a 2-position general switch with the following functionality:

- Normal position. **When the switch is in the normal position, the status of the traffic light exit signals will correspond to the commands given by the controller.**
- Test position. **When the switch switches to the test position, the regulator will enter the test state and the following actions will be performed:**
  - When entering the test position, an alarm will be sent to the Control Centre.
  - The traffic lights will be off, regardless of the orders that the regulator is giving at that time.
  - The regulator will continue to activate the outputs that correspond to the current plan, but will not send alarms to the Control Centre.

When the switch returns to the normal position, the Control Center will be informed and a start-up sequence will begin.

This functionality can optionally be performed by keyboard order.

4.8.2 Departure steering circuits

The switching circuits will be solid-state.

Each group will have independent circuitry for each of the 3 colors (red, amber, and green) and each of them will be able to support up to 5 optical drives in parallel.

Each color will be able to govern a load of 100W and will be permanently shorted without this implying any damage to the equipment other than the replacement of the protection fuse.

Each group can have 2 active colors (See 5.2.3 Color Coding).

The status of each color will be On or Off, where the On state for the physical regulator assembly can have 2 levels:

- Full luminosity.
- Attenuated luminosity (Dimming) The

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organization of the crossing in traffic light groups will be physically reflected in:

- The modularity of electronic circuits
- The connection in the regulator cabinet
- The numbering and identification of groups and colors.

4.8.3 Output test circuits

The regulator shall have an analogue reading mechanism of the common output voltage to the optical units. In the event that the output voltage falls outside the permissible range (nominal voltage, +15%, -20%), the corresponding alarm will be generated, taking into account a certain hysteresis to avoid sending multiple warnings in short periods of time.

In each group:

- The three colored outputs will have voltage sensing circuitry to verify that the output voltage corresponds to the activated voltage level (full illumination, dimmed lighting, or off).

- All three color outputs will have intensity measurement circuits

The accuracy of the above measurements will be adequate to detect variations in consumption of 2 Watts 7 .

4.9 Synchronism (Wired Coordination)

4.9.1 Synchronism Receiver

The regulator will have a potential-free contact input for synchronization.

4.9.2 Synchronism emitter

The regulator will have an output to synchronize to other computers. This output will allow the creation of coordinated areas by connecting teams in cascade,

The synchronism output will be activated when the regulator is in autonomous operation. Under normal conditions, an impulse will be emitted as a replica of the one received by the synchronism input. In the

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absence of a synchronism input signal, an impulse will be generated at the beginning of the plan.

This mechanism will allow synchronism recovery in sections in the event of a rupture of the synchronization cable.

4.10 Guard Key

The regulator will support the installation of a key for manual control. The use of this key is generally reserved for the City Police.

The key will have at least 2 positions:

- Rest: **the key does not act on the regulator.**
- Flashing: **the crossing remains intermittent, i.e. all the headlights are off except for the amber lights of vehicles and pedestrian protection that are in slow intermittency.**

In these two positions the key can be inserted and removed.

In addition, there may be two additional optional positions (in the opposite direction to the fixed positions):

- Manual phase control: The regulator keeps the main phase in progress static.
- Manual phase advance: The regulator advances to the next major phase of the current structure, going through the corresponding transitions. This is not a static position of the key, but corresponds to a "key strike", and has automatic return to the "Manual Phase Control" position

In these two optional positions, the key cannot be inserted or removed.

[7] This accuracy is required to detect failure in an optical drive. This situation does not affect safety. Response times of one or more cycles would therefore be acceptable.

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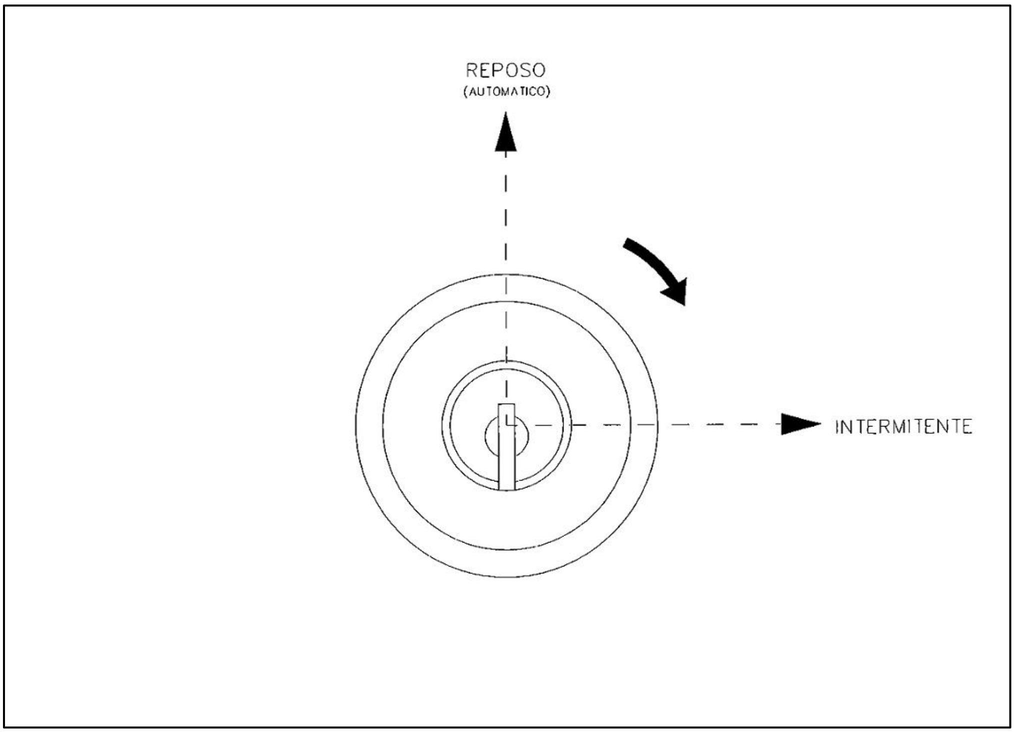

Figure 6. Normal Guard Key Scheme

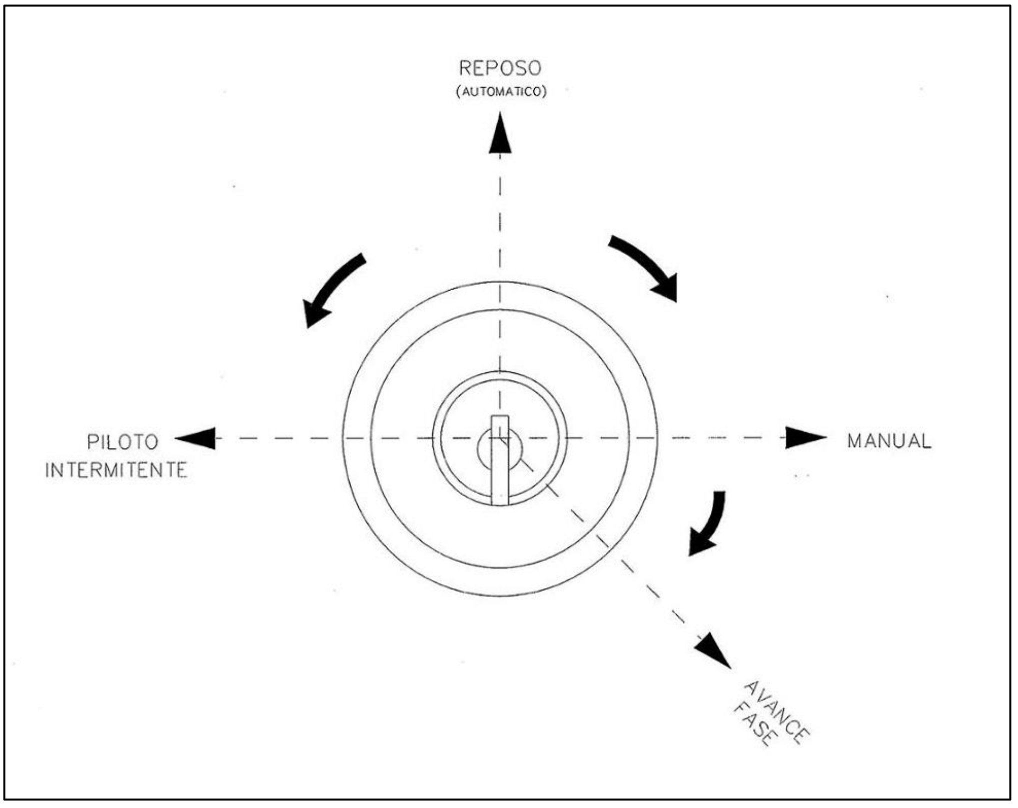

Figure 7. Guard key diagram with manual phase control

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4.11 Communications

The regulator shall have:

- One 10/100Mb Ethernet port. The output signal of the regulator will be made of copper cable, and it will be connected to an external adapter, located at terminal level.
- An RS232 port for connecting a portable maintenance terminal. Any regulator maintenance device must be capable of employing this port. The connection of a terminal will notify the Control Center.
- A backup RS232 port for other uses.
- A backup USB 1.1 port.

4.12 Modularity

Some elements of the regulator must be modular, making it easier to adapt to installations with different requirements.

Modularity implies that:

- Where a capability described in the document is not explicitly defined as modular or optional, it is understood to be part of the core equipment.
- When a service is defined as modular, the only element necessary to extend it is the module itself. The team must have the capacity to host and govern the additional modules without any other requirements.

Based on these requirements, two regulator models are defined:

- Basic Regulator up to 16 traffic light groups
- Extended regulator up to 32 traffic light groups

The following table presents the modularity characteristics that are required in such regulators. In it:

- Minimum equipment, **indicates the minimum number of signals that the equipment must support in its basic configuration.**
- Predicted Capacity, **indicates the minimum number of signals that the equipment must support at its maximum configuration**

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- Modularity, **indicates the number of additional signals that will be supported by the addition of a module.**

Table 2: Modularity

Description **BASIC REGULATOR UP TO 16G**	**Team Minimum**	**Capacity Planned**	**Minimal modularity** (units/module)
Group	8	16	2
Detector or pushbutton input	8	16	8
Auxiliary inputs	8	16	8
Description **REGULATOR EXTENDED UP TO 32G**	**Team Minimum**	**Capacity Planned**	**Minimal modularity** (units/module)
Group	8	32	2
Detector or pushbutton input	8	32	8
Auxiliary inputs	8	32	8

By way of example and referring to the case of the Extended Regulator:

- In its minimum configuration, the regulator must support at least 8 groups.
- The regulator must be expandable to support at least 32 traffic light groups.

- The expansion in the number of groups supported must be possible by inserting output modules with capacity for a minimum of 2 traffic light groups.

5 Traffic Control Features

5.1 Operating and control modes

The controller can operate,

- Insulated
- Being part of a coordinated area

To achieve coordination you can use two procedures,

- By wires (relative coordination)
- Clock-based (absolute coordination)

Traffic control can be carried out:

- By manual advance of phases
- According to a stored plan
- Based on a weekly table of stock plan selection
- According to a plan sent by the Control Center

A plan can have one or more phases such as:

- Demand-independent phase
- Fixed phase of appearance conditional on the existence of demand
- Extended phase by demand, with limited extension due to conflicting demands
- Priority phase sequence

The regulator at any given time can be found in one of the following situations:

- Commissioning sequence (Startup mode)
- Stable correct operation (Control Mode)
- Correct operation in resynchronization (Control Mode)
- Partial operation by alarm detection (Failure Mode)

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5.2 Capacity and programmable elements

5.2.1 Simplified Data Diagram

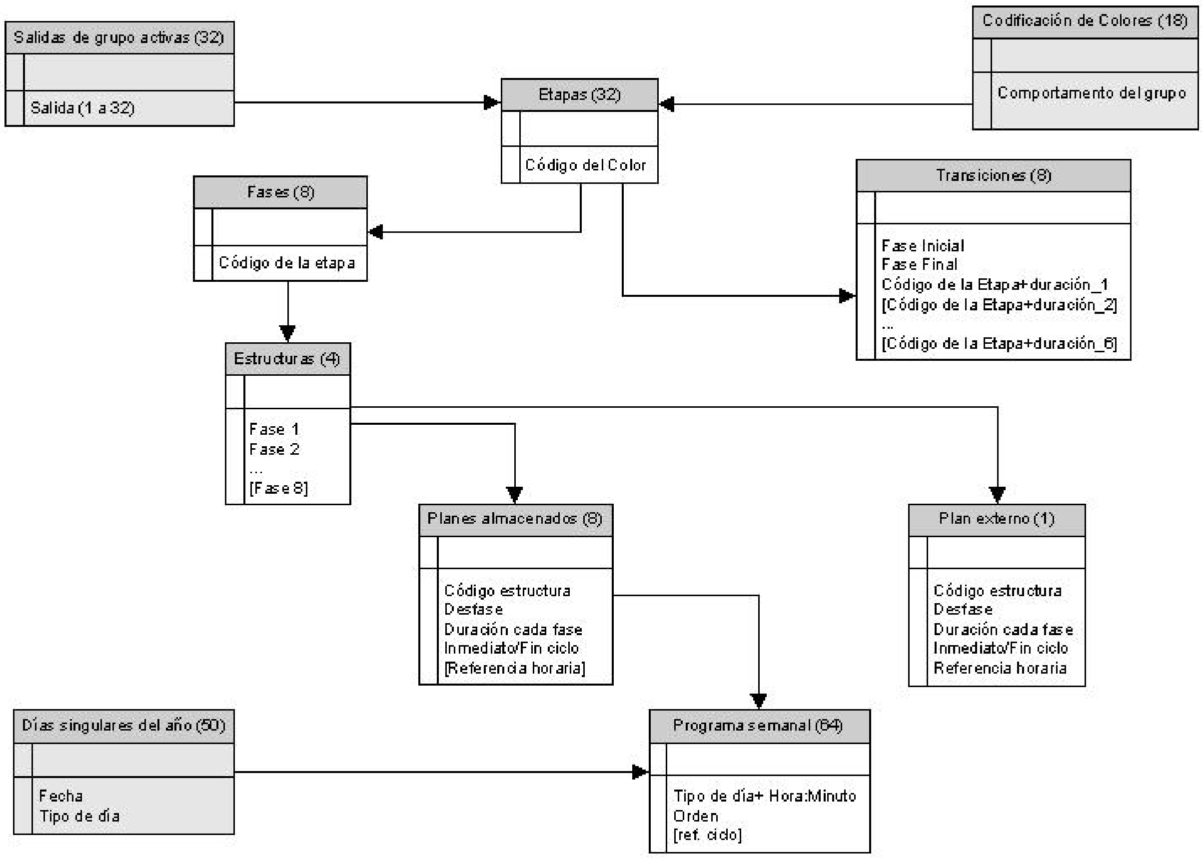

Figure 8. Simplified Data Diagram

5.2.2 Output Types

The regulator must be able to control up to 32 outputs, at least, which can be:

- Traffic light groups
- Direct control groups

5.2.2.1 Traffic light groups

The "active groups" parameter defines the outputs that are assigned to the traffic light group control.

This parameter is used to,

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- Identify the outputs used by the regulator for traffic light control
- Check the existence of the corresponding modules

Table 3: Active group departures
1-32

5.2.2.2 Direct control groups

Groups not assigned to traffic light group control will be considered direct command groups. These groups may govern additional signaling, and their behavior may be conditioned by the table of incompatible movements.

5.2.3 Color Coding

Each group controls 3 independent outputs generically referred to as "Colors". Changes in the status of a group's departures always take place at the same time.

The designations Red, Amber and Green *do not exclude the use of signs that do not display the aforementioned colours (e.g. special urban transport signage).*

18 colors are coded. The letter assigned to each one tries - in the usual cases - to remember its meaning.

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Table 4: Color Codes

CODE	DESCRIPTION	BEHAVIOR
D	Off (Disconnected)	R G V
V	Solid Green	R G V
R	Solid Red	R G V
A	Fixed Amber	R G V
P	Green fast flashing	R G V
J	Solid green and amber slow flashing R G	V
I	and amber R G Green flashing fast flashing slow	V
G	Solid red and amber slow flashing	R G V
F	Amber slow flashing	R G V
C	Slow flashing green	R G V
N	Green and Amber Fixed	R G V
S	Red and Amber Fixed	R G V
B	Red slow flashing	R G V

Table 4: Color Codes		
CODE	DESCRIPTION	BEHAVIOR
H	Red fast flashing	R G V
E	Green and amber fast flashing	R G V
K	Green and amber, alternating slow intermittency	R G V
Z	Red and amber, alternating slow flashing	R G V

5.2.4 Stages

Stages assign colors to outputs.

The stages are identified by the sequence of letters: A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, #, $, %, &, @, *.

The regulator must allow up to 32 stages to be encoded.

Table 5: Stages	
A	Color Code for Each Traffic Group
B	Color Code for Each Traffic Group
…	…
*	Color Code for Each Traffic Group

5.2.5 Phases

The controller must allow you to define up to 8 stages as the main phases, at least. The slider will have an expanded mode in which new stages are defined for transitions, reserving stages from A to * for phases.

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Table 6: Phases	
1	Stage Code
…	…
8	Stage Code

5.2.6 Transitions

The slider will define the transitions between two phases as a sequence of 1 to 6 stages and their duration. The slider must be able to define up to 8 transitions at least.

Table 7: Transitions		
1	Initial Phase	
	Final Phase	
	1	[Stage Code; duration (in seconds)]
	2	[Stage Code; duration (in seconds)]
	...	[Stage Code; duration (in seconds)]
	6	[Stage Code; duration (in seconds)]
…	…	
	…	
	1	[Stage Code; duration (in seconds)]
	2	[Stage Code; duration (in seconds)]
	...	[Stage Code; duration (in seconds)]
	6	[Stage Code; duration (in seconds)]
8	Initial Phase	
	Final Phase	
	1	[Stage Code; duration (in seconds)]
	2	[Stage Code; duration (in seconds)]
	...	[Stage Code; duration (in seconds)]
	6	[Stage Code; duration (in seconds)]

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In extended mode, the Transitions table is different (table 8) and another Transient table is also added (table 9) in which the new stages are defined. The Transitions table refers to the Transients.

Table 8: Transitions (extended mode)		
1	Initial Phase	
	Final Phase	
	Transient Number	
	1	[Stage duration (in seconds)]
	2	[Stage duration (in seconds)]
	...	[Stage duration (in seconds)]
	6	[Stage duration (in seconds)]
…	…	
	…	
	…	
	1	[Stage duration (in seconds)]
	2	[Stage duration (in seconds)]
	...	[Stage duration (in seconds)]
	6	[Stage duration (in seconds)]
8	Initial Phase	
	Final Phase	
	Transient Number	
	1	[Stage duration (in seconds)]
	2	[Stage duration (in seconds)]
	...	[Stage duration (in seconds)]
	6	[Stage duration (in seconds)]

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Table 9: Transients (extended mode)		
1	Transient Number	
	1	[Color Code for each traffic group]
	2	[Color Code for each traffic group]
	...	[Color Code for each traffic group]
	6	[Color Code for each traffic group]
…	…	
	1	[Color Code for each traffic group]
	2	[Color Code for each traffic group]
	...	[Color Code for each traffic group]
	6	[Color Code for each traffic group]
8	Transient Number	
	1	[Color Code for each traffic group]
	2	[Color Code for each traffic group]
	...	[Color Code for each traffic group]
	6	[Color Code for each traffic group]

5.2.7 Structures

The regulator defines structures as sequences of 2 to 8 phases.

The regulator can have at least 4 structures defined.

Table 10: Structures	
1	Phase 1, Phase 2, [Phase 3,] [Phase 4] [Phase 5] [Phase 6] [Phase 7] [Phase 8]
…	…
4	Phase 1, Phase 2, [Phase 3,] [Phase 4] [Phase 5] [Phase 6] [Phase 7] [Phase 8]

5.2.8 Stored Plans

The controller will have a table that can accommodate at least 8 plans. Each plan is

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made up of

- Structure code
- Offset in seconds
- Duration of each phase in seconds
- 1 = Immediate entry / 0 = Wait for end of cycle
- Time reference (optional)

The absence of a time reference implies the use of the first previous scheduled reference

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Table 11: Stored Plans		
1	Structure Code	
	Offset (SS)	
	1	Phase 1 Duration, SS
	2	Phase 2 Duration, SS
	3	[Phase 3 Duration, SS]
	i	[Duration of phase i, SS]
	8	[Phase 8 Duration, SS]
	1= Immediate entry / 0= Wait for end of cycle	
	[Time reference HH:MM:SS]	
…	Structure Code	
	Offset, SS	
	1	Phase 1 Duration, SS
	2	Phase 2 Duration, SS
	3	[Phase 3 Duration, SS]
	i	[Duration of phase i, SS]
	8	[Phase 8 Duration, SS]
	1= Immediate entry / 0= Wait for end of cycle	
	[Time reference HH:MM:SS]	
8	Structure Code	
	Offset, SS	
	1	Phase 1 Duration, SS
	2	Phase 2 Duration, SS
	3	[Duration of Phase 3, SS)]
	i	[Duration of phase i, SS]
	8	[Phase 8 Duration, SS]
	1= Immediate entry / 0= Wait for end of cycle	
	[Time reference HH:MM:SS]	

5.2.9 External plan

The external plan is similar to a stored plan, with the particularity that it is reserved for the Control Center.

It is intended to be written frequently and should not be in permanent memory.

In the External Plan, the time reference is a necessary parameter.

The external plan is activated at the request of the Control Center, and then the change is made from the previous plan. Deactivation is also done at the request of the Control Center, or when more than fifteen minutes pass without refreshment from the external plan. When it is deactivated, the slider returns to the timetable, and switches to the corresponding plan.

Table 12: External Plan		
0	Structure Code	
	Offset (SS)	
	1	Phase 1 Duration, SS
	2	Phase 2 Duration, SS
	3	[Phase 3 Duration, SS]
	i	[Duration of phase i, SS]
	8	[Phase 8 Duration, SS]
	1= Immediate entry / 0= Wait for end of cycle	
	Time reference HH:MM:SS	

5.2.10 Singular days of the year

The concept of a singular day is introduced to enable special operation on special dates. The regulator will have a table of up to 50 entries to determine the singular days throughout the year. Different singular days (e.g. local holidays, football match, etc.) can be coded

On a given date, the definition of a day type takes precedence over the actual day of the week.

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Table 13: Singular days				
1	Day-month	Hour minute	Order	[Ref. cycle]
		...	...	...
		Hour minute	Order	[Ref. cycle]
…	…	…		
50	Day-month	Hour minute	Order	[Ref. cycle]
		...	...	...
		Hour minute	Order	[Ref. cycle]

5.2.11 Weekly program

The regulator will have 7 tables (one for each type of day) of 64 entries each, indicating:

- Time (in HH:MM)
- Order issued (at a minimum, activation of a Plan or direct command order)
- Time reference of the new plan (the start time of the green main road with zero lag)

Table 14: Weekly program			
1	Hour minute	Order	[Ref. cycle]
...	...	...	...
64		Order	[Ref. cycle]

5.3 Coordination procedures

When coordinated with other equipment – maintaining a certain offset for the green main track in an area – the regulator may operate in accordance with one of the following procedures:

- Coordination relative to a reference team, usually called Synchronization

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- Absolute coordination with respect to an objective moment in time (e.g. from Tuesday at 1:05 p.m.).

5.3.1 Relative Coordination or Synchronization

5.3.1.1 Synchronization Method

In this case, the zone regulators are connected by means of a synchronism signal. The headend equipment - the reference regulator, with zero offset - sends an impulse at the beginning of cycle [8] .

All the teams in the area will use a predetermined fixed plan, including the offset of each crossing, modifying only the start time of the plan according to the synchronization received.

5.3.1.2 Loss and recovery of synchronism.

Synchronism is lost due to the lack of periodicity of the impulse (due to increase or defect) within an established tolerance margin. The loss of synchronism causes an alarm.

Synchronism is acquired by stably receiving a period synchronism signal similar to that of the predetermined plan. Once the correction of the signal has been checked, the crossing initiates a "Resynchronization Process".

5.3.2 Absolute coordination with respect to a time reference

Absolute coordination means that all regulators in the area have the correct time. For each zone, an absolute reference moment is defined from which the sequence of plans begins. For example, if the baseline is located at 0:00:00 hours each day and all plans have a 1-minute cycle, a controller joining the zone knows that the reference cycle starts at 00 seconds of each minute.

This coordination procedure requires that the regulators in a zone have the same cycle changes during the validity of the reference.

[8] The start of the cycle is at the beginning of the transition from entry to the main phase

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5.4 Resynchronization procedure

5.4.1 Introduction

On multiple occasions a regulator must implement a new regulation plan that is not yet being used in the regulation of crossing.

Among other cases, we can mention,

- Commissioning. Passage from off-the-go traffic lights to a planned plan.
- End of manual control. Switching from the plan with manual progress of phases, to the plan corresponding to synchronised, hourly or centralised control, as the case may be.
- Synchronism Recovery (In an area using wire coordination) Transition from the present situation - intermittent amber or fixed plan without coordination - to a synchronized plan.
- Switch from Wire Sync to Central Control. By retrieval of communications or by a specific order from the Control Center. It can mean a resynchronization plus a change of plan.
- Change of time plan. Abandonment of the current plan for the newly established one.
- Change of plan ordered by the Control Center. Abandonment of the current plan for the newly established one.
- Time setting (when time coordination is used)

If the regulator is part of a coordinated zone (whether the coordination is relative to a reference crossing, or if the coordination is absolute with respect to a time reference), the new plan has the phase changes at preset times.

5.4.2 Temporal components

There are two distinct temporal components involved in the process of change:

1) The instant the operation is initiated (This can be the event receiving a directive from the Control Center, an order from the time table, an external event such as synchronism recovery, etc.)
2) The moments of change in each phase of the new plan. The moment of the start of the cycle is especially important, on which the phase difference is taken.

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5.4.3 Situation of change

Between the start and the implementation of the planned plan, the crossing:

1) It is not coordinated
2) He is in an exchange operation: he is controlled only by himself
3) The duration and sequence of the phases shown on the street are determined by the resynchronization procedure.

All situations that involve a temporary change in the sequence of phases at a given moment set in motion a resynchronization process. The optimization problem arises by looking for the fastest way to move from a source plan to a destination plan, generating a transitory process.

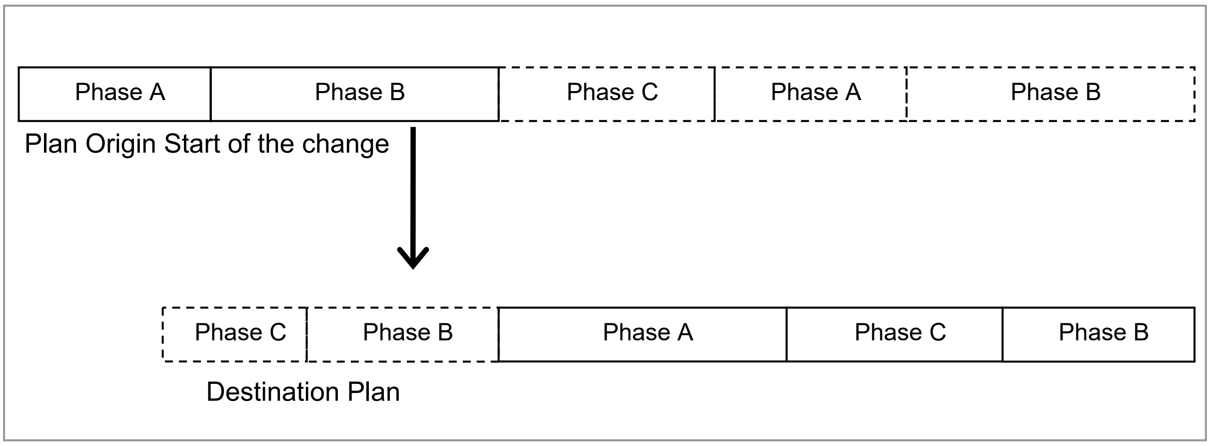

Figure 9. Resynchronization example

It is widely accepted that in coordinated areas, the criterion of "minimum time of change in the zone" is the one that produces the least disturbance in traffic (see 5.4.6: Algorithm in the regulator: abrupt method).

5.4.4 Generic Algorithm Validity

The same algorithm is applicable whether only the coordination speed is modified or the structure is changed. In fact, at points far from the reference node, a change in phase shift can modify the output of

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phases as much or more than a complete change in plan.

5.4.5 Individual cases

The use of the algorithm does not impair the behavior of the crossing when the changes are small, since most of the time the optimal transition will consist of a slight modification of the time of the current phase.

The resynchronization of a thread-coordinated crossing - synchronized - is a particular case of the overall situation and benefits from the safety and speed of the algorithm.

5.4.6 Algorithm in the Regulator: Abrupt Method

In the regulator, this procedure of resynchronization in the shortest possible time is called "abrupt method" and complies with the following rules:

- The transition from the situation of origin to that of destination must be as short as possible without affecting safety. The regulator will work out all possible options by choosing the shortest path, taking into account the transitions between defined phases.
- The green time of any phase must respect its minimum programmed value.
- No phase will cease to appear for a time longer than the major cycle of the two plans: current and future, minus the minimum time of the phase.
- There may be two solutions that take the minimum time of implementation of the new plan: one by reducing green times, the other by extending the phases. Where there is a double solution, the regulator will choose the phase extension.
- If there is no defined transition between phases of the source and destination plan, the regulator will introduce an automatic transition. This situation will generate a specific alarm.

5.5 Time Management Components in the Regulator

The regulator shall have the following time management components:

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- Legal time clock/calendar, with automatic daylight saving time update. By default, the day and time of change will be those currently established by the EC, but alternatively they can be uploaded from the Control Centre.
- Astronomical clock, for the calculation of the rising and setting times that will control the automatic deactivation and activation of the dimming.
- Timers and flashing generators.

The time base for these components will be provided by an internal oscillator with a maximum allowable drift of ±1 s/d.

The time can be set by 3 procedures:

- Specific order provided for in the protocol
- GPS watch (optional)
- DCF77 time signal receiver (optional)

Optional clocks (GPS or DCF77) will set the regulator at least once a day and only when there is no Centralised Control. This ensures the priority of Centralised Control even to distribute different hours.

The regulator must be able to generate two intermittency frequencies:

- Fast flashing
- Slow intermittency

The period of these intermittencies will be determined by a table:

Table 15: Intermittency period	
Fast Intermittency	S.Ds
Slow Intermittency	S.Ds

The On/Off ratio will be 50%.

The resolution of the period will be 0.2s. The table will only admit fractions of a second pairs, so that half-periods always correspond to an integer number of tenths of a second.

5.6 Methods of control by the origin of orders

Once in control mode, the regulator can operate using one of the following control methods:

- Manual
- Autonomous
- Coordinated
- Centralized

according to the state diagram in Figure 10.

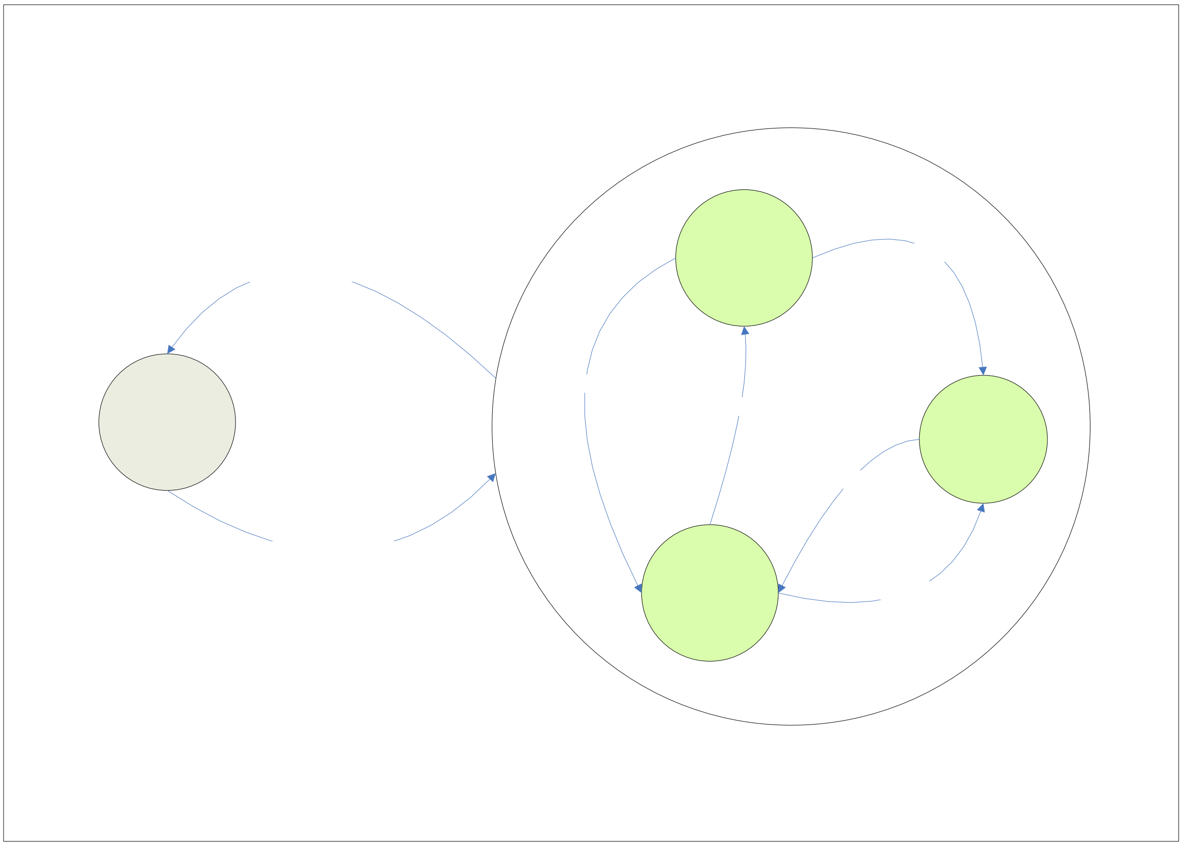

Figure 10: Operation by control source

Manual control corresponds to the presence of the Guard Key in any active position (see 4.10). This situation is a priority over the others.

Autonomous control corresponds to the absence of synchronism and centralization signals regardless of the cause: lack of installation, breakdown, etc. In this

Llave de Guardia activa

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In this situation, the Internal Clock, the Time Table, and the Stored Plans are used. The possibility of having a highly accurate internal clock, through external synchronization via GPS or radio, allows the existence of coordinated areas without the need for external wiring between regulators or with the Control Center.

Coordinated control corresponds to the existence of a Synchronism signal and the absence of Centralization. In this case, coordination is by synchronism. The internal clock is not used. A predetermined plan is used with structure, offset and phase times (= cycle) defined.

Centralized control corresponds to the existence of a Centralization signal. The remote control can control **all the control parameters contemplated in the protocol. For example:**

- Turn off the junction
- Set the junction to Flashing
- Pass the crossover to stored plans
- Update the clock time
- Write a dynamic plan in volatile memory in regulation by plan development
- Select a structure and determine phase offset and cycle by sending in real time of phase completion orders.
- Read and write any of the parameters stored in the slider

5.7 Traffic Handling and External Demands

The regulator will have a software module that will allow it (in each of the control methods described except the manual) to also operate operated by traffic, attending to the inputs of vehicle detectors and pedestrian buttons.

The regulator may have an optional software module that will allow it to react to external demands for immediate termination of a phase, saving the minimum times, and entry into a special phase or sequence of phases (to give priority to special vehicles, such as buses, firefighters, etc.), in a manner defined by the manufacturer.

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5.7.1 Defined Phase Types

As far as its appearance is concerned , a phase can have:

- Fixed appearance, **i.e. it will always be present within a traffic light cycle, regardless of the external conditions.**
- Conditional appearance, **i.e. its existence will depend on the existence or not of demand.**

In terms of duration, a phase can have:

- Fixed duration, independent of demand
- Extendable duration, depending on demand.

These characteristics of occurrence and duration can be combined to give rise to four different types of phase, as shown in the following table:

Table 16: Types of phases

		DURATION	
		Fixed	Extendable
APPEARANCE	Fixed	Independent (of the external conditions)	Fixed with extendable duration (e.g., vehicle detectors)
	Conditional On demand	Conditional with fixed duration (e.g. pedestrian buttons)	Conditional with extendable duration (e.g. vehicle detectors)

5.7.2 Plans implemented

Whether a plan is acted upon or not depends on whether it includes acted phases in its programming.

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There are multiple solutions for the implementation of an acted crossing. The following description is indicative and describes a generic case.

A phase with an extendable duration is determined by the following parameters:

- Fixed output phase (with or without demand)
- Minimum green extension per vehicle waiting in the movement itself
- Extension per vehicle detected
- Maximum interval between detections to grant extension
- Reduced interval per vehicle arriving in competing motion
- Maximum total duration

5.7.3 Drive inputs

The regulator will accept the following requests for action:

- Vehicle detectors
- Pedestrian buttons
- Specific orders included in the protocol

The same phase can be conditioned by more than one demand. In this situation:

- There will be a hierarchy of demand priorities, so that a demand for firefighters will have priority over a tram demand, and the latter over a pedestrian demand.
- The minimum safety time used will always be the longest of those present (e.g. a vehicle extension of 2 s and a pedestrian demand of 3 s will result in a minimum time of 3 s)

5.7.4 Priority Phase Sequence

It is a sequence of phases, or a single phase, with preference (buses, firefighters, etc.) over other demands. Only security criteria are maintained (minimum greens, incompatibilities, etc.)

The claim may come from:

- Assigned local input
- Explicit external request (e.g., hurry-call directive in the protocol) The controller will

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store the schedule of the priority sequence of phases, as well as the necessary transitions.

Optionally, the vehicle passage beacon can be connected to a detector entrance.

5.8 Alarms

5.8.1 Generation

The alarms generated by the regulator come from:

1) Internal diagnostic circuits: Memory test, etc.
2) Integrity and correctness of the operation of the crossing: monitoring of departures, communications...
3) Level changes of the auxiliary inputs, listed in Table 1.

5.8.2 Transmission

The controller will asynchronously send a message to the Control Center each time it detects an activation or deactivation of an alarm. At the request of the Control Center, the regulator will send the current status of all alarms. This will allow for low-frequency sampling.

The management and coding of the alarms generated by the regulator will be carried out in accordance with the provisions of the communications protocol described in ANNEX D.

5.8.3 Regulator Reaction

On entry into service, the regulator will identify the existence of alarms. It will only go into control mode if there is no major failure. Otherwise, it will go into failure mode.

The reaction to an alarm in each of the control situations is described in Figure 11.

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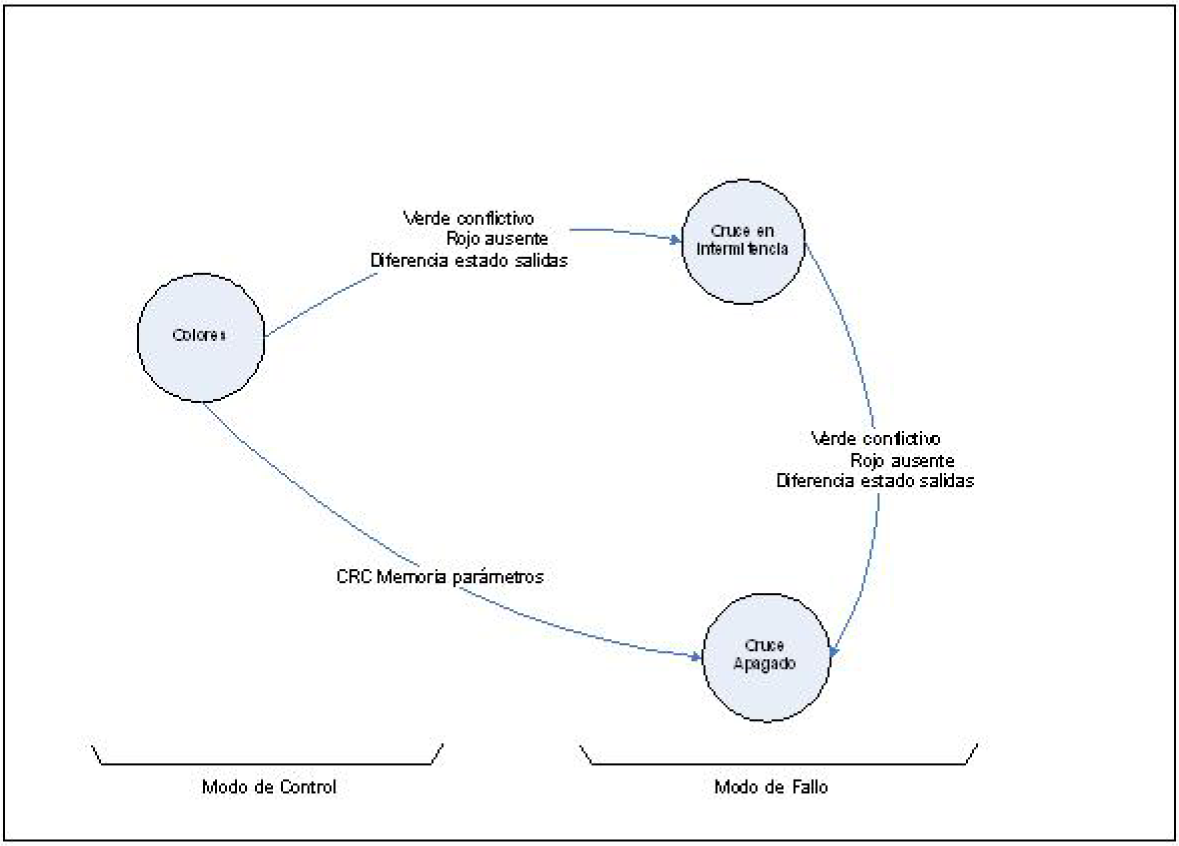

Figure 11. Change of status due to the presence of alarms

5.9 Handling of departures

5.9.1 General condition of departures

The regulator's outputs can have four general logical states described in the following table:

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Table 17: Status of departures	
Off	All groups are ordered to shut down. This state is independent of the Physical disconnection of lamp power
Intermittent crossing	All colors are turned off except for vehicle amber and protection of pedestrians, which will be intermittency
Bright colours attenuated	The color is applied to each group in accordance with the current regulation. The tension of output corresponds to that established for dimmed brightness.
Bright colours full	The color is applied to each group in accordance with the current regulation. The tension of output corresponds to that established for full brightness.

5.9.2 Changing Status

The general condition of the outputs can be modified by:

- Commissioning sequence
- Guard key in "Flash" position
- External direct command (protocol)
- Height of the Sun (Astronomical Clock)
- Specific alarm situations

5.9.3 Dimming

The regulator will have the ability to attenuate the light intensity of the traffic lights, modifying the voltage of the outputs.

The mechanism for activating and deactivating the reduced brightness will be configurable, with at least the following options:

- Remote activation/deactivation from the Control Center
- Local activation/deactivation controlled by the astronomical clock and the defined height of the Sun.
- Activation of full brightness in the event of a communications failure.
- Activation of reduced brightness in the event of UPS entry into service in local mode, according to its configuration. This option is a priority in the face of communications drops.

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5.9.4 Calibration

Based on a command given by the local keyboard, the controller will trigger a calibration session during which the typical consumption of the crossover during a full operating cycle will be recorded on a table. If necessary, the values in this table can be changed from the local dial of the controller.

The calibration procedure must take into account the different consumption values depending on whether or not the dimming is active. In this way, the controller will detect failure of the optical drive, with and without dimming.

Likewise, at those junctions that have the acoustic warning system for blind people, it will be necessary to take into account other normal consumption values. The calibration of the groups of pedestrians will be done with the plate at rest and the excess consumption that occurs when the acoustic signal is put into operation must be filtered.

5.9.5 Anomaly Detection

5.9.5.1 Optical Drive Failure

During operation in Control Mode, the regulator will measure the consumption of each output
and compare the measured values with the recorded standard values. If the discrepancy between the two values is greater than a margin established by the Control Centre, alarms will be generated for lack or excess consumption. This will allow the detection of decommissioned LEDs.

NOTE

Special Symbols

It is assumed that special symbols (arrows, pedestrians, etc.) will be obtained by means of Mask overlay to standard bulbs, for the following reasons:

a) Reduction in the number of spare parts references

b) Replacement of a long casuistry of what to do with each symbol when certain LEDs fail by a generic behavior in the event of a breakdown.

c) LED technology progresses towards a high-performance central illuminator that will make them obsolete the symbols made with discrete pieces.

d) Homogenization of consumption makes the detection of an optical drive out of service much more more reliable.

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5.9.5.2 Incompatible Movements

5.9.5.2.1 Definition

The following table presents a model for defining incompatible movements:

Table 18: Incompatible Movements

Departure	1	2	3	4	5	6	7	8	…	…	32
1		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
2	0/1		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
3	0/1	0/1		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
4	0/1	0/1	0/1		0/1	0/1	0/1	0/1	0/1	0/1	0/1
5	0/1	0/1	0/1	0/1		0/1	0/1	0/1	0/1	0/1	0/1
6	0/1	0/1	0/1	0/1	0/1		0/1	0/1	0/1	0/1	0/1
7	0/1	0/1	0/1	0/1	0/1	0/1		0/1	0/1	0/1	0/1
8	0/1	0/1	0/1	0/1	0/1	0/1	0/1		0/1	0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1		0/1	0/1
…	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1		0/1
32	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	

The contents of each of the cells in the incompatibility matrix can be:

- Movement Allowed (0)
- Movement Not Allowed (1)

By default, all cells in the table have the allowed movement value. In order for the crossing to enter colors, at least one movement must be programmed that is not allowed.

If an incompatibility between a pair of groups but not their reciprocal is programmed into the regulator (for example, the incompatibility between groups 1 and 4, but not between 4 and 1), the regulator will incorporate both into the matrix of incompatibilities (symmetric matrix).

The incompatible movement table will be protected against accidental alterations. To modify the content of the table, there will be a restrictive access procedure, which will also create a register of interventions.

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The UNE 135401-1 standard establishes that the time elapsed between the detection of a fault and the change to a safe state of operation must be less than 500 ms. (class AG5). The action required in the event of the detection of incompatibilities falls within this directive.

5.9.5.2.2 Surveillance of conflicting greens

The regulator will not allow the execution of orders that mean the exit of green for incompatible movements.

The regulator must be able to detect any green-green situation for incompatible movements, and in this case, it will enter fault mode, within the time frames provided for by the standard, send an alarm and put the crossing on intermittent or off, according to the programmed action.

5.9.5.3 Absent Red

The regulator must be able to detect any effective situation of absent red, and in this case, it will enter fault mode, within the time frames provided for by the standard, send an alarm and put the crossing on intermittent or off, according to the programmed action.

5.9.5.4 Difference in group outings

The controller will check that the readings provided by the output check circuits match the commands given to the groups.

When a situation of difference between group orders and readings is detected, the regulator will enter fault mode, within the time frames provided by the standard, send an alarm and put the crossing on intermittent or off, according to the programmed action.

5.9.5.5 Group Differential Current Measurement (Optional)

The regulator shall carry out a continuous measurement of the differential currents per group and send an alarm when the leakage of a group exceeds a certain parameterizable value.

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5.10 Processing of Digital Inputs

5.10.1 Detector inputs

The controller will read the status of the inputs dedicated to the detectors every 10 msec. and it shall store, for each traffic light cycle and for each of the detectors, the average values during the last hour of the following measured variables:

- Volume (Total number of vehicles per cycle)
- Lane Occupancy (Occupancy Percentage)

and of the calculated variables:

- Intensity (number of vehicles per hour)

Based on the information stored, the regulator must be able to give:

- Average values of the variables between all cycles completed in the last N minutes (warning in case no cycle has finished during this period)
- Average values of the variables during the last N cycles.
- Detection value of the last N seconds.

The controller must also be able to supply the instantaneous reading value of all detector inputs.

5.10.2 Auxiliary inputs

Auxiliary inputs will be treated as system alarms (See 5.8)

5.11 Programming

The regulator can be programmed:

- From a terminal, consisting of a keyboard and display connected locally, so that ASCII characters can be sent, received and displayed.
- From the Control Center, using the same commands as in local mode, but with the encapsulation explicit in the protocol plus that of TCP/IP.

To modify the programming of the regulator, there will be a user access control system, which will also create a record of users who have accessed. The access codes will be self-verifiable and particular to each user.

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All configuration modifications will be stored in a temporary memory, until a reversal or validation order is received:

- Upon receipt of an invalidation order, the controller will erase the contents of the temporary memory.
- Upon receipt of a validation order, the regulator will proceed to analyse the consistency of the stored data. If they are correct, the configuration will go to the final memory, and an acceptance message will be sent to the Control Center and the programming terminal if it is connected. Otherwise, the operator will be informed of the configuration errors detected, and the previous programming will be maintained.

If the validation command does not arrive within a certain time interval after making the changes, the controller will generate an alarm and delete the contents of the temporary memory.

5.12 Priority public transport

The regulator must allow the incorporation of priority for public transport, both buses and trams (see 5.7: Traffic action and external demands). The priority management of public transport must be compatible with the management of hurry calls.

5.13 Fire Runners

The regulator must allow the incorporation of emergency sequences that give priority to fire brigade corridors, at the request of the Control Centre by hurry-call.

The emergency sequence is defined from the Control Center, and can be made up of several phases, one of them being the emergency phase itself, of indefinite duration.

The slider will activate the emergency sequence at the request of the Control Center, and will automatically include the input transition, depending on the current color and the color of the emergency phase.

The controller will deactivate the emergency sequence when it detects the passage of the vehicle by means of the signal from the beacon or when it receives the corresponding order from the Control Centre.

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Once the emergency sequence is complete, the controller returns to the plan it was executing, introducing an automatic transition, and will generate a hurry call alarm end warning .

Both the entry and exit transitions will always respect the minimum established times.

5.14 Compatibility with Existing Equipment

The local regulator will be compatible with the regulation and communication systems currently installed in Barcelona and connected to the Control Centre.

The communications protocol with the Control Center will be protocol B.

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6 Defined interfaces

6.1 Interface with the traffic light

At present, CENELEC is in the process of adapting European regulations to LED traffic signs, initially taking as a reference the OCIT (Open Communication Interface for Road Traffic Control Systems) interface proposed by the German ODG consortium, and the one proposed by ASTRIN (Associations of Traffic Industries in the Netherlands) has defined for the Netherlands. This new regulation arises from the need to address specific technical characteristics of LED traffic lights that are not described in the currently available standards, and its main objective is to establish a minimum set of requirements that allow the independent verification of regulators and traffic lights. In this way, it will be possible to guarantee the interoperability of products that comply with the new regulations, even if they come from different suppliers.

The Spanish working group has submitted a new proposal to CENELEC, based on the ASTIN regulations, but with small variations, especially relating to the permissible voltage thresholds.

ANNEX A presents the requirements of the regulator-traffic light interface, based on the Spanish proposal to CENELEC.

Taking into account the values defined by this interface, it will be necessary that:

- The regulator is capable of providing its output with a voltage of 42VAC (+15%, -20%) in the case of full illumination and 25VAC (+15%, -20%) in the case of dimmed lighting.

- The installer should size the cables of the installation appropriately, to avoid a voltage drop of more than 5%, taking into account the maximum consumption defined in ANNEX A, a maximum of 5 bulbs per colour and the possibility of lighting 2 colours simultaneously in each group.

6.2 Interface with Control Center and Handheld

The regulator shall communicate:

- With the Control Center over an Ethernet network with TCP/IP protocol

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- With a portable device via an RS232 port.

The two media outlets will use the same command interpreter.

All messages exchanged between the controller and the maintenance device will be identical to those exchanged between the controller and the Control Centre, regardless of the fact that in the case of communications with the Control Centre the messages will be transmitted with the encapsulation explicit in the protocol plus that of TCP/IP. In addition, there will be additional messages in binary format between the controller and the Control Center.

In general, the communications protocol will allow:

- Entering into the regulator, both from the Control Centre and from the portable device, all the data and parameters necessary to define the junction regulation. The regulator must have a system for checking errors in incoming orders, in order to reject those that contain erroneous data and, especially, a check for those errors or failures in the data that may cause safety problems at the intersection (incompatibilities, phase structure, minimum times, etc.).

- The transmission in asynchronous mode, from the regulator to the Control Centre, of all the alarms that are generated.
- Remote establishment of the controller's operating mode and control methods, and the loading of external plans.
- Consultation of the regulator's status, both from the Control Centre and from the portable device: status of auxiliary inputs, detector data, status of outputs, active alarms, historical alarm record

The communications protocol is described in detail in ANNEX D to this document.

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ANNEX A REGULATOR-TRAFFIC LIGHT INTERFACE

The following tables present the requirements of the regulator-traffic light interface, based on the Spanish proposal to CENELEC. The tables present the values of the main magnitudes under the following working conditions:

- Steady-state operation
- Connection procedure (traffic light illumination)
- Shutdown procedure (traffic light shutdown)

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Table 19: Steady-state operating conditions. Data at traffic lights

Ownership	Definition	Unity	Dimension	Threshold	Value
Tension of Operation with Full Brightness *(from the optical drive)*	Effective voltage at the input of the unit optics with which the intensity luminous corresponds to the class indicated in the EN 12368 standard	*UIN* (nom)	VAC	Nominal	42
		UIN (min)		Minimum	31
		UIN (max)		Maximum	50
Tension of Operation with Reduced brightness	Effective voltage at the input of the unit optics with which the intensity luminous corresponds to the levels desired to operate in bright light Reduced (dimming)	*UIN* *(dimmed)*	VAC	Minimum	18
				Nominal	25
				Maximum	29
Current of Operation	Effective Current Values (RMS) operating in the range of UON – UIN(max) voltages with the unit Optics on and in a steady state	*IIN*	mA	Minimum	184
				Maximum	485
Distortion Total Harmonica	Relationship between the power of the Harmonics above frequency and the power of the Fundamental frequency	THD	%	Maximum	33%
Consumption at voltage nominal of Operation	Optical unit consumption at the nominal voltage UIN	*PIN* (nom)	W	Minimum	7
				Maximum	15
Factor Power (COS *φ*)	Absolute value of the quotient between the Primer Input Current harmonic and input current total, according to EN 61000-3-2, Class C both in Control Mode and in Failure Mode	λ	[1]	Minimum	0,9

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Table 20: Connection procedure (lighting). Data at traffic lights					
Ownership	Definition	Unity	Dimension	Threshold	Value
Interval of Connection (current)	Time interval from the application of the tension of operation until the input current exceeds Minimum Operating Current	*TSET* (current)	more	Maximum	20
Interval of Connection (Light)	Time interval from the application of the tension of operation until the Luminous intensity of the unit optics reach defined levels by EN:12368	*TON* (light)	more	Maximum	50
Tension of Connection	Operating voltage from of which the optical unit Delivers light intensity 10 cd (considered on)	*UON*	V_{AC}	Minimum	15
				Maximum	18
Interval of Overcurrent transitory of Connection	Time interval from the application of the tension of operation until the current stabilizes within certain margins of Operating Current (80%) < IIN < *120%)*	*TON* (current)	more	Maximum	100
Overcurrent of Connection	Maximum permissible value of the I ON connection current during TON period	*ION*	mA	Maximum	1000

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Table 21: Disconnection procedure. Data at traffic lights

Ownership	Definition	Unity	Dimension	Threshold	Value
Interval of Disconnection (Light)	Time interval from the Stress Removal operation until the Luminous intensity of the unit Low optics below 0.05 cd (level considered off)	*TOFF* (light)	more	Maximum	50
Tension of Disconnection	Operating voltage below of which the optical unit supplies a light intensity less than 0.05cd (considered off)	*UOFF*	V_{AC}	Minimum	15
				Maximum	18
Voltage Ratio Residual	Relationship between residual stress measured in the optical unit and the rated operating voltage, at After a Time Interval (50 ms) after elimination of the nominal voltage of operation.	*UREV*/ $U_{IN (nom)}$	%	Maximum	10

ANNEX B GLOSSARY AND ACRONYMS

B. 1 - Glossary

Table 22: Glossary		
Name	**Definition**	**Comments**
Traffic light head *Signal head*	Part of a traffic light consisting of a reinforcement where the entire device has been mounted light signaling.	
Traffic light head *Signal head*		See Traffic Light Head
Traffic light face *Signal face*		View Optical Drive
Cycle (traffic light) *Cycle*	Complete sequence of indications for a set of traffic lights governed by the same traffic.	
Color	Each of the 3 independent outputs of a Same Group	
Coordination of traffic lights *Traffic signal coordination*	Traffic light regulation on an itinerary or network road, in which the indications of the traffic lights are related to each other	
Traffic light control Traffic-driven *Traffic-actuated signal Control*	Variable cycle traffic light control system in the which cycles and phases vary according to the traffic demand recorded by detectors or by the operation of contact buttons.	
Traffic light control Powered by pedestrians *Pedestrian-actuated signal Control*	Variable cycle traffic light control system by means of a contact button that pedestrians can be pressed to make the indication change a traffic light.	
Traffic light cycle control Fixed *Fixed-time signal control*	Traffic light control system in which the duration of The phases are fixed and the indications follow one another alternately at constant intervals.	
Traffic light cycle control Variable	Traffic light control system in which the duration of The phases vary according to the needs of the	The cycle regulation is can be done by means of

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Table 22: Glossary

Name	**Definition**	**Comments**
Variable-time signal control	traffic.	watches, detectors, from a control room, etc.
Detector *Detector*	Device used to detect the presence of a physical phenomenon, a circumstance, a parameter, etc., which affects the circulation	
Structure	Preset sequence of main phases	
Phase diagram *Phase diagram*	Graphical representation of the schema of operation of vehicle movements and pedestrians at an intersection regulated by traffic lights.	
Structure	Stable phase sequence	
Phase *Phase*	Status of a traffic light-regulated intersection in which a series of movements are allowed compatible with each other.	
Main phase	It corresponds to those intervals or phases that represent a stable state of allocation of Intersection usage times to about Traffic movements	It corresponds to the time of access green to a intersection;
Saturated phase *Saturated phase*	Phase in which the number of vehicles you want Passing an intersection during green time is greater than the number of vehicles that can do it.	
Secondary phase	It corresponds to the necessary intermediate states as a transition between the main phases.	It corresponds to the times Safety
Transitional phase		See Secondary phase
Traffic light group *Signal group*	A set of traffic lights that control a movement independent of vehicles or pedestrians, and in which The same color state always coincides.	
Traffic light indication *Signal indication*	Light emitted by a traffic light, of one color or more than one simultaneously, which serves to give or prohibit the passage of vehicles and pedestrians.	

Table 22: Glossary		
Name	**Definition**	**Comments**
Traffic light interval *Signal interval /Signal stage*	Period of time during which all Indications of a group of traffic lights are constant.	
Detention Line *Stop line*	Cross road marking consisting of a line white of continuous stroke that no vehicle or its cargo can pass through as long as the obligation to stop imposed by a stop, a pedestrian crossing, a level crossing, a traffic light or a traffic signal.	
Dimmed brightness *Dimming*	Reduction of the light intensity provided by an LED-based optical unit that is obtained when applying a tension between 65% and 75% of the nominal voltage corresponding to the Full brightness.	
Full Brightness	Luminous intensity of an optical unit based on LEDs that are obtained by applying the nominal voltage of operation.	
Macro-regulation *Area control / Macrocontrol / Strategic control*	Method of traffic regulation that considers the average traffic conditions over long periods and over a wide area in order to ensure the stability of traffic management actions and Establish the appropriate coordination of traffic lights.	
Micro-regulation/ Regulation Tactics *Tactical control*	Method of traffic regulation that considers the individual vehicle circulation, generally in an intersection or in short periods, and that adapts the coordination of traffic lights to respond to a immediate situation.	
Green Wave *Green wave*	Result of a progressive system of coordination traffic lights that allow a vehicle to travel a whole route regulated by traffic lights without having than to stop.	
Traffic light plan *Traffic signals program*	Set of the duration of the cycle, the order of development of the phases and phases required in an intersection, an itinerary or a network of operation of traffic lights.	

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Table 22: Glossary		
Name	**Definition**	**Comments**
Traffic light regulation *Traffic signal control*	Traffic regulation through the use of traffic lights	
Traffic light regulator *Traffic signal controller*	A device that governs the changes of lights of a set of traffic lights controlling the passage of traffic lights various vehicle or traffic flows pedestrians.	
Traffic light *Traffic light/Traffic signal*	Light signalling device to regulate the vehicle and pedestrian traffic, especially in urban centres	
Pre-signalling traffic light	Traffic light with two flashing amber lights that Warn drivers of the presence of a traffic light to the next intersection.	
Audible traffic light	Pedestrian traffic light that emits audible signals so that blind people can identify the phase in which it is	Sound signals They can be beeps of Different frequency depending on The phase or messages spoken that they give, in addition, some other information.
Unwanted signal	Unwanted signal whose light intensity does not meet with "off" signal requirements	
Lead Time/Time Stop *Delayed time/Stop* *time/Waiting time*	The time interval during which a unit of traffic has to be waited at a red light, or in the event of an obstacle before being able to continue the march.	
Time-out *Lost time*	Time during which all traffic lights in a intersection have only the red light on.	
All red *All-red period*	Situation in which all traffic lights in a intersection have only the red light on.	

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Table 22: Glossary		
Name	**Definition**	**Comments**
Transition	Sequence of secondary phases between two phases Main courses	
Optical drive *Signal face*	Component assembly (lens set, bulbs, etc.,) designed to produce a light, with a nominal size, a color, an optical intensity, and a specific way.	

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B. 2 - Acronyms

Table 23: Acronyms	
GMT	Greenwich Mean Time
GPS	Global Positioning System
UPS	Uninterruptible power supply
USB	Universal Serial Bus
LED	Light Emitting Diode
ASCII	American Standard Code for Information Interchange
TCP/IP	Transmission Control Protocol/Internet Protocol
CENELEC	Comité Européen de Normalisation Electrotechnique
0CIT	Open Communication Interface for Road Traffic Control Systems
ODG	OCIT Developer Group
ASTRIN	Association of Traffic Industries in the Netherlands

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Telèfon 93 402 39 67
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ANNEX C REFERENCE STANDARDS

[1] **UNE-HD 638 S1:2001**

Road traffic signalling systems

[2] **UNE 135401-1 EX**

Road Marking Equipment – Traffic Controllers

Part 1: Functional Features

[3] **UNE 135401-2 EX**

Road Marking Equipment – Traffic Controllers

Part 2: Test Methods

[4] **UNE 135401-3**

Road Marking Equipment – Traffic Controllers

Part 3: Electrical Characteristics

[5] **UNE 135401-5 IN**

Road Marking Equipment – Traffic Controllers

Part 4: Communications Protocol, Type V

[6] **UNE 135401-6**

Road Marking Equipment – Traffic Controllers

Electromagnetic Compatibility

[7] **UNE-EN 12675:2001**

Traffic lights. Functional safety requirements

[8] **UNE-EN 50293:2001**

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Fax 93 402 34 18

Electromagnetic Compatibility

Road traffic signalling systems

Product Standard

[9] UNE-EN 60068-2-64

Environmental Testing

Part 2: Test Methods

Fh Test: Broadband Random Vibration (Digital Control) and Guide

[10] EN 50102:1995

Degrees of protection provided by electrical material enclosures against external mechanical impacts (IK code)

[11] EN 60068-2-75

Environmental tests.

Part 2: Essays. Eh Test: Hammer Tests

[12] EN 60259:1991

Degrees of protection provided by the enclosures (IP code)

[13] UNE 20324 Erratum

Degrees of protection provided by the enclosures (IP code)

[14] EN 60068-2-2:1993

Environmental Testing

Part 2: Essays

Test B: Dry heat

[15] EN 60068-2-1:1993

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Environmental Testing

Part 2: Essays

Test B: Cold

[16] EN 60068-2-30:1999

Environmental Testing

Part 2: Essays

Db Test & Guide: Cyclic Wet Heat Test (12+12 Hour Cycle)

[17] EN 60068-2-5:1999

Environmental Testing

Part 2: Essays

Exhibit SA: Artificial solar radiation at the level of the Earth's surface

[18] UNE 20460-5-54:1990

Electrical installations in buildings. Choice and installation of electrical materials. Grounding and protective conductors

[19] IEC 60536

Classification of Electrical and Electronic Equipment with Respect to Electrical Shock Protection

[20] IEC 60-1

High Voltage Testing Techniques

Part 1: General Definitions and Requirements for Testing

[21] UNE-EN 61008-1:1996

Circuit breakers for residual current actuation, without overcurrent protection device, for domestic and analog (ID) applications

[22] UNE-EN 55022

Information Technology Equipment

Characteristics of radio disturbances

Limits and measurement methods

[23] UNE-EN 55014

Electromagnetic Compatibility

Requirements for household appliances, tools

electrical and similar appliances

Part 1: Issuance

[24] UNE-EN 61000-4-2

Electromagnetic Compatibility

Part 4: Testing and Measurement Techniques

Section 2: Electrostatic Discharge Immunity Testing

EMC Basic Standard

[25] UNE-EN 61000-4-3

Electromagnetic Compatibility

Part 4-3: Testing and Measurement Techniques

Electromagnetic field, radiated and radiofrequency immunity tests

[26] UNE-EN 61000-4-4

Electromagnetic Compatibility Part 4:

Testing and Measurement Techniques

Section 4: Rapid Burst Electrical Transient Immunity Tests

[27] UNE-EN 61000-4-5

Electromagnetic Compatibility

Part 4: Testing and Measurement Techniques

Section 5: Shockwave Immunity Tests

[28] UNE-EN 61000-4-6

Electromagnetic Compatibility

Part 4: Testing and Measurement Techniques

Section 6: Immunity to conducted, radiofrequency field-induced disturbances

[29] UNE-EN 61000-4-8

Electromagnetic Compatibility

Part 4: Testing and Measurement Techniques

Section 8: Magnetic Field Immunity Test at Industrial Frequency

EMC Basic Standard

[30] UNE 21308-1:1994

High voltage tests.

Part 1: General definitions and requirements for testing

[31] HD 588.1 S1:1991

High-voltage test techniques

Part 1: General definitions and test requirements

[32] UNE-EN 60950-1:2003

Information technology equipment. Security. Part 1: General Requirements

[33] UNE-EN 61000-3-2:2001

Electromagnetic compatibility (EMC).

Part 3-2: Limits.

Limits for harmonic current emissions (equipment with input current <= 16 A per phase).

[34] UNE-EN 61000-3-3:1997

Electromagnetic compatibility (EMC).

Part 3: Limits.

Section 3: Limitation of voltage variations, voltage fluctuations and flicker in public low-voltage supply networks for equipment with input current <= 16 A per phase and not subject to a conditional connection.

[35] GENERAL ORDINANCE OF THE URBAN ENVIRONMENT

Title III. Noise pollution

Directorate of Mobility Services
Pl. Carles Pi i Sunyer, 8-10, 4th floor
08002 **Barcelona**
Telèfon 93 402 39 67
Fax 93 402 34 18

ANNEX D COMMUNICATIONS PROTOCOL