AN1989
Rev. 1.0, 05/2005

# MC34701 and MC34702 Component Selection Guidelines



The MC34701 and MC34702 devices are two cost-effective DC/ DC converter solutions proposed by Freescale Semiconductor for many applications. They incorporate a high-performance, fully integrated synchronous buck regulator and the control for a low dropout (LDO) linear regulator. These guidelines provide the requisite information to properly tailor all external components needed for using MC34701 and MC34702 devices.

Contents

1 Overview . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
2 Switcher Topology. . . . . . . . . . . . . . . . . . . . . . . . . . 2
2.1 Buck Converter Compensation Loop . . . . . . 2
3 Low Dropout Compensation Loop . . . . . . . . . . . . 3
4 Recommendations . . . . . . . . . . . . . . . . . . . . . . . . . . 4
4.1 Boost Supply . . . . . . . . . . . . . . . . . . . . . . . . . . 4
4.2 Boost Inductor . . . . . . . . . . . . . . . . . . . . . . . . . 4
4.3 Capacitor Selection . . . . . . . . . . . . . . . . . . . . . 5
4.4 Output Voltage Selection . . . . . . . . . . . . . . . . 7
4.5 Inductor Selection . . . . . . . . . . . . . . . . . . . . . . 8
4.6 Low Dropout Converter . . . . . . . . . . . . . . . . . 9
5 Layout Considerations . . . . . . . . . . . . . . . . . . . . . 12
6 Design Example . . . . . . . . . . . . . . . . . . . . . . . . . . 13
6.1 System Description. . . . . . . . . . . . . . . . . . . . . .14
6.2 Calculations . . . . . . . . . . . . . . . . . . . . . . . . . . .14
6.3 Typical Application . . . . . . . . . . . . . . . . . . . . .18
6.4 Bill of Material . . . . . . . . . . . . . . . . . . . . . . . . .19
7 Appendix . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 20
8 References . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 22



ARCHIVE INFORMATION

# 1 Overview

The switching converter uses a DC/DCsynchronous buck topology with integrated power switches and control circuitry.

The LDO linear voltage regulator controller provides the gate control for an external pass transistor. An external sense resistor gives the flexibility for selecting desired maximum current capability of the linear regulator.

Both power supplies have programmable output voltages, via an external resistor divider structure, and are fully independent.

# 2 Switcher Topology

The MC34701/MC34702 switcher is a fully integrated synchronous buck converter. Controller uses a PWM voltage mode control topology with feed forward to achieve excellent line and load regulation.

## 2.1 Buck Converter Compensation Loop

To guarantee the overall stability of the system, a type II compensation network is used.

Figure 1 illustrates the switcher compensation network Freescale Semiconductor recommends for coping with most applications.

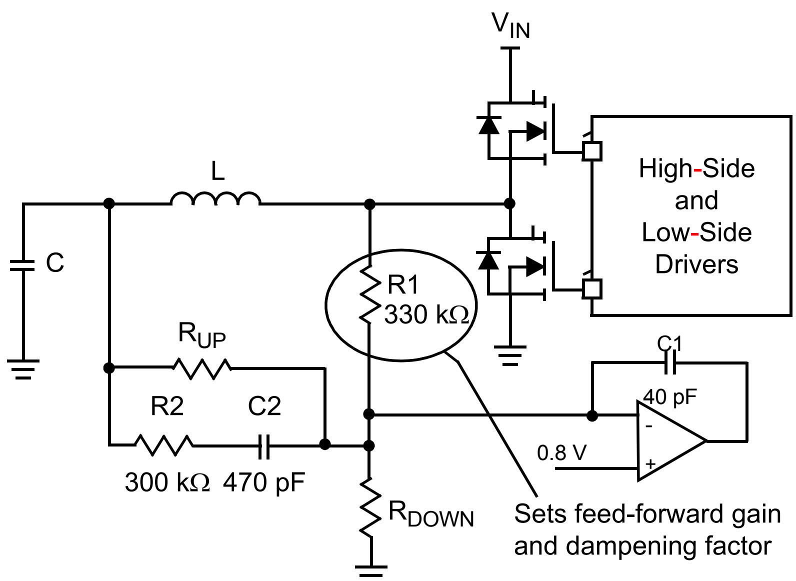



Figure 1. Switcher Compensation Network

# 3 Low Dropout Compensation Loop

Figure 2 illustrates the LDO compensation loop.

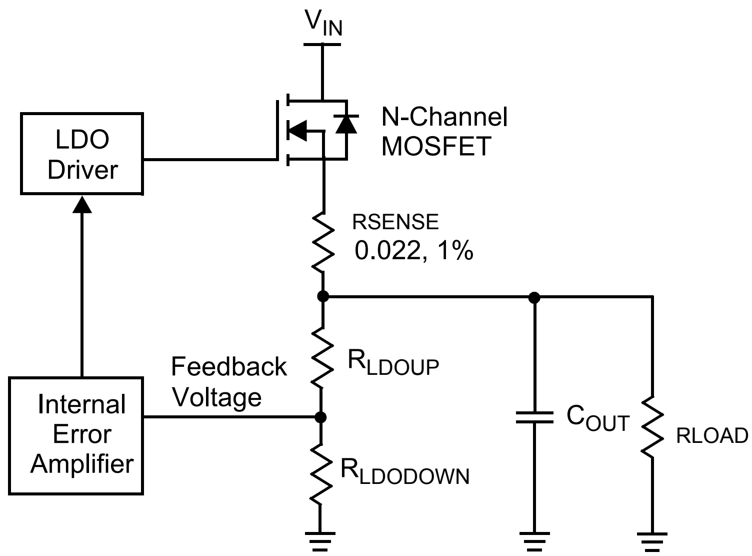



**Figure 2. LDO Typical Diagram**

Figure 3 illustrates the low dropout compensation network Freescale Semiconductor recommends for coping with most applications.

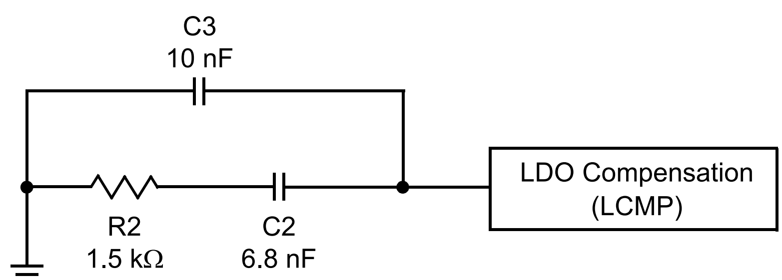



**Figure 3. LDO Compensation Network**

# 4 Recommendations

## 4.1 Boost Supply

In order to properly enhance the gate of the internal high-side N-channel MOSFET, MC34701/MC34702 devices integrate a boost structure to create an internal +8.0 V voltage rail (**Figure 4**).

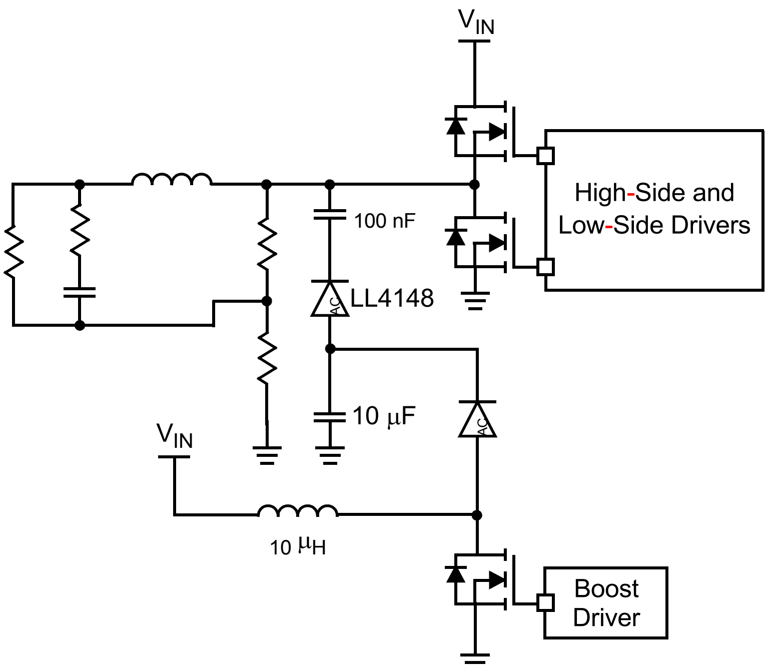



**Figure 4. Boost Structure**

## 4.2 Boost Inductor

The boost inductor should be a 10 µH low DCR inductor, with a saturation current of at least 500 mA DC current. **Table 1** lists boost inductors we particularly recommend.

**Table 1. Recommended Boost Inductors**

| Manufacturer[(1)] | Part Number |
|---|---|
| Coilcraft | 1812PS-103M |
| TDK | SLF6025T-100M1R0 |

**Notes:**

1. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer’s responsibility to validate their application.

### 4.2.1 Boost Capacitor

A standard 10 µF ceramic surface mount capacitor is needed for the boost structure. The package can be 1206 or even 0805.

### 4.2.2 Bootstrap Diode

The bootstrap diode should be a fast recovery diode. A surface mount diode like the LL4148 is a good choice (or any other equivalent diode).

### 4.2.3 Bootstrap Capacitor

A standard 100 nF ceramic surface mount capacitor is needed for the boost structure. The package can be 1206 or 0805.

## 4.3 Capacitor Selection

For input and output capacitors, we recommend using a mix of input and output bypass capacitors in order to lower the overshoots.

Use small ceramic capacitors for high frequency decoupling and bulk capacitors with low ESR to supply currents.

### 4.3.1 Input Capacitors

Input capacitor selection should be based on the current ripple allowed on the input line. The input capacitor should provide the ripple current generated during the inductor charge time. This ripple is dependent on the output current sourced by MC34701/MC34702 so that:

$$I_{RMS} = I_{OUT}\sqrt{d(1-d)} \quad \text{(Eq. 1)}$$

where:

- $I_{RMS}$ is the RMS value of the input capacitor current
- $I_{OUT}$ is the output current
- d is the duty cycle

For a buck converter, a good approximation of the duty cycle is: $d = \frac{V_{OUT}}{V_{IN}}$

Eq. 1 has a maximum at $V_{IN} = 2V_{OUT}$ where $I_{RMS} = \frac{I_{OUT}}{2}$

$$\text{Since} \quad I_{RMS(max)} = \sqrt{\frac{P_{max}}{ESR}} \quad \text{(Eq. 2)}$$




ARCHIVE INFORMATION

where $P_{max}$ is the maximum power dissipation of the capacitor and is a constant based on physical size (generally given in the datasheets under the heading “AC power dissipation”). We derive that the lower the ESR, the higher would be the ripple current capability. In other words, a low ESR capacitor (i.e., with high ripple current capability) can withstand high ripple current levels without overheating.

Therefore, for greater efficiency and because the overall voltage ripple on the input line also depends on the input capacitor ESR, we recommend using low ESR capacitors, several of which are listed in **Table 2**.

**Table 2. Recommended Input Capacitors**

| Manufacturer(2) | Part Number |
|---|---|
| KEMET | C1210C106K8PAC |
| TDK | C3216JB0J106M |

**Notes:**

2. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer’s responsibility to validate their application.

### 4.3.2 Output Capacitors

Output capacitor selection should be based on the output voltage and current ripple requirements. The choice is driven by the following equations (please refer to the appendices for more detailed equations):

$$ESR \le \frac{\Delta V_{OUT}}{\Delta I_{inductor}} \quad \textbf{(Eq. 3)}$$

$$C = \frac{\Delta I_{inductor} * \Delta T}{\Delta V_{OUT}} = \frac{\Delta I_{inductor}}{8 * F_S * \Delta V_{OUT}} \quad \textbf{(Eq. 4)}$$



ARCHIVE INFORMATION

Also, the capacitor should be rated to withstand the output RMS current. We recommend for better efficiency the mixing of low ESR capacitors (ceramic and tantalum), along with Oscon- and Poscap-type capacitors, in order to avoid a low frequency zero for the overall system. **Table 3** lists recommended output capacitors.

**Table 3. Recommended Output Capacitors**

| Manufacturer(3) | Part Number |
|---|---|
| KEMET | C1210C106K9PAC |
| TDK | C3216JB0J106M |
| SANYO | 10THB100ML |

**Notes:**

3. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer’s responsibility to validate their application.

## 4.4 Output Voltage Selection

Output voltage is set by an internal reference voltage and an external voltage divider (**Figure 5**). A part of the output voltage (resistor bridge $R_{UP}$ and $R_{DOWN}$) feeds the inverting terminal of an internal comparator, which is referenced to a 0.8 V bandgap ($V_{REF}$). MC34701/MC34702 will regulate the output voltage so that the inverting terminal input voltage is equal to the internal 0.8 V voltage reference.

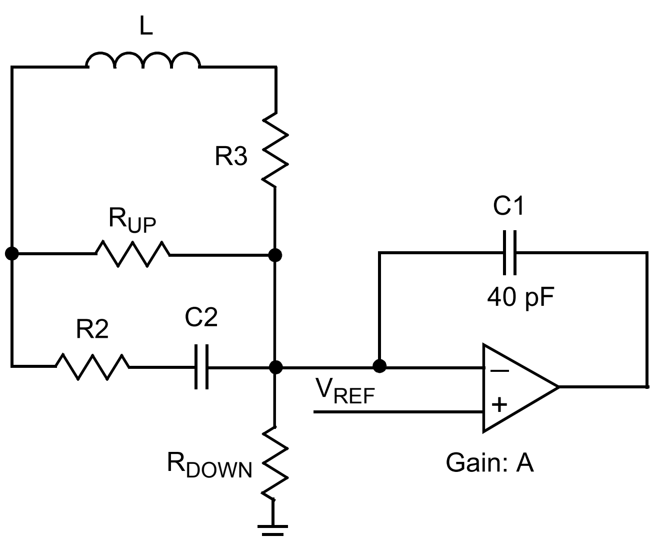



**Figure 5. Output Voltage Divider**


ARCHIVE INFORMATION

The external voltage can be calculated from the following equation:

$$V_{OUT} = 0.8*\left(1 + \frac{R_{UP}}{R_{DOWN}}*\left(\frac{R_3}{R_3 + R_{UP}}\right)\right) \quad \text{(Eq. 5)}$$

We recommend using a 1% resistors for better adjustments. For most applications, the following values are suitable:

R2 = 300 Ω
C2 = 470 pF
R3 = 330 kΩ

## 4.5 Inductor Selection

The choice of the inductor should take into considerations output power, operating frequency, efficiency requirements, and desired output current ripple.

$$I_{peak} - I_{valley} = \Delta I = \frac{(1-d)}{LF}V_{OUT}$$

Since $d = \frac{V_{OUT}}{V_{IN}}$ Although

$$L = \frac{\left(1 - \frac{V_{OUT}}{V_{IN}}\right)}{F_S \Delta I}V_{OUT} = \frac{(V_{IN} - V_{OUT})*V_{OUT}}{V_{IN}F_S\Delta I} \quad \text{(Eq. 6)}$$

Where:

$F_S$ is the switching frequency
$V_{IN}$ is the maximum input voltage
$V_{OUT}$ is the output voltage

At this stage, note that increasing the inductor value will lower the output current and voltage ripples. However, it will also reduce the converter's response time to transients.


ARCHIVE INFORMATION

We recommend using low DCR inductors for better efficiency (refer to **Table 4**).

**Table 4. Recommended Low DCR Inductors**

| Manufacturer[4] | Part Number |
|---|---|
| Coilcraft | DO3316P-472HC |
| Wuerth Elektronik | 74477004 |

**Notes:**

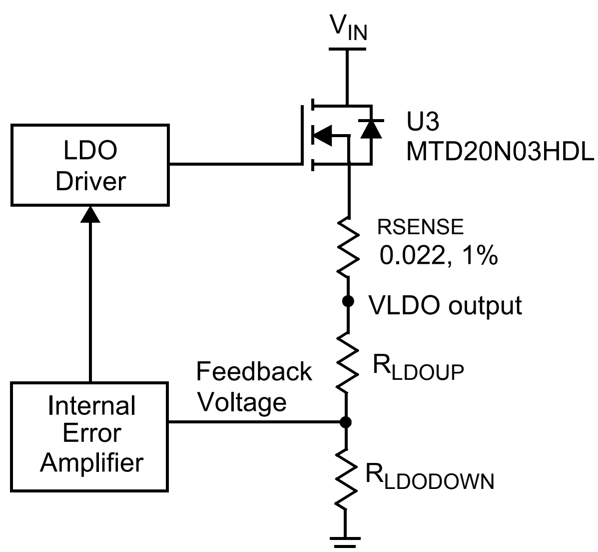
4. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer's responsibility to validate their application.



## 4.6 Low Dropout Converter

### 4.6.1 Output Voltage Selection

Output voltage is selected by an internal reference voltage and an external voltage divider. Part of the output voltage (resistor bridge $R_{LDOUP}$ and $R_{LDODOWN}$) feeds the inverting terminal of an internal comparator, which is referenced to a 0.8 V bandgap (**Figure 6**).The MC34701/MC34702



will regulate the output voltage so that the inverting terminal input voltage is equal to the internal 0.8 V voltage reference.



**Figure 6. LDO Resistor Bridge**

The external voltage can be calculated from the following equation:

$$V_{OUT} = 0.8*\left(1 + \frac{R_{LDOUP}}{R_{LDODOWN}}\right) \quad \textbf{(Eq. 7)}$$

We recommend using a 1% resistor for better accuracy.

### 4.6.2 Sense Resistor

To protect the external MOSFET, the MC34701/MC34702 limits the maximum sense voltage across the sense resistor to 50 mV using an active current limiting circuit. Should an over-current condition occur, the MC34701/MC34702 starts an internal timer and only allows this over-current condition during a 10 ms period. In the case the error hasn't been removed, the MC34701/MC34702 turns the MOSFET off for a 100 ms period and will attempt another cycle after that.

The over-current threshold is set by the following equation:

$$I_{LDO_{MAX}} = \frac{50mV}{R_{SENSE}} \quad \textbf{(Eq. 8)}$$

### 4.6.3 MOSFET Selection

MOSFETs are usually specified with:

- Drain-to-source voltage ($BV_{DSS}$)
- Continuous drain current ($I_D$)
- Drain-source on-state resistance ($R_{DS(ON)}$)
- Gate capacitance
- Power dissipation ($P_D$)

#### 4.6.3.1 BVDSS: Drain to Source voltage

The $BV_{DSS}$ should be chosen higher than the input voltage value.

#### 4.6.3.2 RDS(ON)

Given the targeted application, the $R_{DS(ON)}$ should be defined as follows:

$$R_{DS(ON)} = \frac{V_{IN(LDO)} - V_{OUT(LDO)}}{I_{OUT(LDO)}} \quad \textbf{(Eq. 9)}$$

Because $R_{DS(ON)}$ increases with temperature, it is recommended dividing the calculated $R_{DS(ON)}$ value by a factor of at least 2 to ensure sufficient margin of safety.

### 4.6.3.3 Gate Capacitance

Lowering the gate capacitance of the MOSFET improves overall LDO behavior, especially in terms of transient response.

### 4.6.3.4 Power Dissipation

The power dissipated in the MOSFET is given by:

$$P_{D(Max)} = (V_{IN} - V_{OUT})*I_{OUT} \quad \textbf{(Eq. 10)}$$

The temperature of the MOSFET can be calculated as follows:

$$T_J = (\theta_{J-A}*P_D) + T_A$$

Where:

$T_J$ is the MOSFET junction temperature
$T_A$ is the ambient temperature
$\theta_{J-A}$ is the MOSFET junction to ambient thermal resistance
$P_D$ is the MOSFET dissipated power

Consequently, a first step is to determine the maximum thermal resistance allowed by the MOSFET:

$$\theta_{J-A} = \frac{T_J - T_A}{P_D} \quad \textbf{(Eq. 11)}$$

This thermal resistance should be one of the criteria of the choice.

# 5 Layout Considerations

When designing high-switching frequency power supplies, care must be observed when it comes to the layout (see **Figure 7**, 13, for layout example). We strongly recommend:

- Power components should be placed close to each other.
- Their connections should be made with wide traces, and if possible copper-filled areas.
- In order to reduce EMI, inductor and output capacitors should be as close to each other as possible.
- Input capacitors should be placed right on the drain of the LDO MOSFET and the input terminals of the MC34701/MC34702 device. Output capacitors should be placed right after the sense resistor.
- Feedback traces for the switcher and the LDO should be kept away from any noisy source (power traces).
- Power planes greatly improve the overall behavior.

- Whenever possible, use a power ground plane for power traces and an analog ground plane for the device control circuitries in order to separate as much as possible the interferences generated by power. These two ground planes should be tied together on the PCB at a single point.

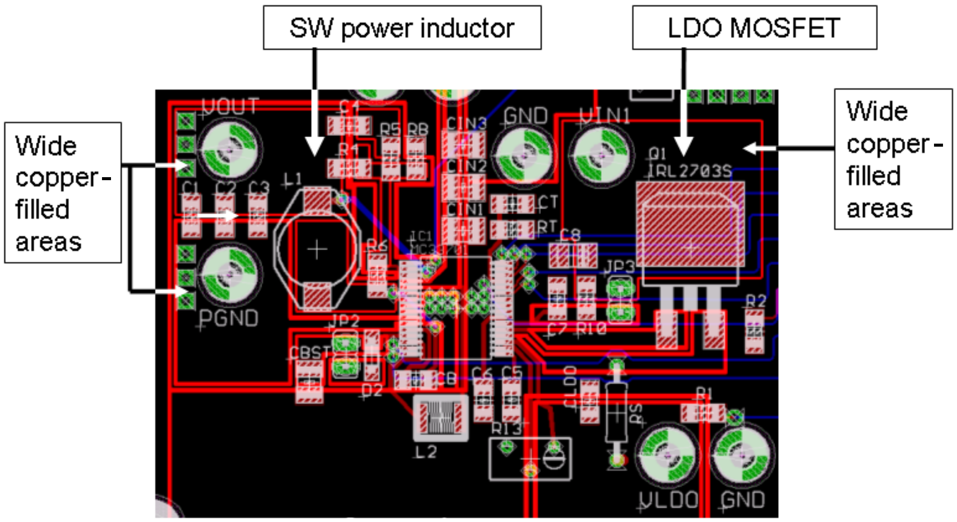



**Figure 7. Layout Example**

# 6 Design Example

This section applies the previous guidelines for a complete MC34701/MC34702 design.

## 6.1 System Description

We assume the following:

- A microprocessor will need 1.8 V core voltage @ 3.0 A
- The I/O voltage supply is 3.3 V @ 2.0 A
- The switching frequency is 300 kHz
- Switcher inductor current ripple is 1.0 A
- Input voltage $V_{IN}$ is 5.0 V
- Ripple on input voltage line is 100 mV
- Ripple on output voltage line is 50 mV

Note that **Figure 8**, on page 18 (schematic), and **Table 6**, 19 (bill of material), apply to many applications such as SDRAM, FPGA, or DSPs provided that the needs are equal to or less than 3.3 V @ 2.0 A and 1.8 V @ 3.0 A.

## 6.2 Calculations

### 6.2.1 Inductor

$F_S$ = 300 kHZ
$V_{IN}$ = 5.0 V
$V_{OUT}$ = 1.8 V
Inductor ripple current = 1.0 A

Using Equation 6 (8), it yields L=4µH. To match with standardized value, we will consider L=4.7µHL.

### 6.2.2 Buck Converter Input Capacitor

$$d = \frac{V_{OUT}}{V_{IN}} = \frac{1.8V}{5V} = 0.36$$

$$I_{OUT} = 3A$$

$$I_{RMS} = 3\sqrt{0.36(1-0.36)} = 1.44A$$

and

$$I_{RMS(Max)} = 3\sqrt{0.5(1-0.5)} = 1.5A$$

Since the input bulk capacitors will provide the energy for any surge current drawn by the converter, a good approximation to calculate it is as follows:

Cin(min) * Input voltage ripple * Vin ≈ 0.5 * L * (Irms)²

Hence, Cin(min) ≈ (0.5*L*(Irms)²)/(Input voltage ripple * Vin)

With previous results, it yields: Cin(min) ≈ (0.5*4.7µ*1.5²)/(100mV*5V)≈10.57uF

Note that the previous value is a minimum for the required specifications. The more capacitors one adds, the better the overall behavior is.

With a bank of 73.4uF capacitors, as shown in the typical diagram Figure 8, the overall ESR (max) of the input capacitors should be:

$$ESR_{max} \approx \frac{(0.1V)}{3A} \approx 33m\Omega$$


ARCHIVE INFORMATION

### 6.2.3 Buck Converter Output Capacitor

Inductor current ripple is 1.0 A. Output voltage ripple is 50 mV.

$$C = \frac{1}{8*300kHZ*50mV} = 8.33\mu F$$

The overall ESR of the bulk capacitors contribute to the overall ripple voltage. Placing low ESR X5R or X7R ceramic capacitors in parallel will decrease the overall ESR to the range of 10mOhms

As per the equations in the appendices, and given the output capacitors bank shown in Figure 8, Ripple due to the finite output capacitance:

$$Ripple(cap) = \frac{0.36*(1-0.36)5}{8*300kHz*4.7uH*126.7uF} = 2.7mV$$

Since we want less than 50mV output ripple, the ESR (max) is:

$$ESR_{max} = \frac{(50-2.7)*300kHz*4.7uH}{0.36*(1-0.36)300kHz*5V} = 57.8m\Omega$$

### 6.2.4 Buck Converter Core Voltage

$$V_{OUT} = 1.8V$$

$$R_{LDOUP} = 39k$$

$$R_{LDODOWN} = \frac{0.8}{(1.8-0.8)*\frac{39k+330k}{39k*330k}} = 28k$$

### 6.2.5 Low Dropout Converter Output Voltage

$R_{LDO\_DOWN}$ = 15 kΩ

$$R_{LDOUP} = \frac{3.3 - 0.8}{0.8} * 15k = 46.9k$$

### 6.2.6 Low Dropout Converter Maximum Allowed Current

$$R_{SENSE} = \frac{50mV}{I_{LDO_{max}}} = \frac{50mV}{2} = 25m\Omega$$

Note that the sense resistor power dissipation rating should be greater than

$$P_D = 25m\Omega * 2^2 = 100mW$$

### 6.2.7 Low Dropout Converter MOSFET Selection

Calculating the $R_{DS(ON)}$:

$$R_{DS(ON)} = \frac{V_{IN(LDO)} - V_{OUT(LDO)}}{I_{OUT(LDO)}} = \frac{5 - 3.3}{2} = 850m\Omega$$

In regulation, the LDO MOSFET dissipates as maximum:

$$P_{D(Max)} = (V_{IN} - V_{OUT}) * I_{OUT} = (5 - 3.3) * 2 = 3.4W$$

Care must be taken to allow enough margin for heatsinking and ensure that the MOSFET remains within its maximum junction temperature at high ambient temperature in accordance with its package thermal resistance specifications.

**Table 5** Suggested MOSFET with drain-to-source voltage of at least 5.0 V.

**Table 5. Recommended MOSFETS**

| Manufacturer[(5)] | Part Number |
|---|---|
| International Rectifier | IRL3713S |
| ON Semiconductor | NTD20N06 |

**Notes:**

5. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer's responsibility to validate their application.



ARCHIVE INFORMATION

## 6.3 Typical Application

**Figure 8** shows a typical application for the MC34701 and MC34702. Refer to the recommended bill of material in **Table 6**, 19.

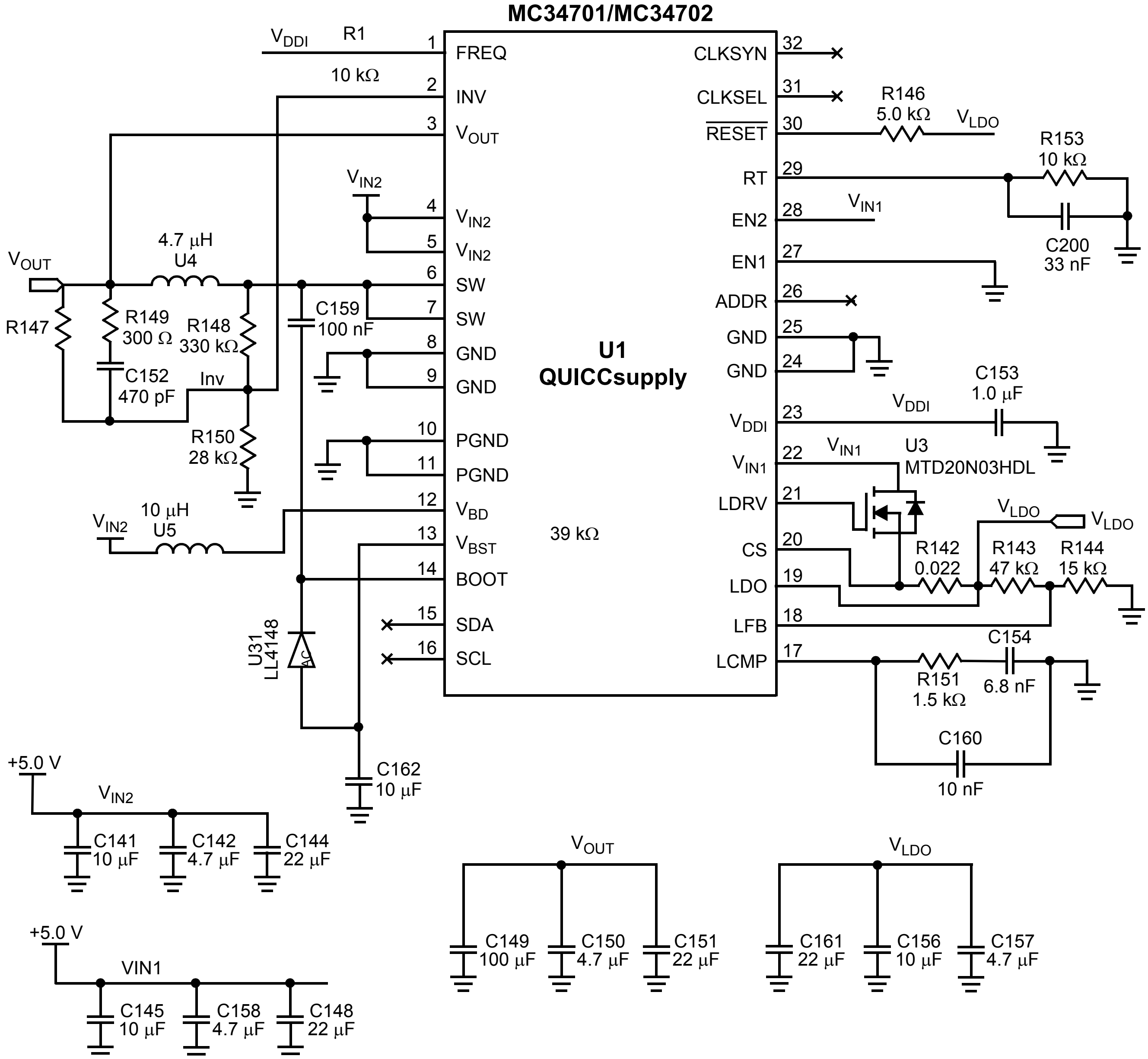



**Figure 8. MC34701/MC34702 Typical Application**

## 6.4 Bill of Material

**Table 6. Bill of Material**

| Designation | Value/Rating | Reference/Part No. | Manufacturer(6) |
|---|---|---|---|
| R1 | 10 kΩ | Any, 1/4 W, 5% | Any |
| R142 | 0.022, 1.0 W, 1% | Serie TL3A | Meggitt CGS |
| R143 | 47 kΩ | Any, 1/4 W, 1% | Any |
| R144 | 15 kΩ | Any, 1/4 W, 1% | Any |
| R146, R152 | 5.0 kΩ | Any, 1/4 W, 5% | Any |
| R147 | 39 kΩ | Any, 1/4 W, 1% | Any |
| R148 | 330 kΩ | Any, 1/4 W, 5% | Any |
| R149 | 300 kΩ | Any, 1/4 W, 5% | Any |
| R150 | 28 kΩ | Any, 1/4 W, 1% | Any |
| R151 | 1.5 kΩ | Any, 1/4 W, 5% | Any |
| R153 | 10 kΩ | Any, 1/4 W, 1% | Any |
| C141, C145, C156 | 10 μF, Ceramic, X7R or X5R, Low ESR, 10 V | C1210C106K8PAC | Murata or other |
| C142, C158, C150, C157 | 4.7 μF, Ceramic, X7R or X5R, Low ESR, 10 V | C1206C475K4PAC | Murata or other |
| C144, C148, C151, C161 | 22 μF, ceramic, X7R or X5R, Low ESR, 10 V | C3216JB0J106M | TDK or other |
| C149 | 100 μF POSCON | 10THB100ML | Sanyo |
| C153 | 1.0 μF, Ceramic, X7R, 10 V | C1206C205K3RAC | Murata |
| C154 | 6.8 nF | Any, ceramic 10 V | Any |
| C159 | 100 nF | Any, ceramic 10 V | Any |
| C160 | 10 nF | Any, ceramic 10V | Any |
| C162 | 10 μF | Any, ceramic 10 V | Any |
| C200 | 33 nF | Any, ceramic 10V | Any |
| U1 | MC34701/MC34702 | MC34701/MC34702 | Freescale Semiconductor |
| U3 | N-Channel MOSFET | NTD20N06<br>IRL2703S | ON Semiconductor<br>International Rectifier |
| U4 | 4.7 μH | DO3316P-472HC<br>74477004 | Coilcraft<br>Wuerth Elektronik |
| U5 | 10 μH | SLF6025T-100M1R0<br>1812PS-103M | TDK<br>Coilcraft |
| U31 | Diode | LL4148 | Vishay |

**Notes:**

6. Freescale does not assume liability, endorse, or warrant components from external manufacturers referenced in figures or tables. Although Freescale offers component recommendations, it is the customer's responsibility to validate their application.


ARCHIVE INFORMATION

# 7 Appendix

**NOTE**

The following definitions are used throughout this appendix:

- d=Duty Cycle
- F=Switching Frequency of Buck Converter
- T=1/F

## 7.1 Output Capacitor Current

Figure 9 shows the current through the output capacitor (red), and the associated output ripple voltage (green):.

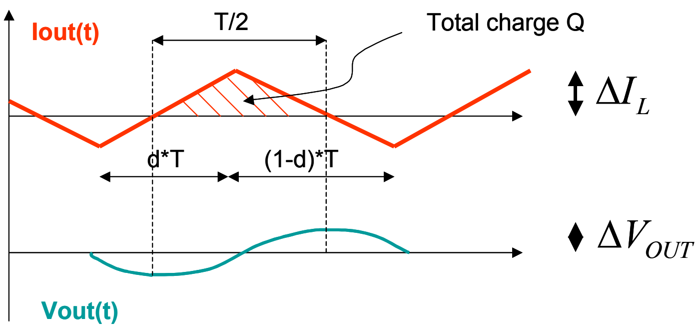



**Figure 9. Output Capacitor Current**

From Previous Diagrams:

$$Q = \frac{1}{2} * \Delta I_L * \frac{T}{2} \approx C_{OUT} * (2 * \Delta V_{OUT})$$

$$2 * \Delta I_L = \frac{V_{IN} - V_{OUT}}{L} * d * T = \frac{d * (1-d) * V_{IN}}{F * L}$$

Hence:

$$C_{OUT} = \frac{1}{8} * \frac{\Delta I_L}{F * \Delta V_{OUT}}$$

When Designing applications, it is more common to consider the peak-to-peak output ripple voltage; rewriting the equations:

$$\Delta I_{P-P} = 2 * \Delta I_L$$
$$\Delta V_{OUT_{P-P}} = 2 * \Delta V_{OUT}$$

$$Hence:$$

$$C_{OUT} = \frac{1}{8} * \frac{\Delta I_{P-P}}{F * \Delta V_{OUT_{P-P}}}$$
$$\Delta I_{P-P} = \frac{d(1-d) * V_{IN}}{F * L}$$

## 7.2 Output Capacitor Noise

From the previous equations it yields as follows:

1. Output voltage ripple due to finite output capacitance:

$$\Delta V_{OUT_{P-P}} = \frac{1}{8} * \frac{d(1-d) * V_{IN}}{F^2 * L * C_{OUT}}$$

2. Noise due to ESR:

$$\Delta V_{OUT_{ESR}} = ESR * \Delta I_{P-P} = ESR * \frac{d(1-d) * V_{IN}}{F * L}$$

## 7.3 Input Capacitor

The purpose of the input capacitor is to store energy to keep the input voltage from not decreasing too much when the switcher draws the current during the high side MOSFET on time.

It can be found in literature that the RMS current seen by the input capacitor is given as follows:

$$I_{RMS} = I_{OUT} \sqrt{d(1-d + \frac{(\frac{\Delta I_L}{I_{OUT}})^2}{12})}$$

Most applications will typically be represented as:

$$r = \frac{\Delta I_L}{I_{OUT}} < 0.5$$


ARCHIVE INFORMATION

Hence:

$$I_{RMS} \approx I_{OUT}\sqrt{d(1-d)}$$

The maximum for the previous equation: d=0.5

$$I_{RMS_{MAX}} \approx \frac{I_{OUT}}{2}$$

The first approach to determine the bulk input capacitor can be derived as follows:

Cin(min) * Input voltage ripple * Vin ≈ 0.5 * L * (Irms)²

Hence, Cin(min) ≈ (0.5*L*(Irms)²)/(Input voltage ripple * Vin)

Where $\Delta V_{IN}$ is the maximum input voltage ripple allowed.

Once the bulk capacitor has been selected, pay attention to the capacitor, since the ESR of the bulk capacitor adds to the input ripple voltage.

From **Figure 9**:

$$\text{CIN- ESRnoise} \approx ESR*(I_{OUT_{Max}} + \frac{\Delta I_{P-P}}{2})$$

$$\text{CIN- ESRnoise} \approx ESR*I_{OUT_{MAX}}$$

Freescale recommends using low ESR, X5R or X7R input bulk capacitor to ally both high capacitor values along with low ESR (in the range of tens of mil Ohms).

# 8 References

The following sources were referenced to produce this document:


[1] *MC34701 Data Sheet,* 1.5 A Switch-Mode Power Supply with Linear Regulator, *Freescale Semiconductor, Inc.*

[2] *MC34702 Data Sheet,* 3.0 A Switch-Mode Power Supply with Linear Regulator, *Freescale Semiconductor, Inc.*

[3] *Analog Selector Guide (SG1002) and Automotive Selector Guide (SG187), Freescale Semiconductor, Inc.*

# NOTES

***How to Reach Us:***

**Home Page:**
www.freescale.com

**E-mail:**
support@freescale.com

**USA/Europe or Locations Not Listed:**
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

**Europe, Middle East, and Africa:**
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

**Japan:**
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

**Asia/Pacific:**
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

***For Literature Requests Only:***
Freescale Semiconductor Literature Distribution Center
P.O. Box 5405
Denver, Colorado 80217
1-800-441-2447 or 303-675-2140
Fax: 303-675-2150
LDCForFreescaleSemiconductor@hibbertgroup.com





AN1989
Rev. 1.0
05/2005