Delta Roadshow

Power Factor Controller
Solution Update
Boost PFC Topologies

• TM: Transition Mode
  – Variable Frequency
  – High Peak Currents
  – Low Cost Diode (D₁)

• CCM: Continuous Conduction Mode
  – Fixed Switching Frequency Eases EMI
  – Ultra Fast or SiC Diode (D₁)
  – Lowest Peak Currents

• DCM: Discontinuous Conduction Mode
  – Variable Frequency
  – Highest Peak Currents
  – Mostly Low Power

- DCM 75W to 100W
- TM 100W to 300W
- CCM 150W to 1kW

TM = Boundary Conduction Mode
= Critical Conduction Mode
Transition Mode Boost PFC

Pros
- Simple Design
- Low Cost
- Standard Rectifier
  - No RRL (Reverse Recovery Losses)

Cons
- High Ripple Current
- Large EMI Filter
- Larger Inductor
- More Output Capacitance from Higher Ripple

Transition Mode PFC (TM) Characteristics
- Zero Current Switching (ZCS) on Rectifier and MOSFET
- Provides PF of 0.90 or better
- Naturally variable frequency
- The TM boost has an inductor ripple of 200%

Envelope is from 60Hz Line Cycle
Continuous Current Mode PFC Inductor (Boost)

Continuous Current means that the boost inductor always has some average current in it except near zero voltage crossing.

Characteristics

- Operates Fixed Frequency
- Provide PF of near unity (1)
- The Inductor size is designed with 20 to 30% inductor ripple

Pros

- Higher Density
- High PF
- Smaller Inductor
- Smaller EMI filter
- Lower Ripple Current
- Smaller output Cap

Cons

- More Complex
- More Expensive
- SiC Diode needed (RRL) (Reverse Recovery Losses)
Parallel PFC Concept

- High peak input current ripple (Same as single-phase)
- Distributed components
- Improved thermal management
- High peak output current ripple (Same as single-phase)

Two Stages in Phase

Output Caps
Interleaved PFC Concept
Operate Two PFC Stages 180° Out of Phase
– (Works with CCM and TM types)

- Distributed components
- Improved thermal management

Cancellation produces
Significant input ripple current reduction

Significantly lower output ripple current from cancellation

Significantly decreases size of output caps

Input and Output Ripple Current Cancellation which allows:
- Physically smaller EMI filter
- Physically smaller output capacitors (less power dissipated because of less ripple current through the caps)
- Physically smaller boost inductors because the current is split in two phases
Boost PFC Selector

- **UCC29950**: PFC/LLC Combo aimed at CCM applications from 150W to 600W

- **Example Part #**
  - UCC28019A
  - UCC2817/18

- **Single Channel CCM**
  - **Example Part #**
    - UCC28050/51

- **Dual Phase Interleaved TM**
  - **Example Part #**
    - UCC28060/61/63

- **Dual Phase Interleaved CCM**
  - **Example Part #**
    - UCC28070

- **Continuous Conduction Mode (CCM)**

- **Transition Mode (TM)**

- **80W to 200W**
- **200W to 800W**
- **800W to 1KW+**
Power Factor Correction (PFC)

UCC29950: PFC/LLC Combo aimed at CCM applications from 150W to 600W

UCD3138
Programmable Digital Power Controller with Three Feedback Loops and Eight DPWM Outputs

UCD3040
Programmable Digital Power Controller with Four Feedback Loops and Eight DPWM Outputs

UCD3028
Programmable Digital Power Controller with up to Two Regulated Outputs and Eight DPWM Outputs

UCD3020
Programmable Digital Power Controller with up to Two Regulated Outputs and Six DPWM Outputs

Fully Programmable Digital Controllers

Buck PFC
1-Phase Transition Mode Boost PFC
2-Phase Interleaved Transition Mode Boost PFC
1-Phase Continuous Conduction Mode Boost PFC
2-Phase Continuous Conduction Mode Boost PFC

UC28910A Buck PFC Controller
UC28051 Transition Mode PFC Controller
UC28063/A Natural Interleaved Dual-Phase Transition-Mode PFC Controller
UCC28061 Natural Interleaved Dual-Phase Transition-Mode PFC Controller
UC28060 Natural Interleaved Dual-Phase Transition-Mode PFC Controller
UC28019A Continuous Conduction Mode PFC Controller
UC28180 Natural Interleaved Dual-Phase Transition-Mode PFC Controller
UC28019A Extended Frequency Upgrade of UCC28070
UCC28070A Extended Frequency Upgrade of UCC28070
UC28070 Two Phase Interleaved Average Current Mode PFC Controller
UC28050 Transition Mode PFC Controller
UC2817A/18A BICMOS Power Factor Preregulator
UC3817A/18A BICMOS Power Factor Preregulator
UCC28051 Transition Mode PFC Controller
UCC29950: PFC/LLC Combo aimed at CCM applications from 150W to 600W

Texas Instruments

TI Information – Selective Disclosure
UCC28060/61
Natural Interleaved™ Dual-Phase Transition-Mode PFC Controller

Features

• Two-Phase natural 180° interleaving

• Transition-mode operation

• Phase management capability

• Fail-Safe OVP so that any single failure does not allow the output to boost above safe levels.

• No reverse recovery losses in diodes

• Two-Power stage architecture

• Brown out, open loop detection, peak current limiting during in-rush and other protection features

Benefits

• Input filter and output ripple current cancellation, leading to physical size reduction of the EMI and bulk storage capacitor.

• Lower system cost and less complex design than continuous conduction mode (CCM) controllers

• Allows a phase to be shut down at light loads making the PFC stage more efficient by eliminating MOSFET switching losses of that phase, making it ideal for Energy Star and 80 Plus power supply requirements.

• Redundant output over voltage protection, monitored by both VSENSE and HVSEN pins. PWM shuts down if either exceeds the over voltage threshold.

• Lower cost diodes can be used instead of 600V silicon carbide rectifiers

• More effectively spreads the heat dissipation from the power stage elements such as diodes, inductors and MOSFETS.

• Brings a higher level of robustness and reliability to the application

Applications

• PFC for 100 W to 1 kW power supplies
• LCD, Plasma and DLP™ TVs
• Computer power supplies
• Entry level servers
• Green Mode power supplies
• Motor drives for white goods
• Electronic lighting ballasts

Tools

• UCC28060EVM

1ku pricing $1.20
UCC28063A
Natural Interleaved™ Dual-Phase Transition-Mode PFC Controller

**Features**

- Two-Phase natural 180° interleaving
- Transition-mode operation
- Phase management capability
- No reverse recovery losses in diodes
- Two-Power stage architecture
- Fail-Safe OVP so that any single failure does not allow the output to boost above safe levels.
- Brown out, open loop detection, peak current limiting during

**Benefits**

- Input filter and output ripple current cancellation, leading to physical size reduction of the EMI and bulk storage capacitor.
- Lower system cost and less complex design than continuous conduction mode (CCM) controllers
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- Redundant output over voltage protection, monitored by both VSENSE and HVSEN pins. PWM shuts down if either exceeds the over voltage threshold.
- Brings a higher level of robustness and reliability to the application

**Applications**

- Digital TVs
- PFC for 100 W to 800W power supplies
- Entry level server power supplies
- Green Mode power supplies
- Motor drives for white goods
- Electronic lighting ballasts

1Ku = $1.10

UCC28063EVM
UCC28063/A versus UCC28061

SUMMARY OF MAJOR IMPROVEMENTS
• Reduced hysteresis currents on high-voltage sense inputs
• Variable gain for small- and large-signal transients to have fast response but minimize audible noise
• Special dropout-handling to avoid recovery peaks & noise
• Revised OVP levels and actions on VSENSE input
• Single-phase condition reduces CS threshold to 0.167V
• Short and Open protection on TSET input; Open on CS (Disabled on UCC28063A)
• Internal gate-drive cross-conduction minimized
• Leading and trailing-edge blanking on CS and ZCD signals
• Lower trans-conductance allows smaller COMP values

CARRY-OVER FROM UCC28061
• Dual-interleaved TM boost-PFC
• ZCD-winding inputs and thresholds
• UVLO: VCCON and VCCOFF thresholds
• No AC-input range-change (same as is -061)
• AC-line zero-crossing distortion correction
• VREF voltage trim and current capability
• TSET gain factor setting and trim
• VSENSE enable threshold & HVSEN thresholds
• COMP offset and clamp levels
• GDA & GDB drive capability and speed
• VINAC brownout 1.4V threshold and 440ms delay
• Phase-fail detection and 12ms delay
• PHB single-phase on and off thresholds
• PWMCNTL function and drive capability
<table>
<thead>
<tr>
<th>Feature</th>
<th>UCC28060</th>
<th>UCC28061</th>
<th>UCC28063/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>VINAC</td>
<td>Loop-gain change between low and high AC-line ranges</td>
<td>No gain change over full AC-line range</td>
<td>Same as UCC28061</td>
</tr>
<tr>
<td>Brownout</td>
<td>After IC enabled, run first and then detect brownout</td>
<td>After IC enabled, detect brownout first then decide to run or not</td>
<td>Same as UCC28061, and hysteresis current reduced from 7uA to 2uA</td>
</tr>
<tr>
<td>HVSEN</td>
<td>Detect severe output UV, FailSafe OVP stops PWM</td>
<td>Detect severe output UV, FailSafe OVP stops PWM</td>
<td>Same as UCC28061, and hysteresis current reduced from 36uA to 12uA, and OV triggers full soft-start</td>
</tr>
<tr>
<td>OVP (VSENSE)</td>
<td>OV stops PWM</td>
<td>OV stops PWM and triggers soft-start</td>
<td>OVP1 threshold increased from 107.5% to 108% and pulls COMP down. OVP2 at 111% triggers full soft-start</td>
</tr>
<tr>
<td>Burst mode</td>
<td>Enter Burst mode when COMP &lt; 150mV</td>
<td>No Burst mode</td>
<td>Same as UCC28061</td>
</tr>
<tr>
<td>Phase-fail detection</td>
<td>Disabled at single-phase mode</td>
<td>Disabled at single-phase mode or when COMP &lt; 222mV</td>
<td>Same as UCC28061, and CS threshold lowered from 0.2V to 0.167V</td>
</tr>
</tbody>
</table>
UCC28070
Two Phase Interleaved Average Current Mode PFC Controller

Features

• Interleaved average current mode PWM control
• Quantized voltage feed-forward
• Advanced current synthesizer current sensing
• Highly linear multiplier output with internal voltage feed-forward correction
• Programmable frequency dithering, both rate and amplitude adjustments
• Voltage amplifier output slew rate correction
• Programmable frequency up to 300kHz
• Numerous circuit protection features

Benefits

• Reduces ripple current taking cost out of the EMI filter and output capacitors
• Significantly improved transient response from line side variations
• Eliminates two current sense transformers, lowering the cost while providing superior power factor and efficiency
• Reduces THD (Total Harmonic Distortion)-allows near unity power factor
• Reduces EMI (agency tested): reduces the peaks by spreading the energy over a wider range
• Improves transient response – allows faster reaction to line or load transients
• Higher frequencies allow the use of smaller passive components
• Bias supply UVLO, over voltage detection and redundant open loop protection features

Applications

• PFC for 300W to multi KW Power Supplies
• Telecom Rectifier Power Supplies
• Server Power Supplies
• Embedded Motor Drive… Refrigerators, Air Conditioners – White Good Motors
• HID lighting Ballasts
• Applications where High Efficiency and High PF are required

1ku pricing $1.95
110V input
1200W output

Single phase
\( \Delta I = \sim 6\text{Appk} \)

Two-phase
\( \Delta I = \sim 1\text{Appk} \)

Differential Mode Noise

1 phase
2 phases

standard

fs 2fs 3fs 4fs

• Cancellation Effects by Interleaving reduces input current ripple dramatically.

• Reduced ripple allows smaller EMi filter design.

• Interleaving also reduces rms current in output capacitor.

• Lower rms current allows smaller, fewer or cheaper caps and higher reliability.
UCC28070
Innovations and Benefits

• Frequency dithering reduces EMI peak signatures, allowing smaller filter design.

• Discrete Vrms detection levels eliminate THD contribution and increase response to line changes with minimized gain variations.

• Current synthesis eliminates 3 lossy resistors or 2 of 4 sense transformers.

• Higher efficiency, smaller volume, less complexity, lower cost.

Frequency dithering reduces EMI peak signatures, allowing smaller filter design.

Discrete Vrms detection levels eliminate THD contribution and increase response to line changes with minimized gain variations.

Current synthesis eliminates 3 lossy resistors or 2 of 4 sense transformers.

Higher efficiency, smaller volume, less complexity, lower cost.
UCC28070 Design Tools

- Application Notes:
  - UCC28070 300W Interleaved PFC Pre-regulator Design Review
  - Implement Bridgeless PFC Pre-Regulator Design

- UCC28070 Excel Applications Design Tool

- UCC28070 PSpice Model (Average & Transient)

- UCC28070, 300-W Interleaved PFC Pre-Regulator EVM

- A 1.2kW Universal Input Interleaved CCM PFC Reference Design
UCC28070
From Interleaved PFC to Bridgeless PFC

Solves EMI problem in Bridgeless PFC (shunts high-frequency current)

- By simple re-wiring, interleaved PFC can be changed into bridgeless PFC
- Retain Bridge rectifier to address EMI & Surge protection concerns in Bridgeless PFC
UCC28070 EVM
Efficiency Measurement on 300W

Efficiency vs Output Power
- Convertional PFC
- Bridgeless PFC

110V input

220V input

- Bridgeless PFC is able to achieve higher efficiency as expected
New UCC28070 Variant: UCC28070A

- UCC28070 Recommended Operating Frequency range is 30kHz to 300kHz
- UCC28070A is required to operate from 10kHz to 300kHz

<table>
<thead>
<tr>
<th>$f_{PWM}$</th>
<th>PWM switching frequency</th>
<th>$R_{RT} = 750 \text{ k}\Omega$, $R_{DMX} = 681 \text{ k}\Omega$, $V_{RDM} = 0 \text{ V}$, $V_{CDR} = 6 \text{ V}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$f_{PWM}$ (kHz)</td>
</tr>
<tr>
<td>10kHz</td>
<td></td>
<td>9.5, 10, 10.5</td>
</tr>
<tr>
<td>20kHz</td>
<td></td>
<td>95, 100, 105</td>
</tr>
<tr>
<td>25kHz</td>
<td></td>
<td>270, 280, 330</td>
</tr>
</tbody>
</table>

- No other electrical difference between UCC28070 and UCC28070A
- Package: PW
UCC28070A Target Market & Applications

- **Target Market:**
  - High-power AC-DC
  - White Good Appliances

- **Target Applications:**
  - AC-DC PFC converter in
    - Inverterized Motor Control Applications such as Air-Conditioner, Washing Machines, Commercial Refrigerators
    - UPS & Server power supply
    - Large panel size slim PDP TV

**Applications**
- 3kW+ AC/DC PFC

**Example Target Customers (OEMs + ODMs):**
- Midea
- Daikin AC
- Samsung
- LG
- Trane
- Hitachi
- Whirlpool
- York
- Electrolux
- AO Smith
- Diamond Electric
- Regal Beloit

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TI Information – Selective Disclosure
UCC29950: TI New PFC/LLC Combo Controller
UCC29950 –CCM Boost PFC + LLC Combo Controller

**Features**
- Fully Internally compensated PFC control (TI Proprietary)
- Fixed 100kHz PFC frequency with dithering
- Fixed LLC frequency range of 70kHz-350kHz
- Auto-scaled dead-time vs. load range (300-900-ns)
- Supports self-bias or Auxiliary (external) bias mode
- True input power limit, independent of AC line
- Line Brownout Protection, with fail indicator
- PFC DC Bulk OVP & UVP protection
- LLC 3-level OCP with Hiccup Mode operation
- Control for HV Start-Up MOSFET (Depletion Mode)
- Integrated X-Cap Discharge Function
- External Gate Drivers for scalability with power level

**Benefit**
- Feature rich Combo controller in a compact SOIC-16 package
- Ease of design, No PFC compensation effort
- Reduced BoM count
- Ease of EMI compliance
- Continuous operation under overload, short-circuit conditions
- Low Standby Power Consumption
- Customizable (Digitally Configurable)

**Application**
- DIN Rail industrial power supplies,
- Audio amplifier, Gaming
- Telecom adaptors
- PC Silver Box
- High Power Chargers for Power Tools

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22 TI Information – Selective Disclosure
## Overview UCC29950 Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Bias Mode allowing off-line operation</td>
<td>Eliminate cost of Auxillary supply in system</td>
</tr>
<tr>
<td>PFC frequency dithering</td>
<td>Simplifies EMI filtering and eases EMI compliance</td>
</tr>
<tr>
<td>True input power limit, independent of line voltage</td>
<td>Limit set by choice of $R_{cs(pfc)}$ allowing designer greater flexibility compared to fixed limits depending on AC line voltage</td>
</tr>
<tr>
<td>Zero Voltage Switching (ZVS) over a wide range of operating conditions</td>
<td>Reduced switching losses in the LLC converter power devices</td>
</tr>
<tr>
<td>Three Level over current protection and Hiccup mode of operation</td>
<td>Allows the power stage to ride through a short-term transient overload but reacts quickly to protect the power stage from heavy overload or output short-circuit events.</td>
</tr>
<tr>
<td>Control output for external high-voltage, depletion mode start-up MOSFET</td>
<td>Eliminates drop resistor from rectified AC line, reduces stand-by power</td>
</tr>
</tbody>
</table>
### Overview UCC29950 Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated X-Cap discharge function using external start-up MOSFET</td>
<td>Eliminates bleed resistor across differential EMI filter capacitor, reduces stand-by power</td>
</tr>
<tr>
<td>PFC stage design in 3 easy steps - (i) design voltage feedback network, (ii) choose current sense feedback resistor, (iii) design power stage</td>
<td>Greatly simplifies design effort</td>
</tr>
<tr>
<td>Advanced control algorithm for PFC Stage</td>
<td>Good iTHD and insensitivity to inductor and bulk capacitor variations, Cycle by cycle PFC overcurrent protection</td>
</tr>
<tr>
<td>Internal compensation of PFC Stage Voltage and Current feedback loops</td>
<td>Reduces Component count, eliminates 2 design steps (voltage and current loop compensation)</td>
</tr>
</tbody>
</table>
| Differential AC Line sensing with fixed 9.3M-ohm resistors              | - Accurate measurement of line conditions under no-load or start-up conditions for improved performance and protection  
                          | - Eliminates 1 design step (AC line sensing)                        |
Overview Simplified Schematic & Pinout

• Boost CCM PFC / LLC Combo Controller in a 16 pin SOIC
UCC29950 Block Diagram
UCC29950 System Features

- Continuous Conduction Mode (CCM) Boost Power Factor Correction
- High Efficiency PFC and Half-Bridge Resonant LLC Combo Controller
- Supports Self-bias or Auxiliary (external) bias mode of operation
- PFC loops fully internally compensated
- PFC stage design in just 3 easy steps (design voltage feedback, current feedback and power stage)
- Fixed 100kHz PFC frequency with dithering for ease of EMI compliance
- True input power limit, independent of line voltage
- Fixed LLC frequency operating range of 70kHz to 350kHz
- Dead-time varied across load range for LLC Half-Bridge power stage to extend ZVS range
UCC29950 System Features

• Three-Level LLC Over-Current Protection

• Hiccup Mode operation for Continuous Overload & short-circuit Power Protection

• Low Standby Power Consumption enabled by Active Control of High-Voltage Start-up MOSFET and X-Cap Discharge Function

• Built in soft-start and converter sequencing to simplify design

• AC Line Brownout Protection, with fail indicator

• PFC Bus Over-Voltage and Under-Voltage Protection.

• Over-Temperature Protection

• External Gate Drivers for scalability with power level

• SOIC-16 Package
UCC29950: Key Selling Points

• PFC + LLC + Start-up control in one compact SOIC-16
  – Compatible with external 600V driver or gate drive transformer
  – Eases PCB layout effort for daughter cards & split PCB designs
  – Eases Scalability vs power level – external gate driver can be optimised

• PFC + LLC
  – Higher Efficiency vs PFC + PWM

• Fully Internally Compensated PFC stage
  – Easy design, only 3 steps (V-feedback, I-sense, Power Stage)

• 3 Level LLC OCP with Hiccup & True input power limit
  – Overload ride-through without shut-down
UCC29950: Key Selling Points

- Promote ease of PCB layout for Daughter cards, split PCBs & scalability vs. power levels offered by separating controller from gate driver
- Look for customers using PFC + PWM combo controller, who want to upgrade to LLC topology for higher efficiency
- **Competitor:** FAN4800, CM6800 (PFC+PWM), NCP1910 (PFC+LLC), discrete solutions

Target Applications

- **AC/DC power supplies** for low-end server, telecom, audio, printers, PC power, 80 PLUS (Bronze, Silver, Gold) PSU
- **AC/DC power supply for LED Lighting** such as Street Lighting, Area lighting, Signage
- **High-power AC/DC Battery Chargers** for Power Tools & other Industrial applications
UCC29950: Design Process - Overall

- Design Process
  - Specification
  - Design the PFC stage
  - PFC Stage Control (fully internal compensation)
  - Design the LLC stage
  - LLC stage Control
  - Design bias supply (self Bias)
  - Layout
  - Test

Full set of design aids available
Including an Excel Calculator – sluc576a
A 300W EVM is also available

UCC29950 DESIGN CALCULATOR TOOL

<table>
<thead>
<tr>
<th>UCC29950 Continuous Current Mode Power Factor correction and LLC Combo Controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please enter design parameters into the <strong>shaded</strong> cells;</td>
</tr>
<tr>
<td>Recommended Component Values will be in <strong>RED</strong></td>
</tr>
<tr>
<td><strong>Be sure to ENABLE EDITING</strong> before attempting to use this design calculator**</td>
</tr>
</tbody>
</table>

This spreadsheet guides the user through the design process of a CONTINUOUS CONDUCTION MODE PFC BOOST CONVERTER and LLC STAGE CONVERTER using the **UCC29950**. User interaction is required in order to get the best possible results. Enter the desired specification where prompted, the highlighted cells are for user inputs; calculations for the design are based upon the inputs.
Design: Overall CCM PFC / LLC System

- CCM PFC front end
  - Power Factor Correction
  - $V_{BLK}$ output to second stage

- UCC29950 Controller

- UCC27714 MOSFET Gate Driver

- LLC output stage
  - High Efficiency
  - Isolation

Diodes Or Synchronous Rectifiers (UCC24610 SR controller)
UCC29950 EVM

- UCC29950 300W EVM
- 12V out at 25A
- Aux Bias or Self Bias
- PF > 0.99
- THD
  - 3% at 115V
  - 6% at 230V
- Average Efficiency
  - 87.8% at 115V (Diode)
  - 90.2% at 230V (Diode)
- Estimate 92% efficient if using SRs
Other PFC Controllers
UCC28180 – Programmable Frequency CCM PFC IC

**Features**

- Wide Range Programmable Switching Frequency (18KHz to 250KHz)
- Integrated 1.5ASRC/2A SNK integrated Gate Driver, with 15.2V Clamped output for IGBT drive
- Average Current mode control
- Audible Noise Minimization circuitry
- Reduced Current Sense Thresholds
- Enhanced Dynamic Response During load transient
- Trimmed Current Loop Circuit for low iTHD
- Rich Protection Functions
- SOIC 8-Pin (D) Package

**Benefits**

- Flexible CCM PFC controller optimized for variety of applications
  - 300W to few-kW
  - 18kHz (IGBTs) to 250kHz (GaN/SiC/Si switches)
- Reduced Power Dissipation in I<sub>SNS</sub> Resistor
- Low iTHD (<5%, medium-to-full load)
- No Audible Noise
  - Pin-to-Pin compatible with Infineon ICE2PCSO1/5

**Applications**

- Universal AC Input, Boost PFC converters
- Server & Desktop Power Supplies
- White Good Appliances (A/C, Refrigerators)
- Industrial Power Supplies (DIN Rail)
- Flat Panel TV (PDP/LCD/LED) TVs
# UCC28180 vs UCC28019A - Feature Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>UCC28180</th>
<th>UCC28019A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq Range</td>
<td>18kHz to 250kHz, Programmable</td>
<td>65kHz, Fixed</td>
</tr>
<tr>
<td>VCC ON (UVLO)</td>
<td>12.1V Max / 10.8V Min</td>
<td>11V Max / 9V Min</td>
</tr>
<tr>
<td>VCC OF (UVLO)</td>
<td>9.1V Min</td>
<td>9V Min</td>
</tr>
<tr>
<td>UVLO Hysteresis</td>
<td>1.7V Typ</td>
<td>1V Typ</td>
</tr>
<tr>
<td>VCC ABS MAX</td>
<td>22V</td>
<td>22V</td>
</tr>
<tr>
<td>Frequency Tolerance over Temperature</td>
<td>+/-10% in Fsw range 18kHz to 180kHz</td>
<td>-12.3% to 9% at 65kHz only</td>
</tr>
<tr>
<td>VREF Tol over Temp.</td>
<td>-2.6% +3%</td>
<td>+/- 2%</td>
</tr>
<tr>
<td>Peak Current Limit</td>
<td>-0.4V Typ, over 50% reduction in R\text{SHUNT} vs. UCC28019A</td>
<td>-1.08V Typ</td>
</tr>
<tr>
<td>Soft Overcurrent Limit</td>
<td>-0.285V, Improved performance</td>
<td>-0.73V</td>
</tr>
<tr>
<td>Current Loop Control Circuits</td>
<td>Trimmed for Low Offset effects on \text{iTHD}</td>
<td>Untrimmed</td>
</tr>
<tr>
<td>Enhanced Dynamic Response (EDR)</td>
<td>Undervoltage, 5X Gain at 95% VREF</td>
<td>Undervoltage Only, 10X Gain at 95% VREF</td>
</tr>
<tr>
<td></td>
<td>Overvoltage, 5X Gain at 105% VREF</td>
<td></td>
</tr>
<tr>
<td>OVP Protection (% of VREF)</td>
<td>Multi-Level protection leading to cycle-by-cycle OVP:</td>
<td>105% VREF, Gate Output shut-off</td>
</tr>
<tr>
<td></td>
<td>- At 105%, 5X Gain to respond faster to voltage loop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- At 107%, VCOMP pin discharges via internal 4kohm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- At 109%, Gate Output shut-off</td>
<td></td>
</tr>
<tr>
<td>OVP recovery threshold after Gate Shut-Off</td>
<td>102%</td>
<td>None</td>
</tr>
<tr>
<td>(% of VREF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audible Noise during burst mode</td>
<td>- No audible noise during burst mode</td>
<td>-need ICOMP pull-up resistor to solve burst mode audible noise issue</td>
</tr>
<tr>
<td></td>
<td>- Eliminates ICOMP pull-up resistors</td>
<td></td>
</tr>
<tr>
<td>Gate Drive (SRC/SNK)</td>
<td>1.5A/2A</td>
<td>1.5A/2A</td>
</tr>
<tr>
<td>Gate Voltage Clamp</td>
<td>15.2V Typ, to support IGBT Gate Drive</td>
<td>12.5V Typ</td>
</tr>
</tbody>
</table>
# UCC28180 vs. Infineon ICE2PCS01 vs. ON NCP1654

<table>
<thead>
<tr>
<th>Feature</th>
<th>UCC28180</th>
<th>ICE2PCS01</th>
<th>NCP1654</th>
<th>Benefit of UCC28180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching Frequency</td>
<td>18-250KHz</td>
<td>50-250KHz</td>
<td>65/133/200KHz</td>
<td>UCC28180 has wide frequency range, can be used for IGBT application</td>
</tr>
<tr>
<td>Start-Up Current</td>
<td>75uA</td>
<td>1100uA</td>
<td>75uA</td>
<td>UCC28180 has much lower startup current, lower power consumption</td>
</tr>
<tr>
<td>Standby Current</td>
<td>2.95mA</td>
<td>1300uA</td>
<td>400uA</td>
<td>lower power consumption</td>
</tr>
<tr>
<td>Operating Current</td>
<td>8.8mA</td>
<td>20mA</td>
<td>4.7mA</td>
<td></td>
</tr>
<tr>
<td>VCC Turn ON</td>
<td>11.5V</td>
<td>11.8V</td>
<td>10.5V</td>
<td></td>
</tr>
<tr>
<td>VCC Turn OFF</td>
<td>9.5V</td>
<td>11V</td>
<td>9V</td>
<td></td>
</tr>
<tr>
<td>VCC Turn ON/OFF Hysteresis</td>
<td>1.7V</td>
<td>0.8V</td>
<td>1.5V</td>
<td>UCC28180 has much bigger hysterisis, more noise immunity on VCC</td>
</tr>
<tr>
<td>Peak Current Limit Threshold</td>
<td>-0.4V</td>
<td>-1.04V</td>
<td>200uA (Rshunt is related to Rcs)</td>
<td>A smaller shunt can be used to improve efficiency, given the much lower threshold. For example, with a 360W PFC, the power loss on current shunt can be reduced from 1.707W to 0.663W</td>
</tr>
<tr>
<td>Soft Over Current Protection(SOC)</td>
<td>-0.285V</td>
<td>-0.68V</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Vref</td>
<td>5V</td>
<td>3V</td>
<td>2.5V</td>
<td></td>
</tr>
<tr>
<td>OVP</td>
<td>109%</td>
<td>108%</td>
<td>105%</td>
<td></td>
</tr>
<tr>
<td>OVP Recovery</td>
<td>102%</td>
<td>None</td>
<td>none</td>
<td>GATE will turn on once Vout drops below 102% of Vref, continously provide power to load</td>
</tr>
<tr>
<td>ISENSE Open Pin Protection</td>
<td>yes</td>
<td>No</td>
<td>no</td>
<td>Prevent PWM stage from increasing the GATE output to maximum duty cycle</td>
</tr>
<tr>
<td>ICOMP Short to GND protection</td>
<td>yes</td>
<td>No</td>
<td>no</td>
<td>Prevent PWM stage from increasing the GATE output to maximum duty cycle</td>
</tr>
<tr>
<td>Trimmed Current Loop</td>
<td>yes</td>
<td>?</td>
<td>?</td>
<td>Low current distortion, better THD</td>
</tr>
<tr>
<td>Gate Rise Time</td>
<td>40ns</td>
<td>60ns</td>
<td>60ns (2.2nF)</td>
<td>Lower switching loss</td>
</tr>
<tr>
<td>Gate Fall Time</td>
<td>25ns</td>
<td>50ns</td>
<td>40ns</td>
<td>Lower switching loss</td>
</tr>
<tr>
<td>Gate Voltage Clamp</td>
<td>15.2V</td>
<td>14.8V</td>
<td>NO</td>
<td>Lower switching loss</td>
</tr>
</tbody>
</table>
UCC28019A
8 pin Continuous Conduction Mode (CCM) Power Factor Controller

Features

- Full-featured Continuous Conduction Mode (CCM) PFC
- Average Current Mode Control PWM
- Brown-out, open loop detection, soft over-current and other protection features
- Slew rate correction
- Trimmed Internal Reference Voltage: 5V, ±2%
- Fast High Peak Current Output
- Fixed 65Khz Oscillator

Benefits

- Provides a low system cost solution that requires very few external components
- Provides near unity Power Factor with low harmonic distortion
- Brings a higher level of robustness and reliability to the application
- Improves transient response
- Provides accurate protection thresholds and regulation set-points to ensure reliable operation
- Significantly reduces main MOSFET switching losses
- Keeps the second harmonic below the EMI testing frequency of 150Khz

Applications

- CCM boost PFC power supplies from 100W to 2KW
- Low standby (Green Mode) power supplies
- Digital TV power supplies
- Consumer products
- White Goods
- Motor drives

Tools

• UCC28019AEVM

1ku pricing $0.75
Replacing ICE1PCS02G

Background

• UCC28019A Continuous Conduction Mode (CCM) PFC Controller is designed to be an improved, pin-to-pin replacement of Infineon’s ICE1PCS02

• The UCC28019APG4 is pin-to-pin compatible with the ICE1PCS02

• The UCC28019ADG4 is pin-to-pin compatible with the ICE1PCS02G

• There are slight electrical differences between these two ICs

• A few minor changes are required due to parameter differences:
  – UCC28019A has better gate driving capability to reduce the switching loss. If it causes more EMI noise to fail EMI standard, higher gate resistor value is required
  – UCC28019A has UVLO level of 10.5V/9.5V, while ICE1PCS02 has UVLO as 11.2V/10.2V. UCC28019A should work well in the ICE1PCS02 system, but it won’t shut down until VCC is less than 9.5V, instead of 10.2V
  – UCC28019A has longer soft start delay time
UCC28050/51
Transition Mode PFC Controller

**Features**

- Transition Mode Control
- UVLO Start-up Voltage of 15V/12.5V
- Non-linear Transconductance Amplifier with Enhanced Slew Currents of 1.3mA Sink and 180 uA Source capability
- Accurate Internal $V_{\text{REF}}$
- Slew Rate Comparator
- Zero Power Detect
- +/- 750-mA Peak Gate Drive Current

**Benefits**

- Ideal for Low to Medium Power Supplies
- Easily controllable by downstream PWM controller and Compatible with Industry Standard Controllers
- Allows gradual start-up while providing fast transient response to output changes
- Tight Output Regulation
- Improved Transient Response
- Prevents Over Voltage During Light Load Conditions
- Improves MOSFET Switching Efficiency

**Applications**

- Switch-Mode Power Supplies for Desktops, Monitors and Set Top Boxes
- AC Adapter Front-End Power Supplies
- Electronic Ballasts

**Tools**

- 100W Reference Design

**1ku pricing $0.85**