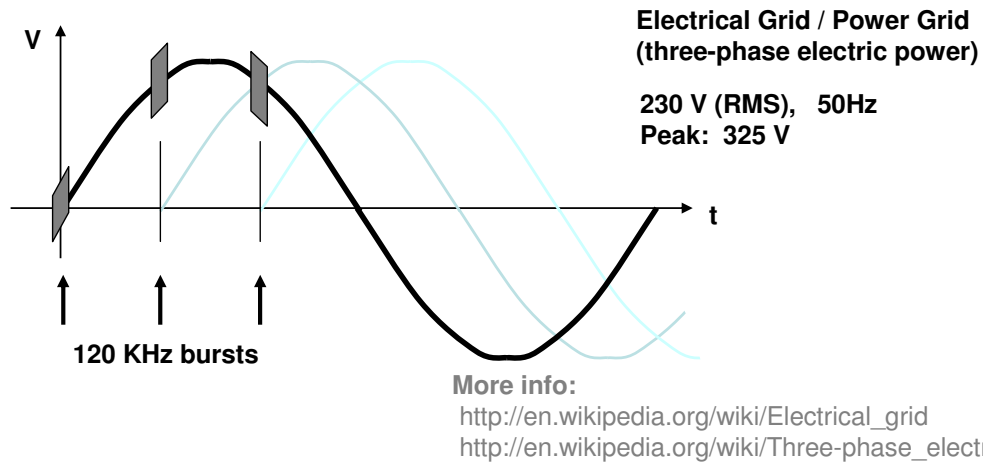# Technology **X10**
for Home Automation

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Technology X10

- Developed in the 70's

- Big commercial success
  (specially in the USA)

- Low cost
  (at least, less expensive than other technologies)

- Uses the power-line as the communication medium

- Is simple and easy to install

Power Line Signaling

**Electrical Grid / Power Grid
(three-phase electric power)**

**230 V (RMS), 50Hz
Peak: 325 V**

120 KHz bursts

More info:
http://en.wikipedia.org/wiki/Electrical_grid
http://en.wikipedia.org/wiki/Three-phase_electric_power

- A 120KHz burst is sent when voltage crosses zero
- To support three-phase electrical installations, two more bursts are sent as depicted (when the other two phases cross zero). A phase coupler can be used to allow signals to travel between different phases
- Each burst lasts for 1ms

Sending Information

Coding of 1

Electric grid
(50Hz)

1 (120kHz)   **0**

Coding of 0

Electric grid
(50Hz)
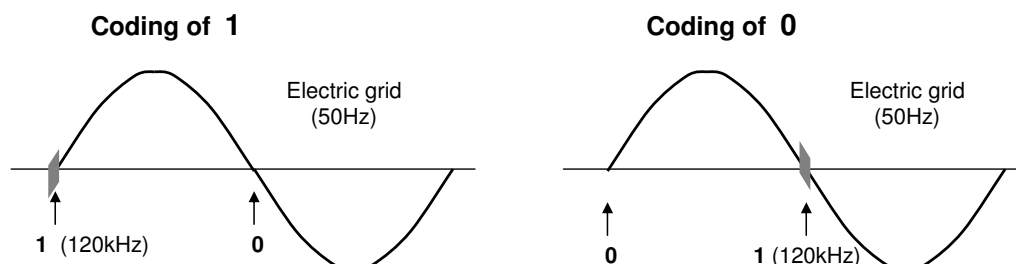
0   **1** (120kHz)

- Sending information "1" corresponds to send a 1 (120KHz burst) followed by nothing (0 = absence of 120KHz)
- Sending information "0" corresponds to do nothing (0 = absence of 120KHz) followed by 1 (120KHz burst)
- Each information bit is coded by two bits (the own bit and its complement: 1 → 1, 0 and 0 → 0, 1)

X10 Frame Format

Start flag	House Code	Device Code or Function Code	Device (0) / Function (1)
1 1 1 0	4 information bits (a total of 8 bits)	4 information bits (a total of 8 bits)	1 information bit (a total of 2 bits)

- Start flag = 1 1 1 0 (note: breaks the rule that each bit is followed by its complement; objective: univocally identify the start of a new frame)
- Every message includes a House Code (2^4 = 16 different houses possible)
- A frame can include a Device Code (2^4 = 16 different devices) **or** can include a Function Code (2^4 = 16 different functions)
- The last field (Device/Function) has 1 information bit that specifies if the previous field identifies a device (if bit is 0) or a function (if bit is 1)
- Maximum number of devices that can be addressed: 2^8 = 256 (if all house codes are used in a single house; some functional restrictions apply !)

X10 Frame Format

Start flag	House Code	Device Code or Function Code	Device (0) / Function (1)
1 1 1 0	4 information bits (a total of 8 bits)	4 information bits (a total of 8 bits)	1 information bit (a total of 2 bits)

- Commanding a device implies sending **two** frames:
  - One that selects the device (specifies its address = house code + device code)
  - Another that specifies the function to be performed (must use same house code as previous frame)
- It is possible to select several devices and then send a command that will be executed by all of them (works if they share the same house code !)

Sending a Frame

- All frames are sent **twice** (<u>except</u> *Dim* and *Bright* – see next slide – because these two functions are sent multiple times to incrementally reduce/increase light intensity)
- Between two **<u>different</u>** frames a silence of 3 cycles must occur (corresponds to six, low-level, zeros).
- Sending a command is very slow: it takes around 1 second.

X10 Function Codes

Code	Function	Description
0 0 0 0	All Units Off	Switch off all devices with the house code indicated in the message
0 0 0 1	All Lights On	Switches on all lamp devices with the house code indicated
0 0 1 0	On	Switches on a device
0 0 1 1	Off	Switches off a device
0 1 0 0	Dim	Reduces the light intensity
0 1 0 1	Bright	Increases the light intensity
0 1 1 0	All lights Off	Switches off all lamp devices with the house code indicated
0 1 1 1	Extended Code	Extension code
1 0 0 0	Hail Request	Requests a response from a device with the house code indicated
1 0 0 1	Hail Acknowledge	Response to the previous command
1 0 1 x	Pre-Set Dim	Allows the selection of two predefined levels of light intensity (x = 0, 1)
1 1 0 0	Extended Data	Extended data (8 bytes)
1 1 0 1	Status is On	Response to Status Request indicating that the device is switched on
1 1 1 0	Status is Off	Response to Status Request indicating that the device is switched off
1 1 1 1	Status Request	Request the status of a device

Setting a Module's Address
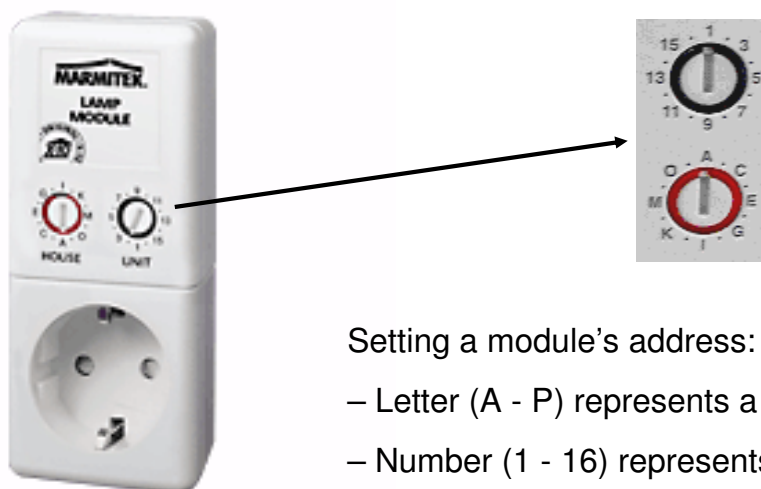
Setting a module's address:

– Letter (A - P) represents a House Code

– Number (1 - 16) represents a Device Code

X10 Encoding Scheme

House Code	Device Code	Value (bin)
A	1	0110
B	2	1110
C	3	0010
D	4	1010
E	5	0001
F	6	1001
G	7	0101
H	8	1101
I	9	0111
J	10	1111
K	11	0011
L	12	1011
M	13	0000
N	14	1000
O	15	0100
P	16	1100

Value (bin)	Function
0000	All Units Off
0001	All Lights On
0010	On
0011	Off
0100	Dim
0101	Bright
0110	All Lights Off
0111	Extended Code
1000	Hail Request
1001	Hail Acknowledge
1010	Pre-set Dim (1)
1011	Pre-set Dim (2)
1100	Extended Data Transfer
1101	Status On
1110	Status Off
1111	Status Request

Types of Modules

- Lamp Module
  - Works only with <u>incandescent lamps</u>
  - Can **turn on**, **turn off**, **dim** (reduce intensity) and **bright** (increase intensity)
  - May implement two pre-set intensity levels

- Appliance Module
  - Works with different types of loads
  - Can **turn on** and **turn off**

Mounting Variants

Connects to powers sockets (external unit)

DIN rail mounted (inside an electrical enclosure)

Wall mounted (flush mounted)

Examples of X10 Modules

Lamp Module

Receives commands (on, off, dim, bright)

Screw mount

Lamp Module

Receives commands (on, off, dim, bright)

Pressing the buttons controls the module directly

Wall mounted (Flush mounted)

Special Modules

- ## These modules issue commands
  - ### Send on/off commands to a specified address (house code + device code)

Thermostat
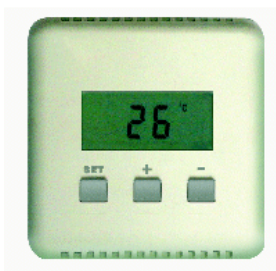
Temperature changes triggers sending an on/off command

Interface module

Applying a signal or closing an electric contact triggers sending an on/off command

Contact becomes closed → send ON
Contact becomes open → send OFF

Radio Frequency Devices

RF interface

Receives RF commands and issues power-line (X10) commands

X10 Controllers

X10 Timer

X10 Controller and PC interface

Allows a PC to monitor and send commands to the power-line.

Ref.: **CM11**
(see also CM15)

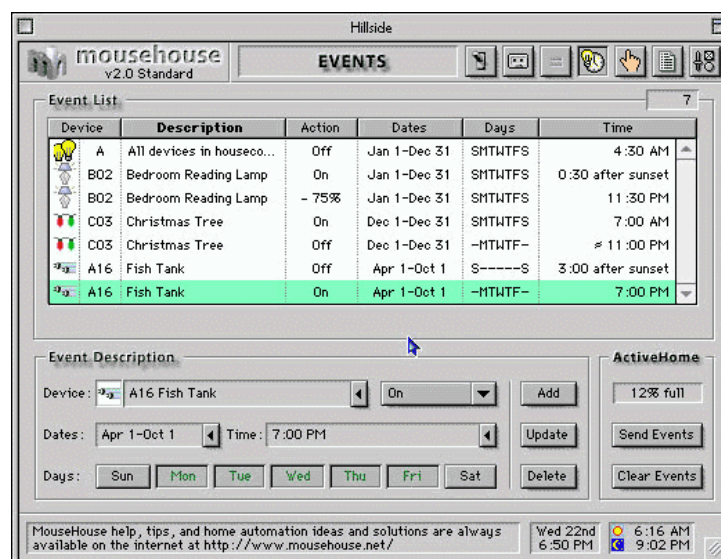**Allows manual commands and automated time programming.**
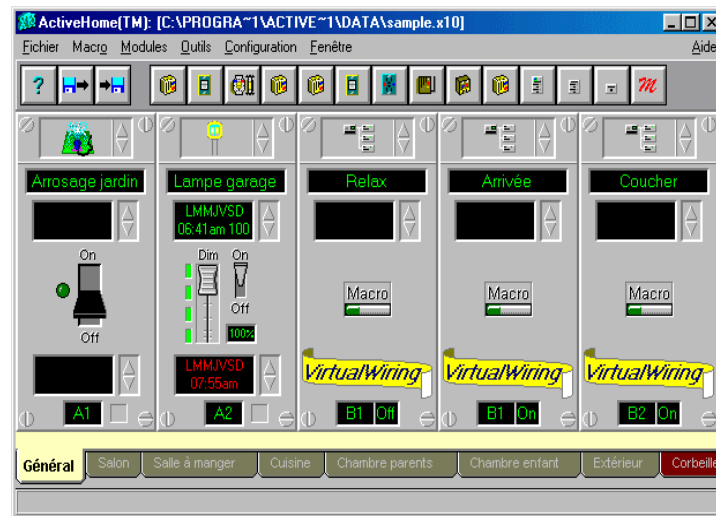
Example of a X10 System
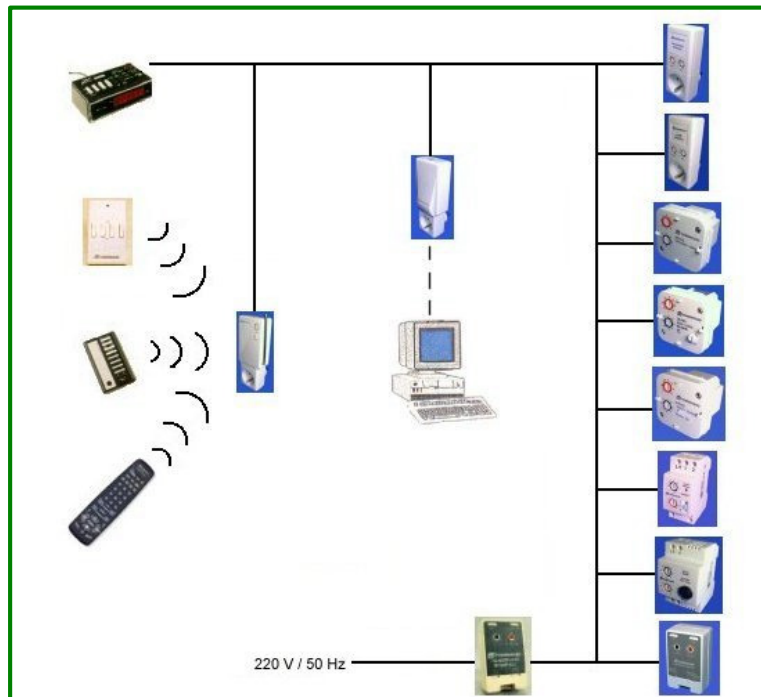
Controlling a X10 System

Controlling a X10 System

Controlling a X10 System

ActiveHome
software
uses the
CM15A
controller

Conclusion

- Main advantages
  - Simplicity and ease of installation
  - Low cost
  - Can be used in an already existing house
- Main disadvantages
  - Very low communication bandwidth
  - Low protocol reliability
  - Low number of possible devices

Questions?