EuP Lot 6 Tier2 Ecodesign requirements for Standby: ST’s Readiness
Power supply energy regulations landscape

Goal: Global convergence of energy standards
Key drivers:
- Climate change
- Energy saving
- Grid capacity
ST’s commitment in reducing standby power consumption

Smart power ICs
- Standby power reduction IC technology
  - VIPer0P unveiled in 2015
  - IR & RF remotely-controlled Zero Standby
- IC leakage current reduction & HV Start-up technology
  - Reaching < 0.5 mW IC consumption
  - Integrated HV start-up: from 200 mW with ext. resistor to 0.05 mW consumption

Power discretes
- Low-loss switching high-efficiency device technology
  - Latest MOSFET tech.: +0.45% efficiency at light load vs. previous technology

Today ST has reached the lowest power consumption in the market during no load.

Leveraging breadth and depth of dedicated SMPS product portfolio

- HV converters
- PFC ICs
- LLC controllers
- Digital controllers
- SRK
- SR controllers
- HV & LV Power MOSFETs
- Schottky and ultrafast diodes
- Protections

Smart power ICs
Power discretes
Understanding EuP Lot 6 Tier2: Standby is a Deep Sleep Mode

- **Standby defined by LoT 6:** “A condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended, and provides only the following functions, which may persist for an indefinite time:
  - Reactivation function, or reactivation function and only an indication of enabled reactivation function, and/or
  - Information or status display”

- **Energy-using products**
  - Household appliances
  - Consumer equipment
  - Information technology equipment
  - Toys, leisure and sports equipment

- **Power consumption in Off-mode** (*) < 0.5 W
- **Power consumption in Standby mode** with reactivation function only < 0.5 W
- **Power consumption in Standby mode** with reactivation function and status display ≤ 1.0 W

(*) “Off-mode” is a condition in which the equipment is connected to the mains power source and is not providing any function.
State-of-the-art controllers effectively help meet EuP Lot 6 Tier2

- Stringent energy regulations require **IC’s dedicated features** to improve the SMPS standby consumption in systems that do not include an auxiliary power supply

### Primary side

- **L6563H**
  - HV start-up TM PFC
- **L4984D**
  - CCM PFC – Line-modulated FOT
- **L6699**
  - Enhanced HV resonant controller

### Secondary side

- **SRK2001**
  - Adaptive synch. rect. controller

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**PFC Standby improvement**

- Integrated 700 V start-up source
- Burst mode operation / Idle state driven by DC-DC converter’s IC through dedicated interface
- Typical IC consumption in Burst mode: 2.2 mA

**LLC Standby improvement**

- Synchronized burst-mode operation with D2D converter controller.
- Typ. idle state quiescent current: 200 μA

**SR Standby improvement**

- Improved burst mode operation at light load or no load
- Self-adaptive deadtime
- IC quiescent current in Burst mode: 1 mA

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**SR Standby improvement**

- Intelligent automatic sleep mode, reducing also IC’s quiescent consumption
- Typ. IC quiescent current for low consumption mode operation: 50 μA
Efficient power MOSFETs enhance the ecodesign performance

- Continuous improvement of HV and LV MOSFET technologies to answer the world’s need for more efficient power supplies

### MDmesh M2 EP

- **STP25N60M2-EP**
  - M2-enhanced performance for 200W PFC
  - Suitable for hard & soft-switching topologies
  - Improved efficiency at light load
  - Higher efficiency at whole load range
  - Lower temperature

- **STF15N60M2-EP**
  - M2-enhanced performance for 150W LLC
  - Extremely low gate charge
  - Optimized Vth and Rg values for soft switching
  - Reduced switching losses for wide range of load and input voltage

### H7 – F7 technology

- **STLD220N3LLH7**
  - STLD130N8F7
  - Extremely low on-resistance
  - Dual side cooling package to increase efficiency and to improve current handling capability
  - Lower temperature

### Efficiency Improvement

- **PFC Efficiency improvement**
- **LLC Light load efficiency improvement**
- **Synchronous Rectification efficiency improvement**
Latest rectifier technologies add value to the ecodesign

Tandem G2

- STTH8T06DI
- STTH8ST06DI
- STTH12T06DI
- Housed inside insulated package

Primary side (PFC)

SiC* diodes

- STPSC8C065D
- STPSC806D
- STPSC12C065D
- STPSC1206D

Secondary Side

FERD* technology

- FERD20U50DJF
- FERD40U45CG

DC/DC Efficiency improvement

PFC Efficiency improvement

- Very low reverse recovery charges (QRR)
- Very low switching losses
- Insulated package with internal ceramic
- Very good thermal behaviors.

- Low forward conduction losses
- Negligible switching losses
- Extremely low reverse recovery charges (QRR)
- \( V_{RRM} \) 600 V, 650 V, 1200 V guaranteed @ -40 °C.
- Low EMC, simplifying certification and speeding TTM
- High Tj, 175 °C ensuring high reliability

- Ultra-low VF technology
- Higher current density (A/mm²)
- Lower leakage current ratio typ. & max
- Lower dependency of IR versus Tj \( \rightarrow \) Lower thermal runaway risk

* Part numbers listed here are examples. This is not an exhaustive list, please contact your sales representative for more available SiC & FERD products.
System solutions compliant with EuP Lot 6 Tier2

STEVAL-ISA170V1
12V - 150 W resonant converter with synchronous rectification based on L6563H, L6699 and SRK2001

EVL400W-ADP/ATX
12V - 400W SMPS for adapter, desktop and AIO using L4984D, L6699 and SRK2000A
System solutions compliant with EuP Lot 6 Tier2

STEVAL-ISA170V1(*)
12V - 150 W resonant converter with synchronous rectification based on L6563H, L6699 and SRK2001

EVL400W-ADP/ATX
12V - 400W SMPS for adapter, desktop and AIO using L4984D, L6699 and SRK2000A
STEVAL-ISA170V1: 12 V - 150 W resonant converter with synchronous rectification

Based on state-of-the-art PFC and LLC controllers, L6563H and L6699

Advanced power stage
- Based on MDmesh™ M2 technology of power MOSFETs

Outstanding performance vs. Ecodesign requirements
- Compliant with ENERGY STAR® requirements or computers ver. 6.1
- Compliant with EuP Lot 6 Tier2 requirements for household and office equipment
- Compliant with European CoC ver. 5 Tier 2 requirements for external power supplies

Uses latest synchronous rectification controller SRK2001, to boost efficiency in all load conditions
Main features and target applications

**Main features**

- Input mains range: 90-264 V\(_{\text{AC}}\), frequency 45-65 Hz
- Output voltage: 12 V at 12.5 A continuous operation
- Mains harmonics: According to EN61000-3-2 Class-D or JEITA-MITI Class-D
- No-load mains consumption: < 0.15 W at 230 V\(_{\text{AC}}\), according to European CoC ver. 5 Tier 2 requirements for external power supplies
- Avg. efficiency> 91% at 115 V\(_{\text{AC}}\), according to ENERGY STAR® 6.1 for external power supplies
- Light load efficiency: According to EuP Lot 6 Tier2 requirements
- EMI: According to EN55022 Class-B
- Safety: According to EN60950
- Protections: PFC brownout protection, LLC anti-capacitive protection, output overcurrent and short-circuit protection

**Target applications**

- All-in—one computer PSU
- ATX desktop PSU
- High power adapters
- Game consoles
Power stage: key technologies

- **MDmesh™ M2 Power MOSFETs**
  - STF24N60M2

- **Turbo 2 Ultrafast Diode**
  - STTH5L06 or STTH5R06

- **EMI filter & rectifier**

- **TM PFC pre-regulator**

- **LLC Half-bridge**

- **Synchr. rectifier**

- **Input voltage**
  - 90 to 264 V_{AC}, 45/65 Hz

- **400 V DC**

- **12 V DC**

- **HF isolation**

- **L6563H**

- **L6699**

- **SRK2001**

- **TSM1014 (CC-CV controller) and TSC101 (amp. for current detector) are used for Burst mode**
STEVAL-ISA170V1: Standby power-saving through reliable Burst mode

- Burst mode operation heavily influences converter efficiency at light loads
- Burst mode threshold set by sensing directly the output load
- L6699 enables also the PFC burst mode and the L6563H idle state
- Burst mode threshold must be properly set
- Standby consumption independent of production spread
- Power supply overall standby consumption improved
STEVAL-ISA170V1: Burst mode operation at light loads

Transition full load to no load at 115 Vac - 60 Hz
Output voltage (purple), output current (green), RES LS GD (yellow) and PFC GD (blue)

Pout = 250 mW operation
STBY Pin (purple), output voltage (green), Half-bridge (orange) and low-side GD (blue)

Very narrow burst pulses, Very few burst pulses

Pout = 250 mW operation – detail
STBY Pin (purple), ISEN pin (green), Half-bridge (orange) and low-side GD (blue)

The maximum operating frequency is approx. 75 kHz

Transition no load to full load at 115 Vac - 60 Hz
Output voltage (purple), output current (green), RES LS GD (yellow) and PFC GD (blue)
STEVAL-ISA170V1: Verification of Ecodesign requirements

### ENERGY STAR® requirements for computers ver. 6.1: PASS

<table>
<thead>
<tr>
<th>Test results</th>
<th>115 Vac - 60 Hz</th>
<th>230 Vac - 50 Hz</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency @ 20% load</td>
<td>84.2%</td>
<td>86.63%</td>
<td>&gt;82%</td>
</tr>
<tr>
<td>Efficiency @ 50% load</td>
<td>91.24%</td>
<td>92.90%</td>
<td>&gt;85%</td>
</tr>
<tr>
<td>Efficiency @ 100% load</td>
<td>90.96%</td>
<td>93.16%</td>
<td>&gt;82%</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.9897</td>
<td>0.9521</td>
<td>&gt;0.9</td>
</tr>
</tbody>
</table>

Avg. efficiency measured at 25%, 50%, 75%, 100% (*), Efficiency @ 250 mW load

Efficiency @ 100 mW load (*)

(*) Source of requirement: ST’s customers

### EuP Lot 6 Tier2 requirements: PASS

<table>
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<td>Avg. efficiency measured at 25%, 50%, 75%, 100%</td>
<td>90.6%</td>
<td>92.20%</td>
<td>&gt;89%</td>
</tr>
<tr>
<td>Efficiency @ 10% load</td>
<td>81.27%</td>
<td>85.21%</td>
<td>&gt;79%</td>
</tr>
<tr>
<td>No-load input power [W]</td>
<td>0.140 W</td>
<td>0.145 W</td>
<td>&lt; 0.15 W</td>
</tr>
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### European CoC ver. 5 Tier2 requirements for external power supplies: PASS

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STEVAL-ISA170V1: Efficiency measurements

- Light load efficiency improved by synchronized Burst mode function of both L6563H and L6699 and by self-adaptive deadtime of L6699
System solutions compliant with EuP Lot 6 Tier2

STEVAL-ISA170V1(*)
12V - 150 W resonant converter with synchronous rectification based on L6563H, L6699 and SRK2001

EVL400W-ADP/ATX
12 V – 400 W SMPS for adapter, desktop and AIO using L4984D, L6699 and SRK2000A
EVL400W – ADP/ATX

Main features and target applications

**Main features**

- Wide input voltage range: 90 to 264 V<sub>AC</sub> (45 ÷ 65 Hz)
- Output voltage: 12V ± 2% at 33 A continuous operation
- Overall efficiency at full load: above 87% according to ENERGY STAR® 6.1 for computers and compliant with 80Plus GOLD level
- Avg. efficiency: > 89%, according to European CoC ver. 5 Tier2 for external power supplies
- No load mains consumption: < 0.15 W at 230 V<sub>AC</sub>, according to European CoC ver. 5 Tier 2 for external power supplies
- Light load efficiency: European CoC ver. 5 Tier2 requirements for external power supplies and EuP Lot 6 Tier2 for office equipment (Pin < 500 mW for Pout = 250 mW@115 V<sub>AC</sub> and 230 V<sub>AC</sub>)
- Mains harmonics: According to EN61000-3-2 Class-D or JEITA-MITI Class-D
- EMI: According to EN55022 Class-B

**Target applications**

- All-in-one computer PSU
- ATX desktop PSU
- High power adapters
EVL400W – ADP/ATX

Block diagram

Power stage: key technologies

- MDmesh™ M2 EP Power MOSFETs
  STF25N60M2-EP (*) (x2)

Turbo 2 Ultrafast / Tandem Diode
STTH8S06FP or STTH8T06DI

- EMI filter & rectifier

- CCM PFC pre-regulator

- 400 V DC

- HF isolation

- 12 V DC

- MDmesh™ M2 EP Power MOSFETs
  STF20N60M2-EP (**) (x2)

- STripFET™ V Power MOSFETs
  STL140N4LLF5 (x2)

- Input voltage 90 to 264 V\textsubscript{AC}, 45/65 Hz

- TSM1014 (CCCV controller) and TSC888 (amp. for current detector) are used for Burst mode

(*) Part number suggested as replacement of STF22NM60N

(**) Part number suggested as replacement of STF19NM50N
EVL400W – ADP/ATX
light-load power consumption and efficiency

- Light-load efficiency improved by synchronized Burst mode function of both L4984D and L6699 and by self-adaptive deadtime of L6699

Power losses calculation with 250 mW load

<table>
<thead>
<tr>
<th>Component</th>
<th>Power Loss (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input signal divider of PFC</td>
<td>45.4 mW</td>
</tr>
<tr>
<td>PFC IC – L4984D</td>
<td>39 mW</td>
</tr>
<tr>
<td>LLC IC – L6699</td>
<td>16.9 mW</td>
</tr>
<tr>
<td>SR IC – SRK200A</td>
<td>6 mW (*)</td>
</tr>
<tr>
<td>Feedback loop</td>
<td>3.6 mW</td>
</tr>
<tr>
<td>Current detector</td>
<td>3.6 mW</td>
</tr>
<tr>
<td><strong>Total power consumption</strong></td>
<td>364.5 mW (**)</td>
</tr>
</tbody>
</table>

(*) <1 mW with SRK2001 option

(**) Not including switching and magnetic losses, input rect. and filter losses
Burst mode operation at light load

The burst pulses are very narrow and their period is quite long. The first initial pulse is shorter than the others.

The resulting equivalent switching frequency is very low, approximately 80 kHz, ensuring high efficiency. No high current peak at half bridge operation restarting.
EVL400W – ADP/ATX: Verification of Ecodesign requirements

**ENERGY STAR® requirements for computers ver. 6.1:** PASS

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<tr>
<td>Efficiency @ 50% load</td>
<td>91.01%</td>
</tr>
<tr>
<td>Efficiency at 100% load</td>
<td>88.22%</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.9963</td>
</tr>
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**EuP Lot 6 Tier2 requirements:** PASS

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<tr>
<td>Avg. efficiency measured at 25%, 50%, 75%, 100% (*)</td>
<td>&gt;89%</td>
</tr>
<tr>
<td>Efficiency @ 10% load</td>
<td>89.56%</td>
</tr>
<tr>
<td>No Load Input Power [W]</td>
<td>0.129 W</td>
</tr>
</tbody>
</table>

(*) Source of requirement: ST’s customers

**European CoC ver. 5 Tier2 requirements for external power supplies:** PASS
EVL400W – ADP/ATX: Efficiency measurements

80 Plus-GOLD requirements: PASS

115 V<sub>AC</sub> / 60 Hz efficiency

230 V<sub>AC</sub> / 50 Hz efficiency