

**DESCRIPTION**

The LX1673 is a highly integrated power supply controller IC featuring one PWM switching regulator stage with an additional onboard linear regulator driver.

With several switching frequencies available (up to 900kHz) the LX1673 can be optimized for both cost and PCB space. Utilizing external compensation, a wide selection of external components can be chosen for use in any application while maintaining stable operation.

The LX1673 incorporates fully programmable soft-start and power sequence capabilities. The LDO and PWM have independent enable pins.

With onboard gate drivers, the switching PWM output is capable of sourcing up to 15A. The LX1673 also features an additional Linear Regulator Controller output, which when coupled with an inexpensive MOSFET is capable of supplying up to an additional 5A for I/O, memory, and other supplies surrounding today's micro-processor designs.

Each regulator output voltage is programmed via a simple voltage-divider network.

Integrated hiccup-mode current limiting is implemented utilizing MOSFET  $R_{DS(ON)}$  impedance. This enables the LX1673 to monitor maximum current limit conditions without the use of expensive current sense resistors.

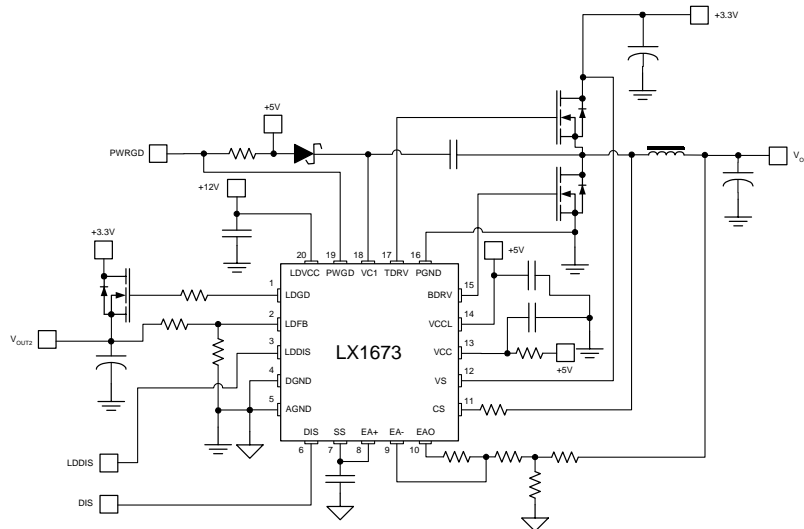
**KEY FEATURES**

- Two Independently Regulated Outputs
- Outputs As Low As 0.8V Generated From An Internal 1% Reference
- Integrated High Current MOSFET Drivers
- 300KHz, 600KHz, and 900KHz High Frequency Operation Minimizes External Component Requirements
- Soft-Start and Power Sequencing Control
- Adjustable Linear Regulator Driver Output
- No current-sense resistors

**APPLICATIONS/BENEFITS**

- Video Card Power Supplies
- PC Peripherals
- Computer Add-On Cards
- 3.3V Power Conversion
- DDR Memory Termination

**IMPORTANT:** For the most current data, consult MICROSEMI's website: <http://www.microsemi.com>

**PRODUCT HIGHLIGHT**

**PACKAGE ORDER INFO**

| T <sub>A</sub> (°C) | Switching Frequency (kHz) | PACKAGE ORDER INFO      |                        |
|---------------------|---------------------------|-------------------------|------------------------|
|                     |                           | PW Plastic TSSOP 20-Pin | LQ Plastic MLPQ 20-Pin |
| -40 to 85           | 300                       | LX1673-03CPW            | LX1673-03CLQ           |
| -40 to 85           | 600                       | LX1673-06CPW            | LX1673-06CLQ           |
| -40 to 85           | 900                       | LX1673-09CPW            | LX1673-09CLQ           |

**ABSOLUTE MAXIMUM RATINGS**

|  |                |
|--|----------------|
| Supply Voltage ( $V_{CC}$ ) DC .....                             | -0.3V to 5.5V  |
| Supply Voltage ( $V_{CC}$ ) Transient .....                      | -0.3V to 6V    |
| Driver Supply Voltage ( $V_{CI}$ , $V_{CL}$ , $LDVCC$ ) DC ..... | -0.3V to 16V   |
| Driver Supply Voltage ( $V_{CI}$ ) Transient .....               | -0.3V to 19V   |
| Input Voltage ( $SS/DIS$ ) .....                                 | -0.3V to 5.5V  |
| Output Drive Peak Current Source (HO, LO) .....                  | 1A (500ns)     |
| Output Drive Peak Current Sink (HO, LO) .....                    | 1A (500ns)     |
| Operating Temperature Range .....                                | -40°C to 85°C  |
| Maximum Operating Junction Temperature .....                     | 150°C          |
| Storage Temperature Range .....                                  | -65°C to 150°C |
| Lead Temperature (Soldering 180 seconds) .....                   | 235°C          |

Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

The limitation on transient time is thermal and is due to zener diodes on the supply pins, application of maximum voltages will increase current into that pin and increase package power dissipation..

**THERMAL DATA**
**PW Plastic TSSOP 20-Pin**

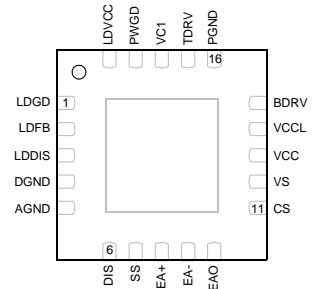
|   |               |
|---|---------------|
| THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$ | <b>90°C/W</b> |
|---|---------------|

**LQ Plastic MLPQ 20-Pin**

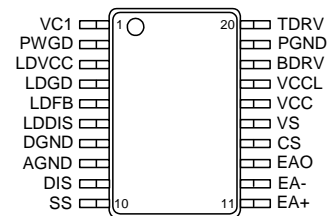
|   |               |
|---|---------------|
| THERMAL RESISTANCE-JUNCTION TO AMBIENT, $\theta_{JA}$ | <b>35°C/W</b> |
|---|---------------|

Junction Temperature Calculation:  $T_J = T_A + (P_D \times \theta_{JC})$ .

The  $\theta_{JA}$  numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no airflow.

**PACKAGE PIN OUT**

**LQ PACKAGE**  
 (Top View)

N.C. – No Internal Connection  
 N/U – Not Used  
 RSVD – Do Not Use


**PW PACKAGE**  
 (Top View)



**FUNCTIONAL PIN DESCRIPTION**

| <b>NAME</b> | <b>DESCRIPTION</b>   |
|-------------|--|
| EA-         | Voltage Feedback – Output voltage is connected through a resistor network to this pin for feedback to set the desired output voltage of the switching PWM output.  |
| EAO         | Error Amplifier Output – Sets error amplifier gain and external compensation if used.  |
| EA+         | Voltage Reference – Connect to the SS pin or any other external voltage. Used in conjunction with EA-, and an external resistor divider, to set the desired output voltage for the PWM output.   |
| VCC         | IC supply voltage (nominal 5V).  |
| VCCL        | Power supply pin for Low side drivers.   |
| LDFB        | Low Dropout Regulator Voltage Feedback – Sets output voltage of external MOSFET via resistor network.  |
| CS          | Over-Current Limit Set – Connecting a resistor between CS pin and the source of the high-side MOSFET sets the current-limit threshold for the PWM output. A minimum of 1K $\Omega$ must be in series with this pin.  |
| SS          | PWM Soft-start/Hiccup Capacitor Pin – During start-up, the voltage on this pin controls the output voltage of the switching regulator. An internal 20k $\Omega$ resistor and the external capacitor set the time constant for soft-start function. The Soft-start function does not initialize until the supply voltage on V <sub>CC</sub> exceeds the UVLO threshold. When an over-current condition occurs, this capacitor is used for the timing of hiccup mode protection. |
| AGND        | Analog ground reference.   |
| DGND        | Digital ground reference.  |
| LDGD        | Low Dropout Regulator Gate Drive – Connect to gate of external N-Channel MOSFET for linear regulator function.   |
| PGND        | MOSFET Driver Power Ground. Connects to the source of the bottom N-channel MOSFETS of the switching regulator.   |
| TDRV        | High Side MOSFET Gate Driver   |
| BDRV        | Low Side MOSFET Gate Driver  |
| VC1         | High-Side MOSFET Gate Driver Supply – Connect to separate supply or boot strap supply to ensure proper high-side gate driver supply voltage.   |
| LDDIS       | LDO Disable Input – High disables LDO output. This pin has a 100K $\Omega$ pulldown resistor.  |
| VS          | Voltage reference for Short Circuit Current sense. This pin is also the supply pin for the Current Sense Comparator. This pin cannot be left floating, if current limit is not used connect to VCC.  |
| PWGD        | Power Good Output – Open drain output , goes high at end of Soft Start and no Fault. Pulls low if any Fault condition occurs.  |
| LDVCC       | LDO VCC Supply – Connect to voltage supply greater than supply rail for LDO MOSFET drain.  |
| DIS         | PWM Disable Input –High disables the PWM output. This pin has a 80K $\Omega$ pulldown resistor.  |

**ELECTRICAL CHARACTERISTICS**

Unless otherwise specified, the following specifications apply over the operating ambient temperature  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$  except where otherwise noted and the following test conditions:  $V_{CC} = 5\text{V}$ ,  $V_{CCL} = 5\text{V}$ ,  $V_{C1} = 12\text{V}$ ,  $LDVCC = 12\text{V}$   $TDRV = BDRV = 3000\text{pF}$  Load.

| Parameter                                  | Symbol            | Test Conditions  | LX1673 |      |       | Units         |
|--|-------------------|--|--------|------|-------|---------------|
|  |                   |  | Min    | Typ  | Max   |               |
| <b>SWITCHING REGULATORS</b>                |                   |  |        |      |       |               |
| Input Voltage                              | $V_{CC}$          |  | 4.5    |      | 5.5   | V             |
|  | $V_{CCL}, V_{C1}$ |  |        |      | 16    |               |
| Operation Current                          | $I_{CC}$          | Static and Dynamic                                     |        | 6    |       | mA            |
| LDO Operating Current                      | $I_{LDVCC}$       |  |        | 1    |       | mA            |
| Reference Voltage                          | $V_{SS}$          | $T_A = 25^{\circ}\text{C}$                             | 0.792  | 0.8V | 0.808 | V             |
|  |                   | $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$   | 0.784  |      | 0.816 | V             |
| Line Regulation Note 1                     |                   |  | -1     |      | 1     | %             |
| Load Regulation Note 1                     |                   |  | -1     |      | 1     | %             |
| Dead Time                                  |                   | 3000pF Load 2 Volt Level                               |        |      | 160   | nS            |
| Minimum Pulse Width                        |                   | All Frequencies  |        |      | 150   | nS            |
| Maximum Duty Cycle                         |                   | LX1673-03 Load = 3000 pF                               | 85     |      |       | %             |
| Maximum Duty Cycle                         |                   | LX1673-06 Load = 3000pF                                | 75     |      |       | %             |
| Maximum Duty Cycle                         |                   | LX1673-09 Load = 3000 pF                               | 70     |      |       | %             |
| <b>ERROR AMPLIFIERS</b>                    |                   |  |        |      |       |               |
| Input Offset Voltage                       | $V_{OS}$          | Common Mode Voltage = 1V                               | -6.0   |      | 6.0   | mV            |
| DC Open Loop Gain                          |                   |  |        | 70   |       | dB            |
| Unity Gain Bandwidth                       | UGBW              |  |        | 16   |       | MHz           |
| High Output Voltage                        | $V_{OH}$          | I Source = 2mA   | 3.8    | 5.0  |       | V             |
| Low Output Voltage                         | $V_{OL}$          | I Sink = 10uA  |        |      | 100   | mV            |
| Input Common Mode Voltage Range            |                   | Input Offset Voltage $\leq 20\text{mV}$                | 0.1    |      | 3.5   | V             |
| Input Bias Current                         |                   | 0 and 3.5 V Common Mode Voltage                        |        | 100  |       | nA            |
| <b>CURRENT SENSE</b>                       |                   |  |        |      |       |               |
| Current Sense Bias Current                 | $I_{SET}$         | $V_{CS} = V_{VS} - 0.3\text{V}$ , $V_{VS} = 5\text{V}$ | 45     | 50   | 55    | $\mu\text{A}$ |
| Trip Threshold                             | $V_{TRIP}$        | Referenced to VS, $V_{VS} = 5\text{V}$                 | 260    | 300  | 340   | mV            |
| Current Sense Delay                        | $T_{CSD}$         |  |        | 350  |       | nS            |
| Current Sense Comparator Operating Current | $I_{CS}$          | Current into VS pin                                    |        | 2    | 5     | mA            |
| <b>OUTPUT DRIVERS – N-CHANNEL MOSFETS</b>  |                   |  |        |      |       |               |
| Low Side Driver Operating Current          | $I_{VCC}$         | Static   |        | 2.5  |       | mA            |
| High Side Driver Operating Current         | $I_{V_{C1}}$      | Static   |        | 3    |       | mA            |
| Drive Rise Time, Fall Time                 | $T_{RF}$          | $C_L = 3000\text{pF}$                                  |        | 50   |       | nS            |
| High Level Voltage                         | $V_{DH}$          | $I_{SOURCE} = 20\text{mA}$ , $V_{CCL} = 12\text{V}$    | 10     | 11   |       | V             |
| Low Level Voltage                          | $V_{DL}$          | $I_{SINK} = 20\text{mA}$ , $V_{CCL} = 12\text{V}$      |        | 0.15 | 0.25  | V             |
| <b>OSCILLATOR</b>                          |                   |  |        |      |       |               |
| PWM Switching Frequency                    | $F_{SW}$          | LX1673-03  | 255    | 300  | 345   | KHz           |
|  |                   | LX1673-06  | 510    | 600  | 690   |               |
|  |                   | LX1673-09  | 765    | 900  | 1035  |               |
| Ramp Amplitude                             | $V_{RAMP}$        |  |        | 1.25 |       | $V_{PP}$      |

**ELECTRICAL CHARACTERISTICS**

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| Parameter   | Symbol     | Test Condition                                       | LX1673 |      |     | Units            |
|---|------------|--|--------|------|-----|------------------|
|   |            |  | Min    | Typ  | Max |                  |
| <b>UVLO AND SOFT-START (SS)</b>                       |            |  |        |      |     |                  |
| Start-Up Threshold ( $V_{C1}$ , $V_{CCL}$ , $LDVCC$ ) |            |  | 3.5    | 4.0  | 4.5 | V                |
| Start-Up Threshold ( $V_{CC}$ )                       |            |  | 4.0    | 4.25 | 4.5 | V                |
| Hysteresis $V_{CC}$                                   |            |  |        | 0.1  |     | V                |
| SS Input Resistance                                   | $R_{SS}$   |  |        | 20   |     | $\text{K}\Omega$ |
| SS Shutdown Threshold                                 | $V_{SHDN}$ |  |        | 0.1  |     | V                |
| Hiccup Mode Duty Cycle                                |            | $C_{SS} = 0.1\mu\text{F}$                            |        | 10   |     | %                |
| <b>LINEAR REGULATOR CONTROLLER</b>                    |            |  |        |      |     |                  |
| Voltage Reference Tolerance                           |            | $V_{LDFB} = .8\text{V}$ , $C_{OUT} = 330\mu\text{F}$ |        | 2    |     | %                |
| Source Current  | $I_{HDRV}$ | $V_{out} = 10\text{V}$                               | 30     |      |     | mA               |
| Sink Current  | $I_{LDRV}$ | $V_{out} = 0.4\text{V}$                              |        | 0.2  |     | mA               |
| <b>DISABLE INPUTS</b>                                 |            |  |        |      |     |                  |
| PWM Disable   | DIS        | Threshold  |        | 1    |     | V                |
|   |            | Internal Pulldown Resistance                         |        | 80   |     | $\text{K}\Omega$ |
| LDO Disable   | LDDIS      | Threshold  |        | 2.5  |     | V                |
|   |            | Internal Pulldown Resistance                         |        | 100  |     | $\text{K}\Omega$ |
| <b>POWER GOOD</b>                                     |            |  |        |      |     |                  |
| Drain to Source Voltage                               |            | $I = 3\text{mA}$                                     |        | 0.4  |     | V                |
| Leakage   |            |  |        | 0.05 |     | $\mu\text{A}$    |

Note 1- System Specification

Note 2 – Low duty cycle pulse testing techniques are used which maintain junction and case temperatures equal to the ambient Temperature

Note 3 – Functionality over the  $-40$  to  $85$  deg C operating temperature range is assured by design, characterization, and statistical Process control

**BLOCK DIAGRAM**

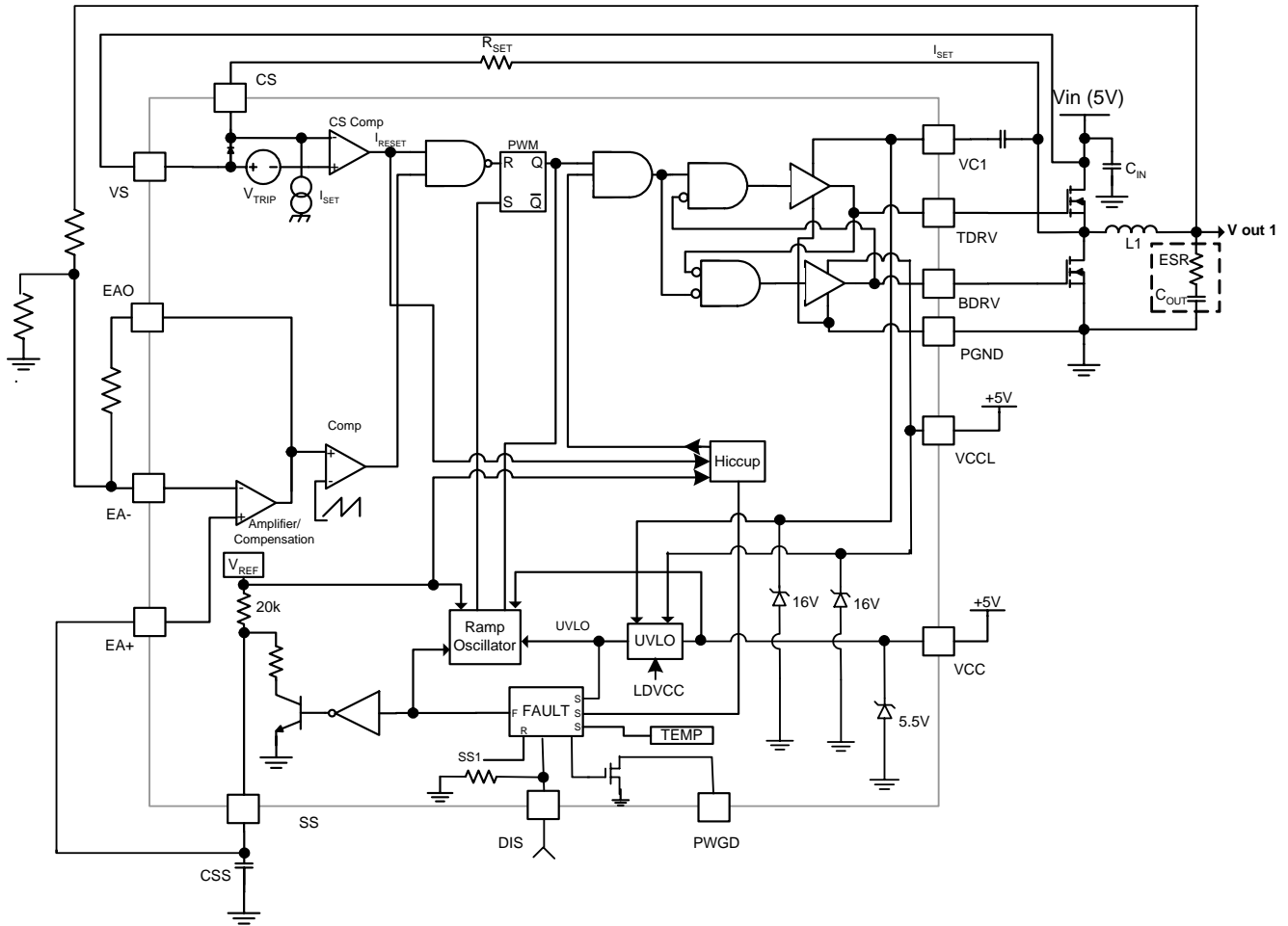


Figure 1 – Block Diagram of PWM Phase

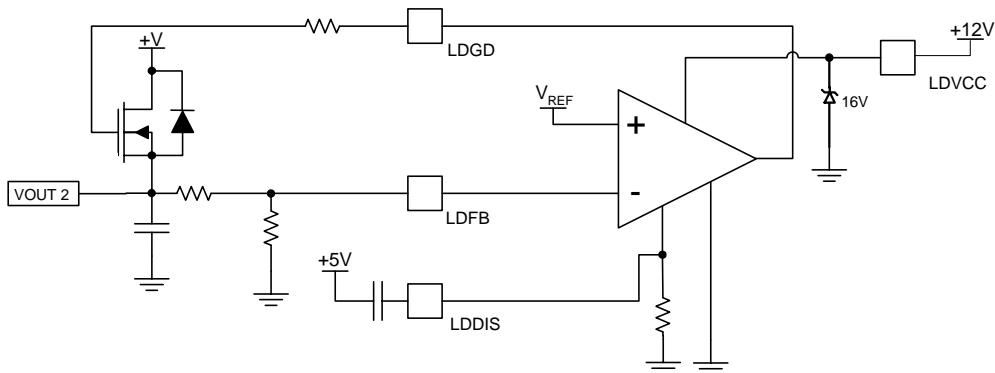
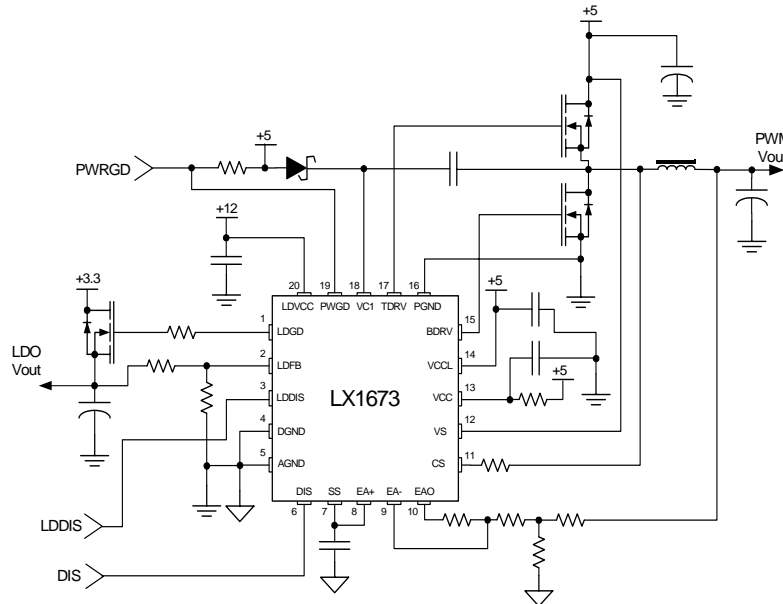
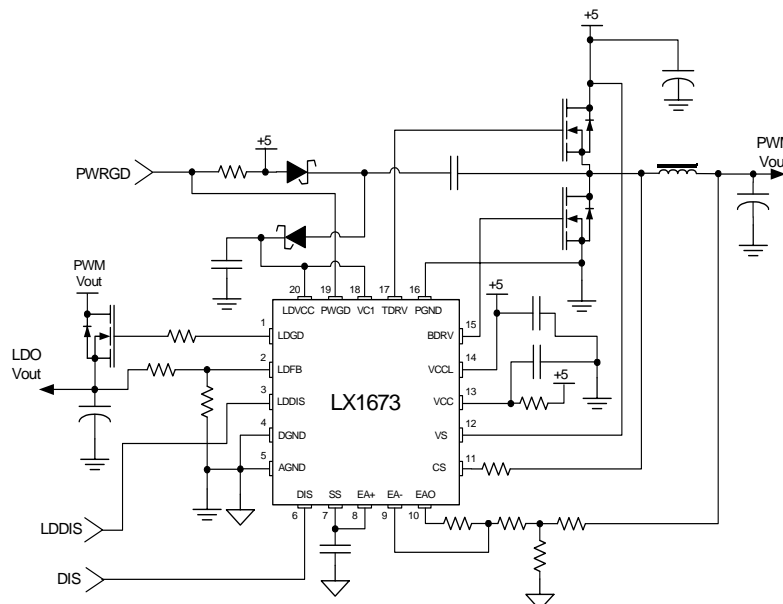


Figure 2 – LDO Controller Block Diagram

**APPLICATION SCHEMATIC**



**Figure 3 – Schematic with Bootstrap Supply for PWM High Side Drive**



**Figure 4 – Schematic for 5 Volt only Input**

**THEORY OF OPERATION****GENERAL DESCRIPTION**

The LX1673 is a voltage-mode pulse-width modulation controller integrated circuit. The internal oscillator and ramp generator frequency is fixed to 300kHz, 600kHz, or 900kHz. The device has external compensation, for more flexibility of output current magnitude.

**UNDER VOLTAGE LOCKOUT (UVLO)**

At power up, the LX1673 monitors the supply voltage for VCC, VCCL, LDVCC and VC1 (there is no requirement for sequencing the supplies). Before all supplies reach their under-voltage lock-out (UVLO) thresholds, the soft-start (SS) pin is held low to prevent soft-start from beginning, the oscillator is disabled and all MOSFETs are held off. There is an internal delay that will filter out transients less than 1.5µSec.

**SOFT-START**

Once the supplies are above the UVLO threshold, the soft-start capacitor begins to be charged by the reference through a 20kΩ internal resistor. The capacitor voltage at the SS pin rises as a simple RC circuit. The SS pin is connected to the error amplifier's non-inverting input that controls the output voltage. The output voltage will follow the SS pin voltage if sufficient charging current is provided to the output capacitor.

The simple RC soft-start allows the output to rise faster at the beginning and slower at the end of the soft-start interval. Thus, the required charging current into the output capacitor is less at the end of the soft-start interval. A comparator monitors the SS pin voltage and indicates the end of soft-start when SS pin voltage reaches 95% of  $V_{REF}$ .

**OVER-CURRENT PROTECTION (OCP) AND HICCUP**

The LX1673 uses the  $R_{DS(ON)}$  of the upper MOSFET, together with a resistor ( $R_{SET}$ ) to set the actual current limit point. The current sense comparator senses the MOSFET current 350nS after the top MOSFET is switched on in order to reduce inaccuracies due to ringing. A current source supplies a current ( $I_{SET}$ ), whose magnitude is 50µA. The set resistor  $R_{SET}$  is selected to set the current limit for the application.  $R_{SET}$  and VS should be connected directly at the upper MOSFET drain and source to get an accurate measurement across the low resistance  $R_{DS(ON)}$ .

When the sensed voltage across  $R_{DS(ON)}$  plus the set resistor exceeds the 300mV,  $V_{TRIP}$  threshold, the OCP comparator outputs a signal to reset the PWM latch and to start hiccup mode. The soft-start capacitor ( $C_{SS}$ ) is discharged slowly (10 times slower than when being charged up by  $R_{SS}$ ). When the voltage on the SS pin reaches a 0.1V threshold, hiccup finishes and the circuit soft-starts again. During hiccup both MOSFETs are held off.

Hiccup is disabled during the soft-start interval, allowing the circuit to start up with maximum current. If the rate of rise of the output voltage is too fast, the required charging current to the output capacitor may be higher than the limit-current. In this case, the peak MOSFET current is regulated to the limit-current by the current-sense comparator. If the MOSFET current still reaches its limit after the soft-start finishes, the hiccup is triggered again. When the output has a short circuit the hiccup circuit ensures that the average heat generation in both MOSFETs and the average current is much less than in normal operation.

Over-current protection can also be implemented using a sense resistor, instead of using the  $R_{DS(ON)}$  of the upper MOSFET, for greater set-point accuracy.

**OSCILLATOR FREQUENCY**

An internal oscillator sets the switching frequency at 300kHz, 600kHz, or 900kHz.



**APPLICATION NOTE**
**OUTPUT INDUCTOR**

The output inductor should be selected to meet the requirements of the output voltage ripple in steady-state operation and the inductor current slew-rate during transient. The peak-to-peak output voltage ripple is:

$$V_{\text{RIPPLE}} = \text{ESR} \times I_{\text{RIPPLE}}$$

where

$$\Delta I = \frac{V_{\text{IN}} - V_{\text{OUT}}}{L} \times \frac{D}{f s}$$

$\Delta I$  is the inductor ripple current,  $L$  is the output inductor value and  $\text{ESR}$  is the Effective Series Resistance of the output capacitor.

$\Delta I$  should typically be in the range of 20% to 40% of the maximum output current. Higher inductance results in lower output voltage ripple, allowing slightly higher  $\text{ESR}$  to satisfy the transient specification. Higher inductance also slows the inductor current slew rate in response to the load-current step change,  $\Delta I$ , resulting in more output-capacitor voltage droop. When using electrolytic capacitors, the capacitor voltage droop is usually negligible, due to the large capacitance

The inductor-current rise and fall times are:

$$T_{\text{RISE}} = L \times \frac{\Delta I}{(V_{\text{IN}} - V_{\text{OUT}})}$$

and

$$T_{\text{FALL}} = L \times \frac{\Delta I}{V_{\text{OUT}}}$$

The inductance value can be calculated by

$$L = \frac{V_{\text{IN}} - V_{\text{OUT}}}{\Delta I} \times \frac{D}{f s}$$

**OUTPUT CAPACITOR**

The output capacitor is sized to meet ripple and transient performance specifications. Effective Series Resistance ( $\text{ESR}$ ) is a critical parameter. When a step load current occurs, the output voltage will have a step that equals the product of the  $\text{ESR}$  and the current step,  $\Delta I$ . In an advanced microprocessor power

supply, the output capacitor is usually selected for  $\text{ESR}$  instead of capacitance or RMS current capability. A capacitor that satisfies the  $\text{ESR}$  requirements usually has a larger capacitance and current capability than strictly needed. The allowed  $\text{ESR}$  can be found by:

$$\text{ESR} \times (I_{\text{RIPPLE}} + \Delta I) < V_{\text{EX}}$$

Where  $I_{\text{RIPPLE}}$  is the inductor ripple current,  $\Delta I$  is the maximum load current step change, and  $V_{\text{EX}}$  is the allowed output voltage excursion in the transient.

Electrolytic capacitors can be used for the output capacitor, but are less stable with age than tantalum capacitors. As they age, their  $\text{ESR}$  degrades, reducing the system performance and increasing the risk of failure. It is recommended that multiple parallel capacitors be used, so that, as  $\text{ESR}$  increase with age, overall performance will still meet the processor's requirements.

There is frequently strong pressure to use the least expensive components possible, however, this could lead to degraded long-term reliability, especially in the case of filter capacitors. Microsemi's demonstration boards use the CDE Polymer AL-EL (ESRE) filter capacitors, which are aluminum electrolytic, and have demonstrated reliability. The OS-CON series from Sanyo generally provides the very best performance in terms of long term  $\text{ESR}$  stability and general reliability, but at a substantial cost penalty. The CDE Polymer AL-EL (ESRE) filter series provides excellent  $\text{ESR}$  performance at a reasonable cost. Beware of off-brand, very low-cost filter capacitors, which have been shown to degrade in both  $\text{ESR}$  and general electrolytic characteristics over time.

**INPUT CAPACITOR**

The input capacitor and the input inductor, if used, are to filter the pulsating current generated by the buck converter to reduce interference to other circuits connected to the same 5V rail. In addition, the input capacitor provides local de-coupling for the buck converter. The capacitor should be rated to handle the RMS current requirements. The RMS current is:

$$I_{\text{RMS}} = I_L \sqrt{d(1-d)}$$

Where  $I_L$  is the inductor current and  $d$  is the duty cycle. The maximum value occurs when  $d = 50\%$ , then  $I_{\text{RMS}} = 0.5I_L$ . For a 5V input and output voltages in the range of 2 to 3V, the required RMS current is very close to  $0.5I_L$ .

**SOFT-START CAPACITOR**

The value of the soft-start capacitor determines how fast the output voltage rises and how large the inductor current is required to charge the output capacitor. The output voltage will follow the voltage at the SS pin if the required inductor current does not exceed the maximum allowable current for the inductor.

**APPLICATION NOTE (CONTINUED)**

The SS pin voltage can be expressed as:

$$V_{SS} = V_{ref} \left( 1 - e^{-t/R_{SS}C_{SS}} \right)$$

Where  $R_{SS}$  and  $C_{SS}$  are the soft-start resistor and capacitor.

The current required to charge the output capacitor during the soft start interval is.

$$I_{out} = C_{out} \frac{dV_{SS}}{dt}$$

Taking the derivative with respect to time results in

$$I_{out} = \frac{V_{ref}C_{out}}{R_{SS}C_{SS}} e^{-t/R_{SS}C_{SS}}$$

and at  $t=0$

$$I_{max} = \frac{V_{ref}C_{out}}{R_{SS}C_{SS}}$$

The required inductor current for the output capacitor to follow the soft start voltage equals the required capacitor current plus the load current. The soft-start capacitor should be selected to provide the desired power on sequencing and insure that the overall inductor current does not exceed its maximum allowable rating.

Values of  $C_{SS}$  equal to .1uF or greater are unlikely to result in saturation of the output inductor unless very large output capacitors are used.

**OVER-CURRENT PROTECTION**

Current limiting occurs at current level  $I_{CL}$  when the voltage detected by the current sense comparator is greater than the current sense comparator threshold,  $V_{TRIP}$  (300mV).

$$I_{CL} \times R_{DS(ON)} + I_{SET} \times R_{SET} = V_{TRIP}$$

So,

$$R_{SET} = \frac{V_{TRIP} - I_{CL} \times R_{DS(ON)}}{I_{SET}} = \frac{300 \text{ mV} - I_{CL} \times R_{DS(ON)}}{50 \mu\text{A}}$$

*Example:*

For 10A current limit, using FDS6670A MOSFET (10mV  $R_{DS(ON)}$ ):

$$R_{SET} = \frac{0.3 - 10 \times 0.010}{50 \times 10^{-6}} = 4 \text{ K}\Omega$$

Note: Maximum  $R_{SET}$  is 6K $\Omega$ . Any resistor 6K $\Omega$  or greater will not allow startup since  $I_{CL}$  will equal zero (50uA x 6K $\Omega$ =300mV).

At higher PWM frequencies or low duty cycles where the upper gate drive is less than 350nS wide the 350nS delay for current limit enable may result in current pulses exceeding the desired current limit set point. If the upper MOSFET on time is less than

350nS and a short circuit condition occurs the duty cycle will increase, since  $V_{out}$  will be forced low. The current limit circuit will be enabled when the upper gate drive exceeds 350nS although the actual peak current limit value will be higher than calculated with the above equation.

Short circuit protection still exists due to the narrow pulse width even though the magnitude of the current pulses will be higher than the calculated value.

If OCP is not desired connect both  $V_{SX}$  and  $V_{CX}$  to VCC. Do not leave them floating.

**OUTPUT DISABLE**

The LX1673 PWM MOSFET driver outputs are shut off by pulling the disable (DIS) pin above 1.2V. There is a 80K $\Omega$  pulldown resistor on this input.

The LDO voltage regulator has its own Disable pin (LDDIS) for control of this output voltage. Pulling this pin above 3 V disables the LDO. There is a 100K $\Omega$  pulldown resistor on this input.

**PROGRAMMING THE OUTPUT VOLTAGE**

The output Voltage is sensed by the feedback pin ( $FB_X$ ) which is compared to a 0.8V reference. The output voltage can be set to any voltage above 0.8V (and lower than the input voltage) by means of a resistor divider (see Figure 1).

$$V_{OUT} = V_{REF} (1 + R_1/R_2)$$

Note: This equation is simplified and does not account for error amplifier input current. Keep  $R_1$  and  $R_2$  close to 1k $\Omega$  (order of magnitude).

**DDR  $V_{TT}$  TERMINATION VOLTAGE**

Double Data Rate (DDR) SDRAM requires a termination voltage ( $V_{TT}$ ) in addition to the line driver supply voltage ( $V_{DDQ}$ ) and receiver supply voltage ( $V_{DD}$ ).

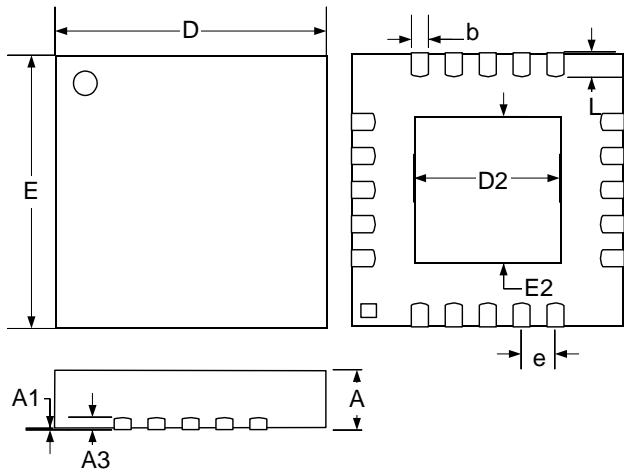
$V_{TT}$  for DDR memory can be generated with the LX1673 by using the positive input of the phase 2 error amplifier RF2 as a reference input from an external reference voltage  $V_{REF}$  which is defined as one half of  $V_{DDQ}$ . Using  $V_{REF}$  as the reference input will insure that all voltages are correct and track each other as specified in the JEDEC (EIA/JESD8-9A) specification. The phase 2 output will then be equal to  $V_{REF}$  and track the  $V_{DDQ}$  supply as required.

When an external reference is used the connection between the error amplifier positive input and the Soft Start pin is lost and Soft Start will not function. It is recommended that the external reference voltage have an R-C time constant that will be long enough to allow the output capacitor to charge slowly.

See Microsemi Application Note 17 for more details

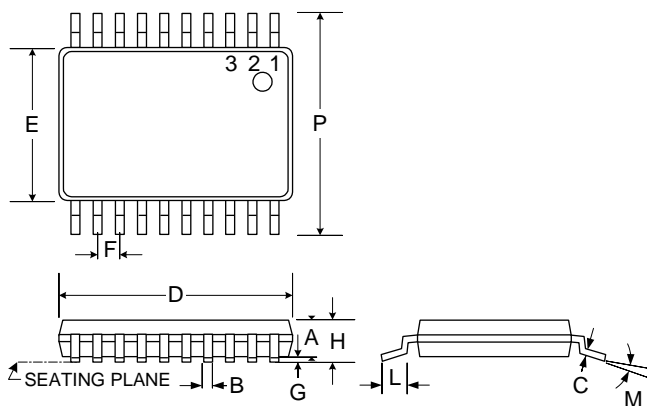
**APPLICATION NOTE CONSIDERATIONS**

1. The minimum Rset resistor value is 1k ohm for the current limit sensing. If this resistor becomes shorted, it will do permanent damage to the IC.
2. A resistor has been put in series with the gate of the LDO pass transistor to reduce the output noise level. The resistor value can be changed to optimize the output transient response versus output noise.
3. To delay the turn on of the LDO controller output, a capacitor should be connected between the LDDIS pin and the +5volts. The LDDIS input has a 100K pull down resistor, which keeps the LDO active until this pin is pulled high. During the power up sequence the capacitor connected to the LDDIS pin will keep the LDO off until this capacitor, being charge by the 100K pull down resistor, goes through the low input threshold level.
4. . If current limit is not used connect the VS and VC pins together and to VCC. Do not leave them floating. A floating VS pin will result in operation resembling a hiccup condition.

**PACKAGE DIMENSIONS**
**LQ 20-Pin Micro Leadframe Package (MLPQ) Package**


| Dim | MILLIMETERS |      | INCHES |       |
|-----|-------------|------|--------|-------|
|     | MIN         | MAX  | MIN    | MAX   |
| A   | 0.80        | 1.00 | 0.031  | 0.039 |
| A1  | 0           | 0.05 | 0      | 0.002 |
| A3  | 0.25 REF    |      | 0.010  |       |
| b   | 0.23        | 0.38 | 0.009  | 0.015 |
| D   | 5.00 BSC    |      | 0.197  |       |
| D2  | 1.25        | 3.25 | 0.050  | 0.128 |
| E   | 5.00 BSC    |      | 0.197  |       |
| E2  | 1.25        | 3.25 | 0.050  | 0.128 |
| e   | 0.65 BSC    |      | 0.026  |       |
| L   | 0.35        | 0.75 | 0.014  | 0.030 |

**Note:** Dimensions do not include mold flash or protrusions; these shall not exceed 0.155mm(0.006") on any side. Lead dimension shall not include solder coverage.

**PW 20-Pin Thin Small Shrink Outline (TSSOP)**


| Dim | MILLIMETERS |       | INCHES    |        |
|-----|-------------|-------|-----------|--------|
|     | MIN         | MAX   | MIN       | MAX    |
| A   | 0.80        | 1.05  | 0.032     | 0.041  |
| B   | 0.19        | 0.30  | 0.007     | 0.012  |
| C   | 0.09        | 0.180 | 0.0035    | 0.0071 |
| D   | 6.40        | 6.60  | 0.252     | 0.260  |
| E   | 4.30        | 4.48  | 0.169     | 0.176  |
| F   | 0.65 BSC    |       | 0.025 BSC |        |
| G   | 0.05        | 0.15  | 0.002     | 0.005  |
| H   | —           | 1.10  | —         | 0.0433 |
| L   | 0.50        | 0.70  | 0.020     | 0.028  |
| M   | 0°          | 8°    | 0°        | 8°     |
| P   | 6.25        | 6.50  | 0.246     | 0.256  |
| *LC | —           | 0.10  | —         | 0.004  |

solder coverage.



**NOTES**

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