Smart Street Light Dimmer

Group-3 (IIT ROPAR)

under BYTE program

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EMPATHISE

User Research:

- Interviews with urban municipal workers and street maintenance staff to understand current lighting control systems.
- Surveys of residents and night-shift workers to gauge visibility and safety needs at night.
- Observations of traffic patterns during late-night hours in different city zones.

Key Insights:

- Streetlights remain fully powered even in low or no traffic zones post-midnight.
- City budgets are strained by electricity bills, especially in high-density areas.
- Pedestrians and vehicles often do not require maximum brightness in empty roads.

Pain Points:

- Wastage of power and taxpayer money.
- Light pollution in residential areas.
- Environmental impact due to unnecessary energy consumption.

DEFINE

Urban streetlights operate at full brightness irrespective of foot or vehicle traffic during low-demand hours, leading to high energy consumption and carbon emissions.

Scope Definition:

- Focus on late-night operation (10 PM – 5 AM).
- Target low-traffic residential and industrial areas first.
- Streetlights controlled individually or in clusters based on real-time traffic flow.

GOAL:

To design an energy-efficient streetlight dimming system that dynamically adjusts brightness based on traffic presence, without compromising public safety.

DEATE

Texas Instruments

CORE DESIGN FORCE

SENSOR SELECTION STUDY

OUR SYNERGISTIC APPROACH

DEATE : CORE DESIGN FORCE

What ultimately defines success?

SAFETY

- Consistent lighting for safe pedestrian movement
- No cameras to ensure privacy protection
- Sensor-based control to avoid sudden darkness

FORECASTING

- Detect motion in advance of pedestrian arrival.
- Ensure sufficient lead time for smooth brightness transition

RESPONSIVE ILLUMINATION

- Dimmed for calm, Brightened for activity
- Modular design : API - driven logic -> easy upgrade or customize

DEATE : SENSOR SELECTION STUDY

INFRARED/ULTASONC(0-3m)

- ✓ Very Cheap(Rs.50-100)
- ✓ Any Object Detection
- ✗ Less Range and Coverage
- ✗ Needs Perfect Alignment

Radar(0-200m)

- ✓ Long Range, all weathers
- ✓ AWR- automotive detection
- ✓ Datasheet/model available by TI for vehicle detection
- ✓ Priority override can be done
- ✗ Costly

PIR Motion(5-10m)

- ✓ Human Focusd
- ✗ Less Range and Coverage
- ✗ Misses clod vehicles
- ✗ Unable to detect non-stationary obejcts

Camera(0-50m)

- ✓ Rich data and future proof
- ✗ High power use
- ✗ Short life span
- ✗ Expensive

INFRARED/ULTASONC(0-3m)

- ✓ High accuracy and precision
- ✓ Work in low light conditions
- ✗ Very expensive
- ✗ Affected by fog , rain and dust

DEATE : WIRELESS COMMUNICATION

Bluetooth(0-10m)

- ☑ Ultra low power
- ✗ Too short for MCU spacing
- ✗ 10 m range is very short.

WiFi(Range: 50-100 m)

- ☑ Wifi is everywhere, suppprts fast data
- ✗ Use a lot of power
- ✗ Nees router to cover an area
- ✗ Risk of interference

LoRa(Semtech)(5-15KM)

- ☑ Ultra low power
- ✗ Not a product of TI
- ✗ Extra bill of material and certification needed

DEATE : TI CC1312R7(OUR CHOICE)

TI CC1312R7(1KM)

- Integrated MCU + AES-128 radio
- SimpleLink SDK for SP/I2C and PWM drivers
- On-chip flash for logs and OTA firmware updates
- Low power modes(<1uA sleep)
- Fully in TI family - one vendor, one toolchain, one BOM

Features

- Ultra-low sleep current
- Built-in MCU with Sub-GHz Radio Frequency
- 128-bit AES Hardware Encryption
- Internal Timers
- Wireless OTA Firmware Upgrades
- PWM-Based Brightness Control
- Wireless Communication Over 1 km

DEATE : AWR6843 RADAR

AWR6843 Radar

- **FMCW** (Frequency-Modulated Continuous Wave) mmWave radar
- Operating in the **60 GHz ISM band** to enable high-resolution object detection up to 200 meters.
- Delivers real-time measurements of both range and radial velocity, allowing the system to perform predictive brightness control for streetlights based on approaching object motion, independent of weather conditions.

- 1 AWR6843 radar is installed on first lamp of each 5-lamp group.
- Lamps are spaced 35 meters apart, covering a 175-meter stretch.
- The radar detects approaching objects and sends a signal.
- This signal is broadcast via TI CC1312R7 (Sub-1 GHz) to the other 4 lamps.
- All 5 lamps brighten in sync, enabling smooth, anticipatory lighting.
- When no motion is detected, lamps dim to 10–20%, saving energy.

BLOCK DIAGRAM

Texas Instruments

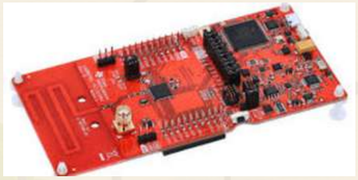
Solar panel

Charge control

Capacitor

Lithuim ion battery

3.3V Rail BUCK

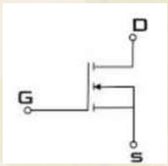


CC1312R

LDR sensor

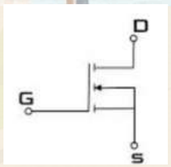
Radar

PWM



MOSFET

LED



MOSFET

Message to other street lights

Prototype

Here is our demo via TinkerCad on Arduino board: SIMULATION LINK: https://www.tinkercad.com/things/b3ShjQMp1lT-smart-street-light-?sharecode=pYmFXSowwQA3zFg-XhGliW5zqv3pkTI-yd5uiAeoYkk

Instructions:-

1. Go to start simulation
2. Check the light level of the photoresistor
3. If it's bright, the lights stay off
4. If it's dark, it allows the light to turn on, and at the same time, the ultrasonic sensor detects if anyone is nearby
5. If a person or object is within the specified range, the system understands the presence of a vehicle or pedestrian
6. Hence, this kind of dual-conditions system is beneficial in smart streetlights

Cost Analysis and Power Requirements

AWR6843 Radar

- All-in-one radar solution Compact,
- low-power, and cost-effective
- cost : ₹2500-₹2850
- power consumed: 13.641Wh(11h)

CC1312R(MCU)

- Long-Range, Low-Power Wireless
- Dual-Core MCU with TI Tool Support
- cost : ₹3000-₹4000
- power consumed: 0.22968Wh

IP65

- Offers higher protection level, suitable for harsher environments.
- cost : ₹290

LDR(CdS)

- Inexpensive and easy to integrate with Arduino or any MCU. Dual-Core MCU with TI Tool Support.
- cost : ₹5-₹10
- power consumed: 1.2-6Wh(24h)

INMP441

- Can capture both quiet and loud sounds without distortion.
- Operates in -40°C to +85°
- Cost : ₹250-₹600
- Power consumed: 0.0418(11h)

Electric cables

- Cost : ₹25-₹50 /m
- ₹15000 (for set of 5)

- **Total cost of one Streetlight is ₹6070**

Daily Power Consumption

- Power used by normal street light per day: 3016Wh/day
- Power consumed by smart light per day:
- Other Components (MCU, Sensors, etc.)

1. MCU (CC1312R): 0.23 Wh
2. TIAWR6843: 13.64 Wh
3. LDR (CdS): 3.6 Wh (average)
4. INMP441: 0.04 Wh
5. Power consumed by other components = 0.2313.64+3.6+0.04 =17.51 W
6. Daily power consumed is 1455.9Wh/day

so power we are saving is 1560Wh/day


Thank You