Power Factor Corrector Controllers

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PFC in Applications

**COMPUTER PERIPHERAL**
- Workstation
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- Server
- Printer

**INDUSTRIAL**
- SMPS
- Home Appliance – White Goods
- AC-DC Adapters

**CONSUMER**
- Games
- Flat panel TV
- Set Top Box

**LED Lighting**
- LED luminaires
- Lamp ballast
## ST PFC - Competitive Advantages

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| **Performance & Solution Cost** | • Allow THD reduction making SMPS more efficient and compliant with EN61000-3-2 and energy saving regulations  
• Solutions from 25W up to 3kW |
| **Robustness and reliability**  | • Advanced protection features integrated  
• Output Overvoltage, Brownout detection, inductor saturation detection, Feedback loop disconnection |
| **Easy design**                 | • Perfect Synergy with ST primary controllers for all topologies: Flyback, Quasi-Resonant & Resonant  
• Full support and tools available |
| **WW reference**                | • L6562A recognized as PFC world wide reference |
A Power Factor Control is the SMPS stage connected to AC input Mains that addresses the need to limit THD.

PFC pre-regulator between the bridge and the bulk draws from the mains a quasi-sinusoidal current in-phase with the line voltage.

Harmonic current emission is regulated by standards EN 61000-3-2. Lighting requirements > 25W, SMPS & chargers > 75W.

Maximize the energy delivery to load means to reduce the Total Harmonic Distortion (THD) and therefore maximize the Power Factor.
PFC – Topologies & ICs Portfolio

**TM**
Transition Mode

- L6562A, L6562AT DIP8, SO8
- L6563H SO16
- L6563S SO14
- L6564D SSOP10
- L6564H SO14
- L6564T SSOP10

**CCM**
Continuous Conduction Mode

- L4981A/B DIP20, SO20
- L4984D SSOP10

Power Ranges:
- 25W
- 75W
- 600W
- 3KW
PFC Transition-Mode Family positioning

L6562A / AT
INV: 1, COMP: 2, MULT: 3, CS: 4, Vcc: 8, GD: 7, GND: 6, ZCD: 5

L6564D / T
INV: 1, COMP: 2, MULT: 3, CS: 4, Vcc: 10, GD: 9, GND: 8, ZCD: 7, PFC_OK: 6

Low Cost
Advanced Features

Interface to PWM ctrl
+ High Voltage Start up

L6564H
INV: 1, COMP: 2, MULT: 3, CS: 4, VFF: 5, PFC_OK: 6, N.C.: 9, HVS: 8

L6563S
INV: 1, COMP: 2, MULT: 3, CS: 4, VFF: 5, TBO: 6, PFC_OK: 7

L6564D / T
INV: 1, COMP: 2, MULT: 3, CS: 4, VFF: 5, PFC_OK: 6, N.C.: 9, HVS: 8

Advanced features
+ High Voltage Start up

Interface to PWM ctrl
+ High Voltage Start up
L6562 family – TM PFC

**L6562A**
- 8 pin
- Very accurate adjustable output overvoltage protection
- Ultra-low (30μA) start-up current
- Low (2.5mA) quiescent current
- Proprietary multiplier design for minimum THD
- Disable function
- Internal Voltage reference with 1% precision @ Tj = 25 °C
- Packages: DIP8, SO8

**L6562AT**
- 8 pin
- Same features and functions as L6562A
- Guaranteed for extreme temperature range (outdoor), down to -40°C
- Packages: DIP8, SO8

**APPLICATIONS**
- IEC61000-3-2 compliant SMPS (Flat TV, monitors, desktop PC, games)
- AC-DC adapter/charger up to 250W
- Electronic ballast
- Entry level server & web server
L6562A/T – Design Resources

**APPLICATION NOTES**
- AN2755: 400 W FOT-controlled PFC pre-regulator with the L6562A
- AN2761: Solution for designing a transition mode PFC preregulator with the L6562A
- AN2782: Solution for designing a 400 W fixed-off-time controlled PFC preregulator with the L6562A
- AN2835: 70 W HID lamp ballast based on the L6569, L6385E and L6562A
- AN2838: 35 W wide-range high power factor flyback converter evaluation board using the L6562A
- AN2928: Modified buck converter for LED applications
- AN2983: Constant current inverse buck LED driver using L6562A
- AN3111: 18 W single-stage offline LED driver
- AN3105: 48 V - 130 W high efficiency converter with PFC for LED street lighting applications - European version
- AN3106: 48 V - 130 W high-efficiency converter with PFC for LED street lighting applications

**EVALUATION BOARDS & TOOLS**
- EVL6562A-400W  L6562A 400W FOT-controlled PFC pre-regulator evaluation board
- EVL6562A-35WFLB  35W WIDE RANGE HIGH POWER FACTOR FLYBACK CONVERTER USING THE L6562A
- STEVAL-ILL013V1  80 W offline PFC and LED driver demonstration board with dimming based on the L6562A
- EVL6562A-LED  Constant current inverse buck LED driver using L6562A
- STEVAL-ILL027V2  18 W single-stage offline LED driver based on the L6562A (European version)
- STEVAL-ISA102V1  80 W high performance transition mode PFC demonstration board
- STEVAL-ILL042V2  60 W, high power-factor flyback LED driver based on the L6562AT and TSM101
L6563 family – TM PFC

L6563S
14 pin

• Easy and noise immune OCP and OVP circuitry
• Fast and bidirectional voltage feedforward
• Inductor Saturation Protection No Latched
• Voltage Reference precision 1% @ Tj = 25 °C
• Tracking boost function
• Protection against feedback loop failure (Latched shutdown)
• Remote ON/OFF control
• Low (≤ 90μA) start-up current
• Quiescent current 5mA max.
• Adjustable Brownout
• PWM interface
• Package: SO14

L6563H
16 pin

• Same features and functions as L6563S
• High Voltage Start-up with on-board 700 V start-up source
• Package: SO16

APPLICATIONS

- HI-END AC-DC adapter/charger
- Desktop PC, server, WEB server
- IEC61000-3-2 OR JEIDA-MITI compliant SMPS, up to 250W
- SMPS for LED luminaires
**MAIN FEATURES**

- **OVP** → higher noise immunity
- **Fast and “Two ways” Voltage Feed forward** → Complete rejection of Mains surges and drops
- **PWM interface pin** → turn off PMW if PFC fault or PFC at light load
- **Inductor Saturation Protection** No Latched → higher reliability

**HV STARTUP**

- **VBR** = 700V
- **ICHARGE** = 0.85 mA Typ
- **Min start Voltage** = 80V Typ
- **HV generator restart voltage**: 6V/9.5V
L6563H & L6563S – Design Resources

**APPLICATION NOTES**
- AN3014: 19 V, 90 W resonant converter with synchronous rectification using the L6563H, L6599A and SRK2000
- AN3118: 250 W transition-mode PFC pre-regulator with the new L6563H
- AN3063: 100 W transition-mode PFC pre-regulator with the L6563H
- AN3172: 19 V - 90 W adapter with PFC for Laptop computers using the L6563H and L6599A
- AN3233: 12 V - 150 W resonant converter with synchronous rectification using the L6563H, L6599A, and SRK2000
- AN2941: 19 V - 75 W SMPS compliant with latest ENERGY STAR® criteria using the L6563S and the L6566A
- AN2994: 400 W FOT-controlled PFC pre-regulator with the L6563S
- AN3027: How to design a transition-mode PFC pre-regulator with the L6563S and L6563H
- AN3065: 100 W transition-mode PFC pre-regulator with the L6563S
- AN3119: 250 W transition-mode PFC pre-regulator with the new L6563S
- AN3142: Solution for designing a 400 W fixed-off-time controlled PFC preregulator with the L6563S and L6563H
- AN3180: A 200 W ripple-free input current PFC pre-regulator with the L6563S
- AN3203: EVL250W-ATX80PL: 250W ATX SMPS demonstration board
- AN4027: 12 V - 150 W resonant converter with synchronous rectification using the L6563H, L6699 and SRK2000A
- AN4677: 12 V - 150 W resonant converter with synchronous rectification based on L6563H, L6699 and SRK2001

**EVALUATION BOARDS**
- EVL6563S-100W 100 W transition-mode PFC pre-regulator with the L6563S
- EVL6563S-200ZRC A 200 W ripple-free input current PFC pre-regulator with the L6563S
- EVL6563S-250W 250W TRANSITION-MODE PFC PRE-REGULATOR WITH L6563S
- STEVAL-ISA149V1 19 V - 75 W SMPS compliant with latest Energy Star criteria using the L6563 and the L6566A
- STEVAL-ISA145V1 250 W ATX SMPS demonstration board
- STEVAL-ISA170V1 12 V - 150 W resonant converter with synchronous rectification based on L6563H, L6699 and SRK2001
L6564 family – TM PFC

**L6564D**
10 pin

- Evolution of L6562A & Compact version of L6563S
- AC brownout detection
- Protection against feedback loop disconnection (latched shutdown)
- Inductor saturation protection
- Low (≤100 μA) start-up current
- Max. operating bias current 6 mA
- Fast “bidirectional” input voltage feed-forward
- Accurate adjustable output overvoltage protection
- Package: SSOP10

**L6564T**
10 pin

- Same features and functions as L6564D
- Electrical Parameters Guaranteed from -40°C to +125°C
- Recommended for OUTDOOR LED Luminaries.
- Package: SSOP10

**L6564H**
14 pin

- Same features and functions as L6564D
- Onboard 700 V startup source for high voltage startup
- Package: SO14

**APPLICATIONS**
- HI-END AC-DC adapter/charger
- Desktop PC, server, WEB server, Flat TV
- IEC61000-3-2 OR JEIDA-MITI compliant SMPS, up to 250W
- SMPS for LED luminaires
L6564D/T & L6564H

**MAIN FEATURES w.r.t. L6562A**
- Suitable for more complex applications
- Full set of protections embedded
  - Brown-out, Inductor Saturation Detection, Feedback Disconnection
- Improved Noise immunity
- Voltage feed forward

**HV STARTUP**
- $V_{BR} = 700V$
- $I_{CHARGE} = 0.85 \text{ mA Typ}$
- Min start Voltage: 80V Typ
- HV generator restart voltage: 6V/9.5V
L6564D/T & L6564H – Design Resources

• APPLICATION NOTES
  • AN3009: How to design a transition mode PFC pre-regulator using the L6564D
  • AN3112: Solution for designing a fixed off-time controlled PFC pre-regulator with the L6564D
  • AN3329: 170 W power supply with PFC and standby supply for flat TV using the L6564D, L6599A, and Viper27LN
  • AN3339: 185 W power supply with PFC and standby supply for LED TV using the L6564D, L6599A, and Viper27LN
  • AN3410: A 93% efficient LED driver solution for the US market
  • AN4214: High power factor flyback converter using L6564D
  • AN4339: BLDC motor based ceiling fan solution proposal
  • AN4077: 100 W transition-mode PFC pre-regulator with the new L6564H
  • AN4314: 25 W wide-range high power factor buck-boost converter demonstration board using the L6564H

• EVALUATION BOARDS
  • STEVAL-ISA142V1  50 W wide-range high power factor flyback converter using the L6564D
  • EVL6564-100W  L6564 transition mode PFC evaluation board
  • STEVAL-ILL041V1  A 93% efficient LED driver solution for the US market
  • EVL6564H-25W-BB  25 W wide-range high power factor buck-boost converter demonstration board using the L6564H
Software & Tools

L6562A/T

• STSW-PFC001
  Software tool for designing a power factor corrector using the L6562A controller operating in transition mode
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6562ATL431Flyrelease20.xls
• Power factor corrector L6562A in flyback topology
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6562A%20PFC_TM_release%201.3.xls
• Power factor corrector L6562A in transition mode
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6562A%20FOT%20release%201.4.xls

L6563H & L6563S

• DESIGNING A TM PFC USING THE L6563S (AVAILABLE UPON REQUEST)
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6563S_H_TMPFC_release30.xls
• DESIGNING A FOT PFC USING THE L6563S (AVAILABLE UPON REQUEST)
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6563S_H_FOTrelease30.xls

L6564D/T & L6564H

• DESIGNING A TM PFC USING THE L6564 (AVAILABLE UPON REQUEST)
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6564TMPFC_release20.xls
• DESIGNING A FOT PFC USING THE L6564 (AVAILABLE UPON REQUEST)
  http://ims.st.com/pub/documents/ipc/off-line_power_supply/software/L6564FOTrelease20.xls
• DESIGNING A High Power Factor Flyback USING THE L6564 (AVAILABLE UPON REQUEST)
**L4981A, L4981B**

**Fixed Frequency  CCM PFC**

- Average Current Mode PWM controller with Power Factor up to 0.99
- L4981A: Fixed Frequency operation - L4981B: Frequency Modulation
- Universal Input Mains: 85V to 265V without any line switch
- Input voltage Feed-forward
- Load feed forward improving load transient
- UVLO with hysteresis and programmable turn-on threshold
- OVP/OVC protection
- Low start-up current <0.5mA
- Precise 2% on-chip reference externally available
- Synchronization available (L4981A only)
- Packages: DIP20, S020

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**Features**

**AN1606**  A “bridgeless PFC configuration” based on L4981 PFC controller
**AN2649**  A power factor corrector with MDmeshII and SiC diode
**AN510**  Circuits for power factor correction with regards to mains filtering
**AN628**  Designing a high power factor switching preregulator with the L4981 continuous mode
**AN827**  A 500W High Power Factor with the L4981A continuos Mode IC
**AN828**  1500W - 440V power factor corrector preregulator
**AN829**  Semiconductor kit for Power Factor Corrector
**AN832**  L4981A Synchronization
**AN833**  Frequency Modulation on L4981B
L4984D – CCM PFC

- Line-modulated fixed-off-time (LM-FOT) control – proprietary solution - for nearly fixed frequency operation
- Low Start-up Current (<100µA)
- Fast Bidirectional Input Voltage Feedforward (1/V² correction)
- Precise Internal Reference (1% @25°C)
- Protection against Feedback Loop Failure (Latched Shutdown)
- AC Brownout Detection
- Adjustable OVP on output voltage (No Latched)
- Inductor saturation protection (No Latched)
- Open loop protection
- Input Mains under-voltage detection
- Digital Leading-edge blanking on Current Sense
- Soft Start
- Remote ON/OFF control input pin
- Package: SSOP10

Features

Application Notes & Evaluation Boards
- AN4149: Designing a CCM PFC pre-regulator based on the L4984D
- AN4163: EVL4984-350W: 350 W CCM PFC pre-regulator with the L4984D
- EVL400W-ADP/ATX 12V - 400W SMPS for Adapter, Desktop and AIO using L4984D, L6699 and SRK2000A
- EVL4984-350W 350 W CCM PFC pre-regulator demonstration board based on the L4984D
# Competitive Advantages

- Right solution for **middle-high power SMPS**
- Best **trade-off between full set features, performance and price, form factor**
- Address a **wide range of applications**: from simple, such as high-end game consoles, desktop, and workstation to the more complex high-end servers, EV battery chargers, solar inverters or SMPS for data centers

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<th>Feature</th>
<th>Benefits</th>
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<tr>
<td>Proprietary LM-FOT modulator for nearly fixed frequency operation</td>
<td>• Simple design and reduced BOM</td>
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<tr>
<td>Fast bidirectional input voltage feed forward</td>
<td>• Mains drops and surges rejection</td>
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<tr>
<td>Soft start</td>
<td>• Perfect inrush energy management</td>
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<tr>
<td>Proprietary THD optimizer circuit</td>
<td>• Enhanced performance</td>
</tr>
<tr>
<td>Full set protections embedded</td>
<td>• Prevent from inductor and MOSFET damage, bulk capacitors burning and down stream converter damaging</td>
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Mid Power LED lighting: directions & solutions

**Single Stage**

- **Isolated Fly Back**
  \[ L6562A – L6564D/H \]

- **Not Isolated Flyback (Buck-Boost)**
  \[ L6564H \]

**Dual Stage**

- **Boost + Inversed Buck**
  \[ L6562A - L6562A \]

- **Low Cost** solution for medium power Lighting applications in the range 25W to 80W

- **Low THD and high PF**
Isolated flyback – Single LED column

- Cheap and flexible
- Work in wide range input voltage solutions
- No electrolytic input capacitor, no electrolytic output capacitor according to acceptable ripple current
- PF > 0.9 and Efficiency up to 90% thanks to Quasi-resonant topology
- Most used low cost solution up to 80/90W for commercial and industrial fixtures
- Open/Short protections embedded
- Compliant with the European regulation EN61000-3-2 Class-C and Japanese regulation JEIDA-MITI Class-C
- AN2838 EVL6562A-35WFLB, STEVAL-ISA142V1
Isolated flyback – Multiple LED columns (1/2)

- For Multiple LED Columns the L6562A based Inversed buck is the simplest and cheapest solution (see next slide)
- AN2983-AN2928 (EVAL6562A-LED)
Ripple current is constant also when input and output (no. LED)voltage change
- The system can work at high frequency – up to 600KHz – in order to address small form factor solutions
- Fast restart after disable. Very deep dimming (< 1%) is possible
- Drive the power stage mosfet at high frequency
- Adjustable current sense threshold in order to minimize power losses
- Open/Short protections embedded
Non-Isolated flyback – Buck Boost

- Wide Input Range, cost effective, high PF not isolated solution for LED Tube and Ceiling

- Line voltage range: 85 to 265 VAC
- No transformer, No Photo-coupler
- LED string voltage drop: 70 V ±10% (23 LED p.n. X42182)
- LED nominal current: 350mA
- Rated output power: 25 W
- Conducted EMI: In acc. with EN55022 Class-C
- Protections to overvoltage, open loop and short circuit
- AN4314, EVL6564H-25W-BB
Dual stage - Boost + Inversed Buck

- Optimum Power Factor and very low THD over wide input voltage range

- **STEVAL-ILL013V1**: demo board for general purpose LED applications based on L6562A used in Boost topology and a second stage using L6562A Inversed buck
- **UM0670** documentation
Thank you!

ST stands for life.augmented