

# Switch Mode Constant Current LED Driver with High Efficiency, High Precision and Wide Dimming Ratio

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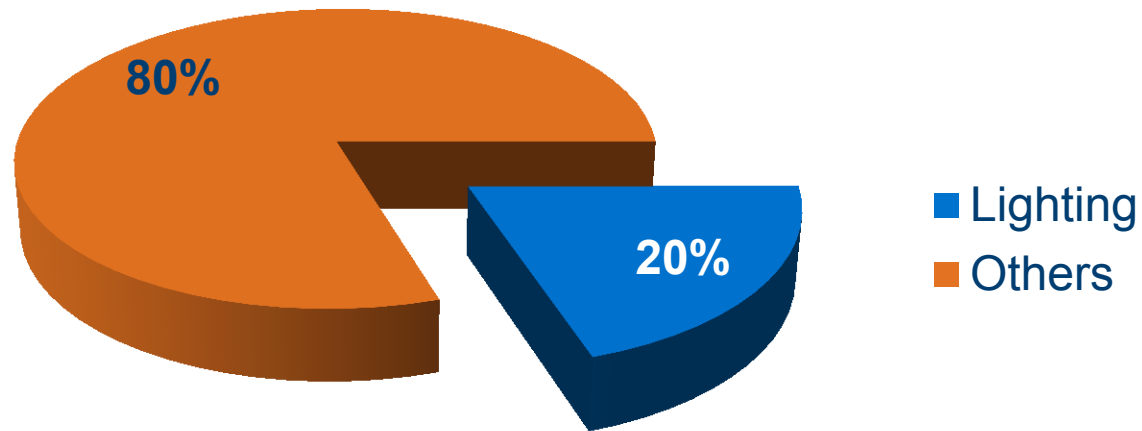
Department of Engineering

# Keynotes

- Background
- LED Driver assessments
- Buck topology (core switching)
- Duo-Pulse gate drive
- Conclusion

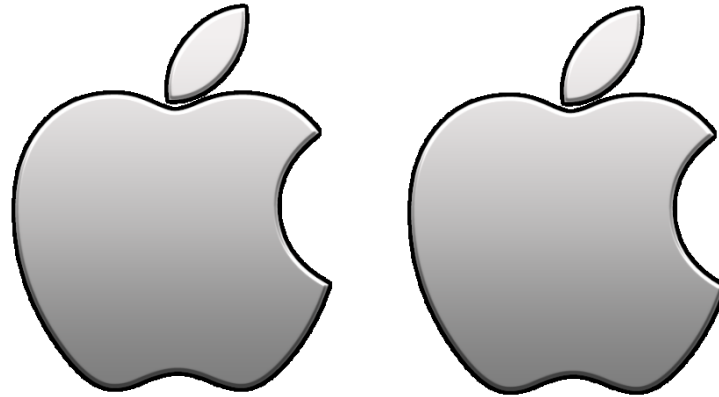
# Background

## Electricity Consumption



4 000 000 000 000 kWh = 800 billion US\$

# Background



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4 000 000 000 000 kWh = 800 billion US\$

# LED Driver Assessments

## Driver Property

- Simplicity
- Reliability
- Cost
- Efficiency
- Dimming Ratio
- Current Precision
- Current Ripple
- Flicker-free
- Chromatic Stability
- ...

## Lighting Application

- Street Lighting
- Public Lighting
- Surveillance lighting
- Office Lighting
- Reading Lighting
- LCD Backlighting

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- Simplicity
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# LED Driver Assessments

## Driver Property

- Simplicity
- Reliability
- Cost
- Efficiency
- Dimming Ratio
- Current Precision
- Current Ripple
- **Flicker-free**
- **Chromatic Stability**
- ...

## Lighting Application

- Street Lighting
- Public Lighting
- Surveillance lighting
- Office Lighting
- Reading Lighting
- **LCD Backlighting**

# My Research

## Driver Property

- Simplicity
- Reliability
- Cost
- Efficiency
- Dimming Ratio
- Current Precision
- Current Ripple
- Flicker-free
- Chromatic Stability
- ...

## Lighting Application

- Street Lighting
- Public Lighting
- Surveillance lighting
- Office Lighting
- Reading Lighting
- LCD Backlighting



# My Proposed LED Driver

## Driver Property

- **Efficiency**

More than 90%

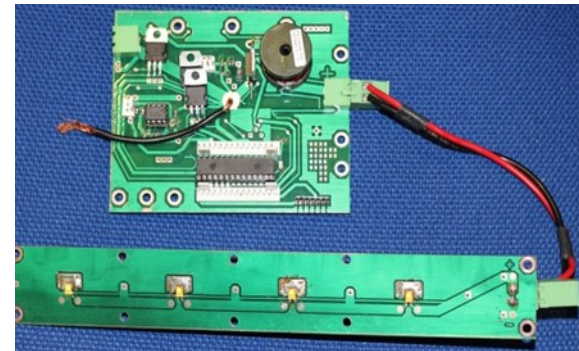
- **Dimming Ratio**

Less than 1%.

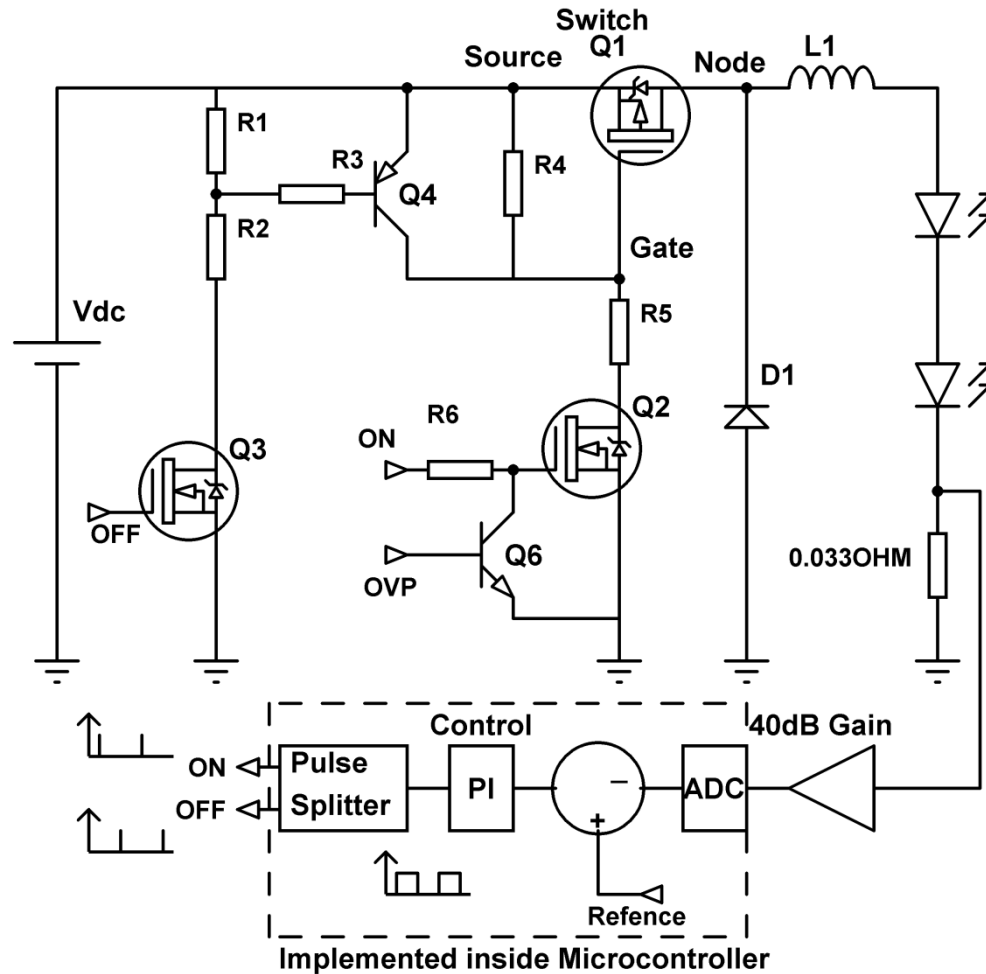
- **Current Precision**

More than 95%.

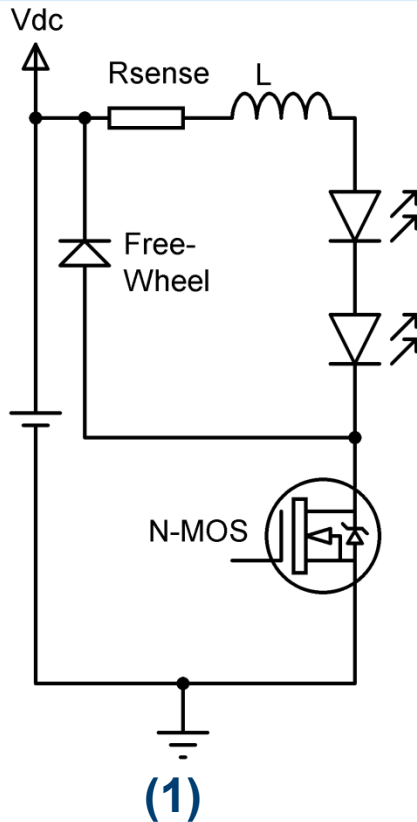
## Proposed LED Driver



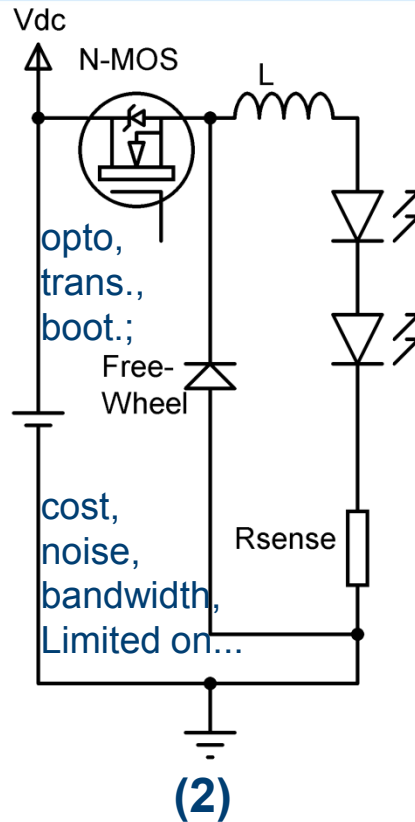
# Proposed LED Driver



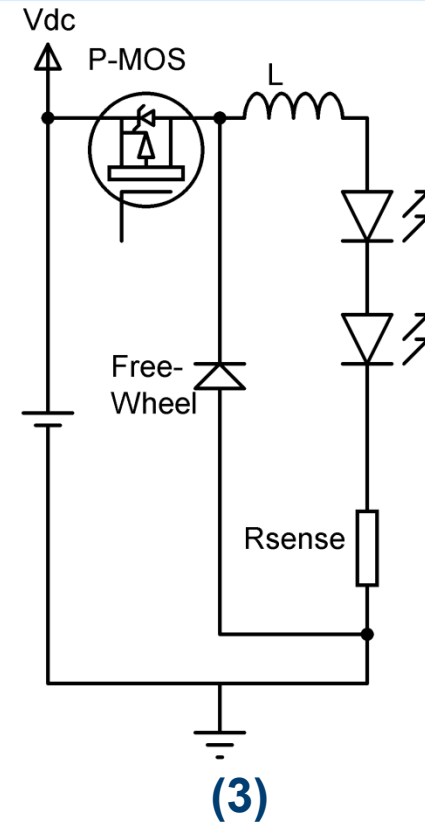
# Buck Topology – core switching circuit



- **Simplest gate Drive**
- **Poor precision**

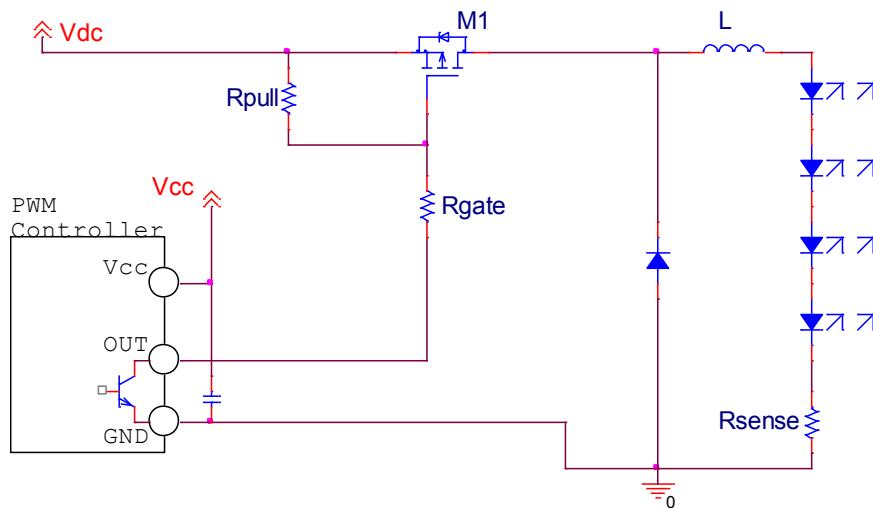


- **High Precision**
- **Complex gate drive**



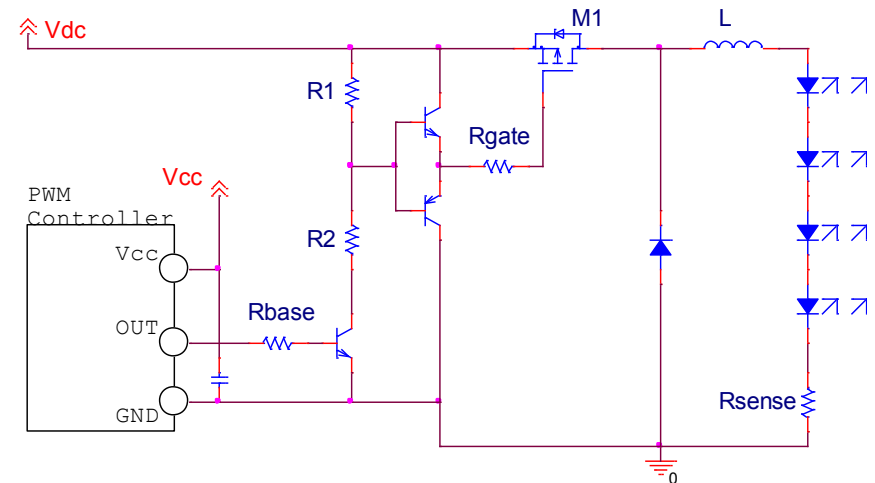
- **Simple**
- **High Precision**
- **High Rds-on**

# Conventional PMOS Gate Drive



(a) Open Collector

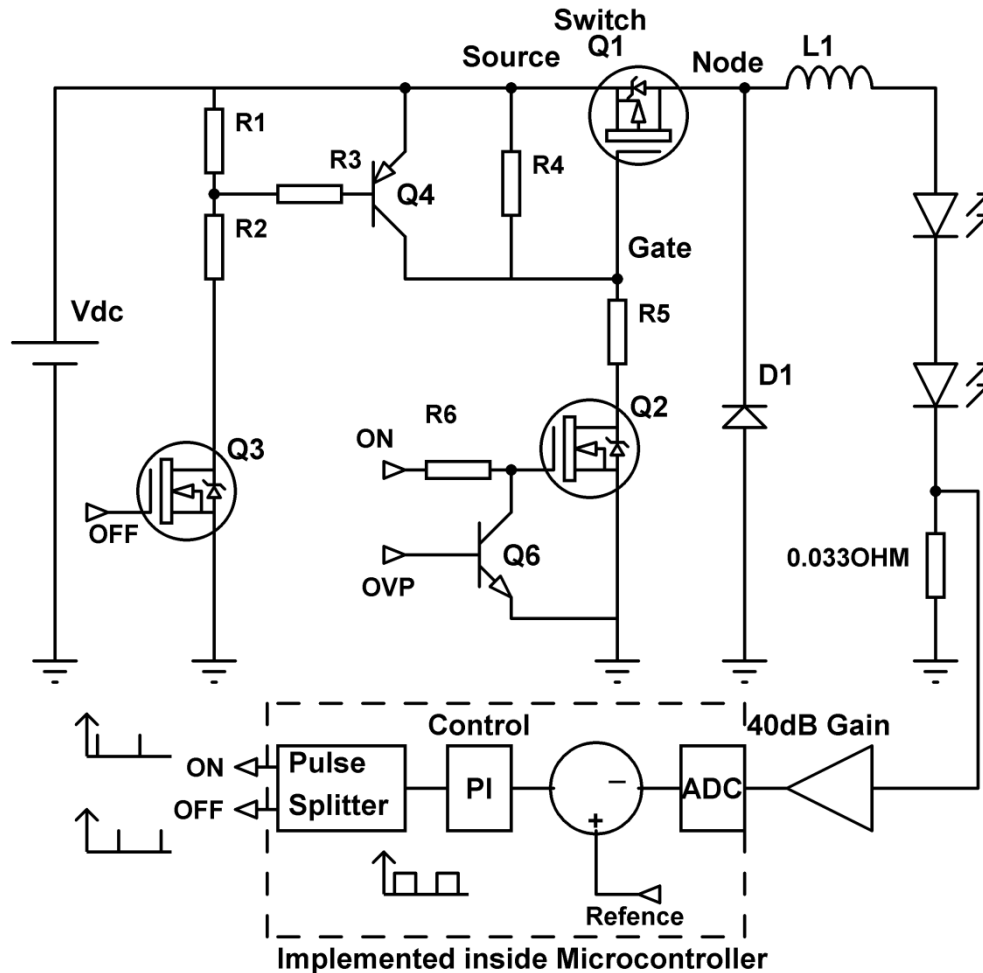
Simple, low speed, low efficiency



(b) level-shifted

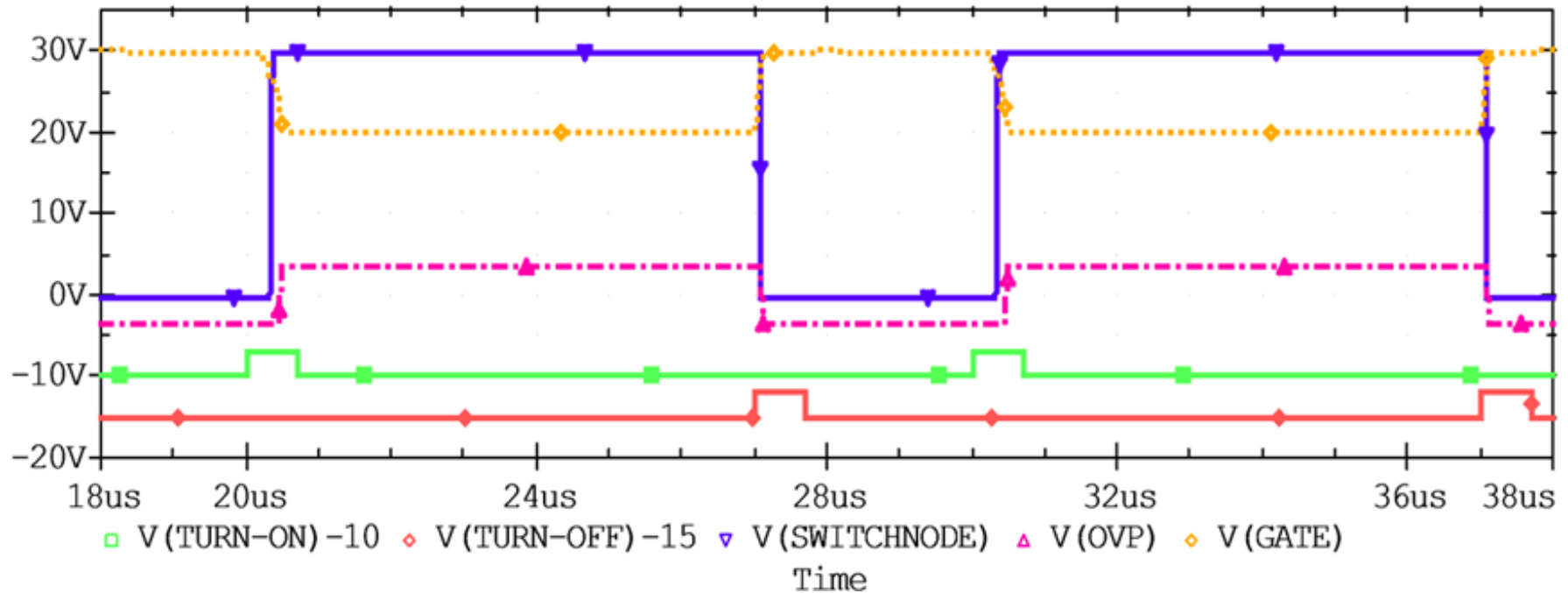
High efficiency, Limited 20V input

# Proposed LED Driver: Duo-Pulse



- **Q2 turn on**
- **Q3 turn off**
- **Off-set = duty ratio**
- **Over Voltage Protection**
- **OVP reset at turn off**
- **33 mohm curent sensor**
- **40dB pre-amplifier**
- **Digital**

# Simulated Switching Waveform (simulation)

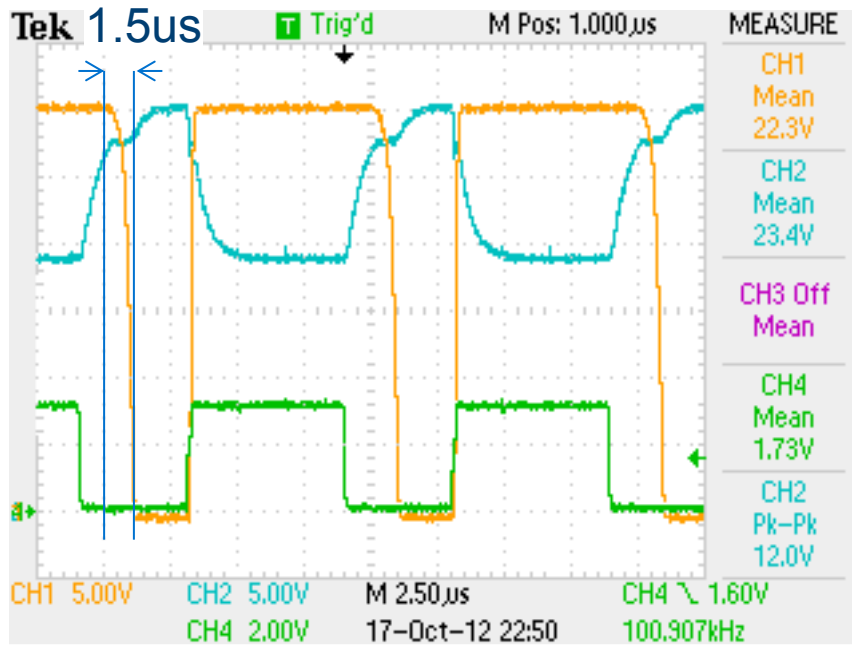


**Green:** Turn-on Pulse  
10us period  
**Red:** Turn-off Pulse

**Blue:** Switch Node (fast)  
**Pink:** OVP (before Green)  
**Orange:** Gate ( $V_{gs} = -10V$ )

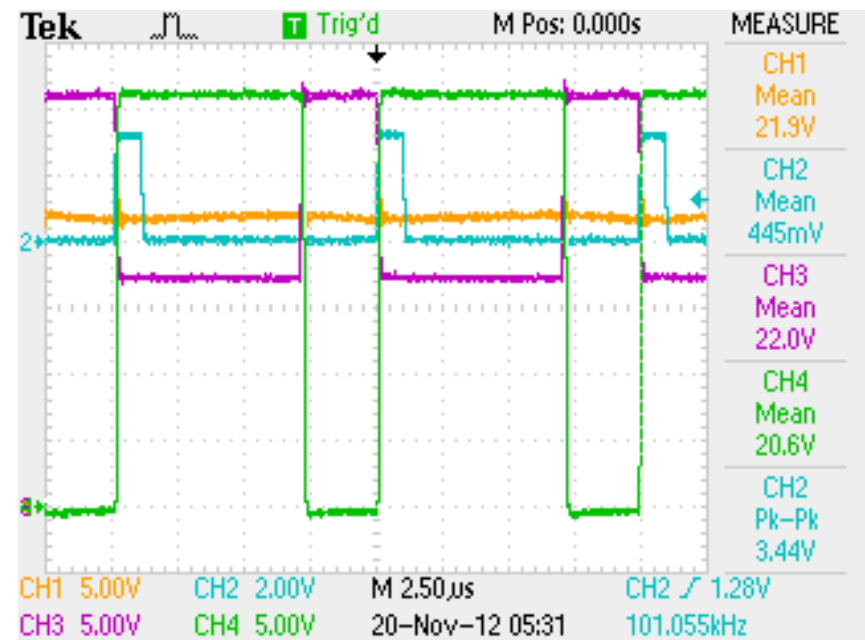
# Switching Waveform Comparison (experiment)

## Open Collector



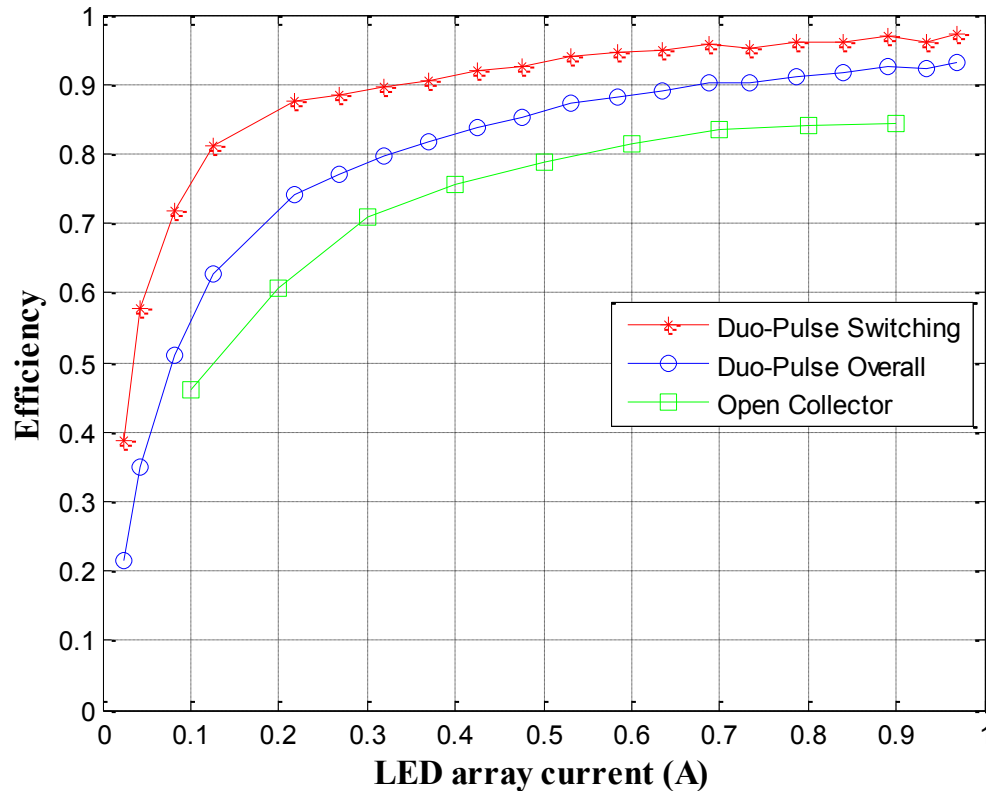
**CH1, Switch Node voltage;**  
**CH2, Gate voltage;**  
**CH4, PWM pulse**

## Duo-Pulse



**CH1, Voltage across LED array**  
**CH2, Turn on pulse**  
**CH3, Gate voltage  $V_{gs} = -15V$**   
**CH4, Switch Node voltage**

# Efficiency Comparison



- **8 series LED array**
- **22W**
- **+90%**
- **1W auxiliary-power**



# Conclusion

- **Successful design and realisation of a switch mode constant current LED driver based on Buck current source is reported.**
- **The constant current drive circuit is an effective route to achieve high system efficiency, high stability, flicker-free and wide dimming ratios in LED lighting.**

# Thank you

