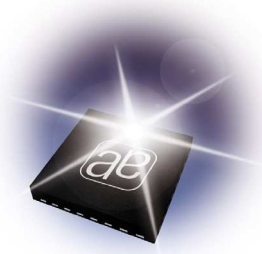


AS3642

Ultra Small 500mA Inductive White LED Flash Driver



1 General Description

The AS3642 is an inductive high efficient DCDC step up converter driving a current source. The DCDC step up converter operates at a fixed frequency of 4MHz and includes soft startup to allow easy integration into noise sensitive RF systems. The current source operates in flash/torch/assist (video/autofocus) and indicator mode.

The AS3642 includes flash timer, overvoltage, overtemperature, undervoltage and LED short circuit protection functions.

The AS3642 is able to detect a broken coil. Together with the LED short and open detection the AS3642 can be used to verify the connection to its external components and allowing in-circuit test. This reduces test time and simplifies production test procedures.

The AS3642 is controlled by an I²C interface to allow sophisticated control of all settings like currents and timings.

The complete flash driver solution measures only 11mm² PCB area.

The AS3642 is available in a space-saving WL-CSP package measuring only 1.5x1.1x0.6mm and operates over the -30°C to +85°C temperature range.

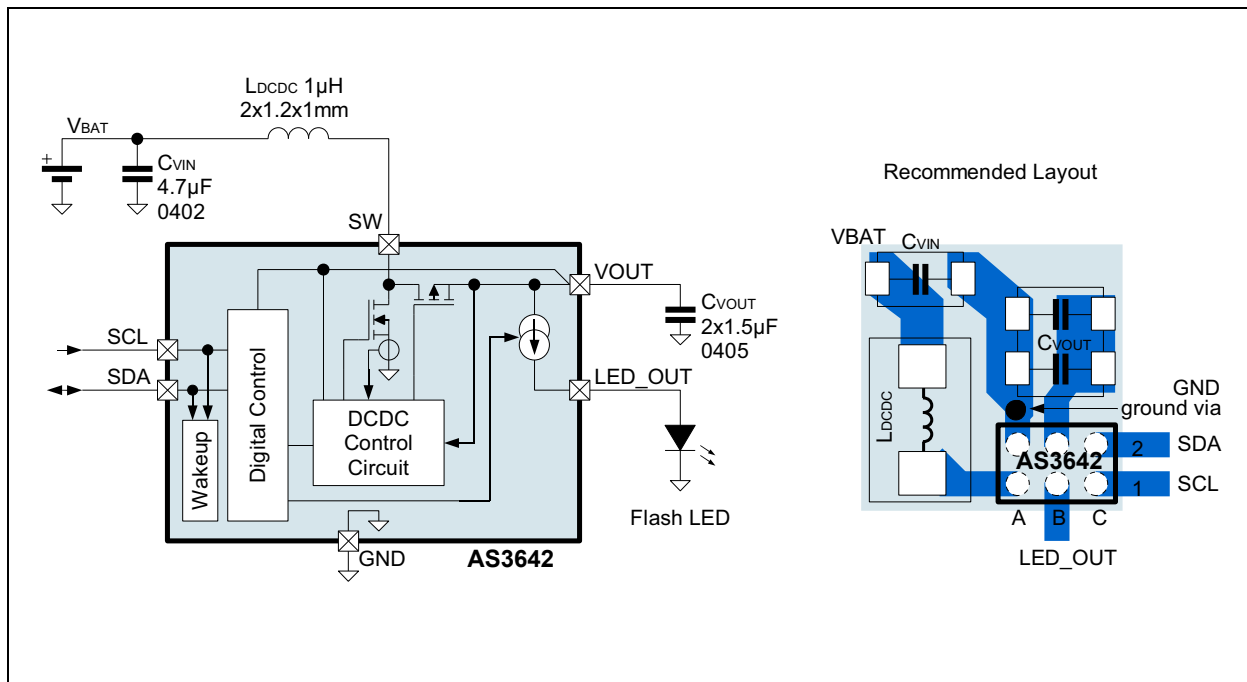
2 Key Features

- Total flash driver solution only 11mm²
- High efficiency 4MHz fixed frequency DCDC Boost converter with soft start allows small coils
- LED currents
Up to 500mA flash current (15.6mA steps)
Up to 320mA torch current (10mA steps)
1.35mA, 2.9mA, 4.4mA or 6mA indicator light current (PWM with 1...4/32 duty cycle)
- Flash LED(s) cathode connected to ground:
Improved thermal performance (ground = heat sink)
Simplified PCB layout
- Adjustable Flash Timer
30ms to 480ms in 30ms steps
- Flash, Torch, Assist and Indicator Mode
- Protection functions:
Automatic Flash timer to protect the LED
Overvoltage and undervoltage Protection
Overtemperature Protection
LED short circuit protection
- Available in tiny WL-CSP Packages
2x3 balls 0.5mm pitch, 1.5x1.1x0.6mm package size

3 Applications

Flash/Torch for mobile phones, digital cameras and PDA

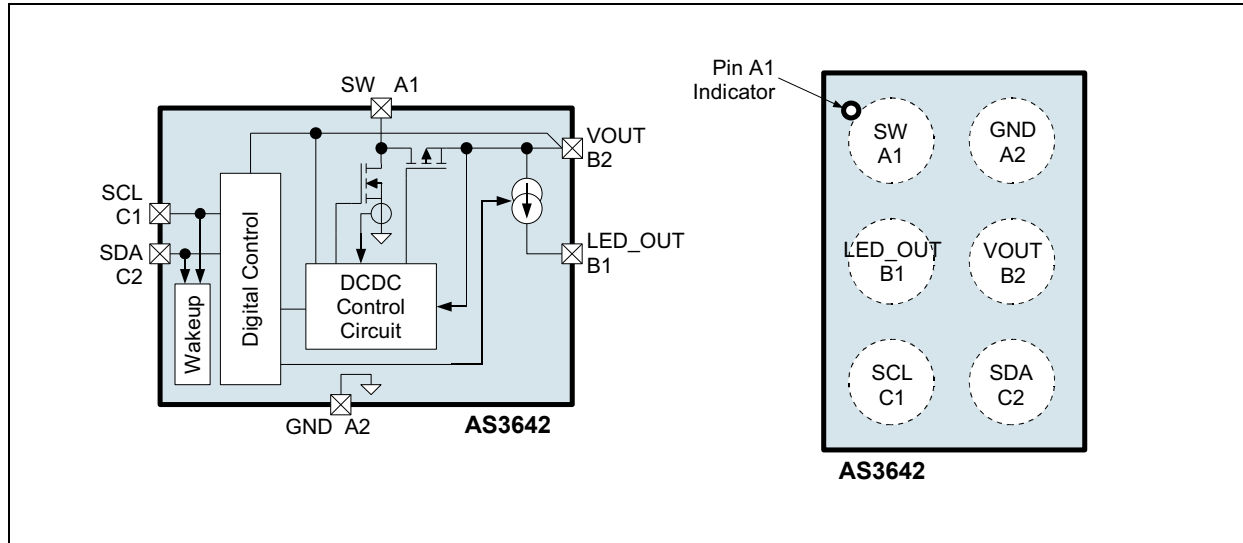
Figure 1. Typical Operating Circuit



4 Pinout

Pin Assignment

Figure 2. Pin Assignments (Top View)



Pin Description

Table 1. Pin Description for AS3642

| Pin Number | Pin Name | Description |
|------------|----------|--|
| A1 | SW | DCDC converter switching node - make a short connection to the coil L _{DCDC} |
| A2 | GND | Power and signal ground - connect to GND and make a short connection to C _{VOUT} |
| B1 | LED_OUT | Flash LED current source output |
| B2 | VOUT | DCDC converter output capacitor and supply for AS3642 - make a short connection to C _{VOUT} |
| C1 | SCL | serial clock input in I ² C interface |
| C2 | SDA | serial data input/output for I ² C interface (needs external pullup resistor) |

5 Absolute Maximum Ratings

Stresses beyond those listed in [Table 2](#) may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in [Table 3, "Electrical Characteristics," on page 4](#) is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 2. Absolute Maximum Ratings

| Parameter | Min | Max | Units | Comments |
|---|-------|--------------|-------|---|
| VOUT, SW to GND | -0.3 | +7.0 | V | |
| SCL, SDA, LED_OUT to GND | -0.3 | VOUT+ 0.3 | V | max. +7V |
| VOUT to SW | -0.3 | | V | Note: Diode between VOUT and SW |
| Input Pin Current without causing latchup | -100 | +100 +IIN | mA | Norm: EIA/JESD78 |
| Continuous Power Dissipation (T_A = +70°C) | | | | |
| Continuous power dissipation | | 530 | mW | P _T ¹ at 70°C ambient |
| Continuous power dissipation derating factor | | 7.2 | mW/°C | P _{DERATE} ² |
| Electrostatic Discharge | | | | |
| ESD HBM | | ±2000 | V | Norm: JEDEC JESD22-A114F |
| ESD CDM | | ±500 | V | Norm: JEDEC JESD 22-C101C |
| ESD MM | | ±100 | V | Norm: JEDEC JESD 22-A115-A level A |
| Temperature Ranges and Storage Conditions | | | | |
| Junction Temperature | | +150 | °C | Internally limited (overtemperature protection) max. 20000s |
| Storage Temperature Range | -55 | +125 | °C | |
| Humidity | 5 | 85 | % | Non condensing |
| Body Temperature during Soldering | | +260 | °C | according to IPC/JEDEC J-STD-020 |
| Moisture Sensitivity Level (MSL) | MSL 1 | | | Represents a max. floor life time of unlimited |

1. Depending on actual PCB layout and PCB used; for peak power dissipation during flashing see document 'AS3642 Thermal Measurements'
2. P_{DERATE} derating factor changes the total continuous power dissipation (P_T) if the ambient temperature is not 70°C. Therefore for e.g. T_{AMB}=85°C calculate P_T at 85°C = P_T - P_{DERATE} * (85°C - 70°C)

6 Electrical Characteristics

$V_{VIN} = +2.7V$ to $+5.5V$, $T_{AMB} = -30^{\circ}C$ to $+85^{\circ}C$, unless otherwise specified. Typical values are at $V_{VIN} = +3.7V$, $T_{AMB} = +25^{\circ}C$, unless otherwise specified.

Table 3. Electrical Characteristics

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|---|---|--|-------|------|-------|-------------|
| General Operating Conditions | | | | | | |
| V_{VIN} | Supply Voltage | | 2.7 | 3.7 | 4.5 | V |
| $V_{VINREDUCE_D_FUNC}$ | Supply Voltage | AS3642 functionally working, but not all parameters fulfilled ¹ | 2.5 | | 5.0 | V |
| $I_{SHUTDOWN}$ | Shutdown Current | $SCL=L$, $SDA=L$, $V_{VIN}<3.7V$, $0^{\circ}C < T_{AMB} < 50^{\circ}C$ | | 0.5 | 1.0 | μA |
| I_{STANBY} | Standby Current | interface active, $V_{VIN}<3.7V$ | | 0.5 | 5 | μA |
| T_{AMB} | Operating Temperature | | -30 | 25 | 85 | $^{\circ}C$ |
| DCDC Step Up Converter | | | | | | |
| V_{VOUT} | DCDC Boost output Voltage (pin VOUT) | For high supply voltages the output voltage can reach up to $V_{VOUTMAX}$ (the AS3642 always runs in PWM mode unless $V_{VOUT}>V_{VOUTMAX}$ or during startup) | 2.8 | | 4.7 | V |
| η | Efficiency | $I_{LED_OUT}=300mA$, $V_{VOUT}=4.2V$ | | 82 | | % |
| f_{CLK} | Operating Frequency | All internal timings are derived from this oscillator | -7.5% | 4.0 | +7.5% | MHz |
| | | DCDC operating frequency for short pulses (close to 100% operating mode) | -7.5% | 1.0 | +7.5% | |
| Current Source | | | | | | |
| I_{LED_OUT} | LED_OUT current source output | | 0 | | 500 | mA |
| $I_{LED_OUT\Delta}$ | LED_OUT current source accuracy | $I_{LED_OUT}=300mA$ | -7 | | +7 | % |
| $I_{LED_OUT_RAMP}$ | LED_OUT ramp time at $I_{LED_OUT}=300mA$ | Ramp-up During startup | 0.6 | | 1.0 | ms |
| | | Ramp-down after AS3642 is disabled by interface | 0.2 | | 0.7 | ms |
| $I_{LED_OUT_RIPPLE}$ | LED_OUT current ripple | $I_{LED_OUT} = 300mA$ | | 10 | | mAPP |
| V_{ILED_COMP} | LED_OUT current source voltage compliance | Minimum voltage between pin VOUT and LED_OUT for operation of the current source (applicable for <code>current_mode=00, 01 and 10</code>) | | 210 | 350 | mV |
| Protection and Fault Detection Functions (see page 10) | | | | | | |
| $V_{VOUTMAX}$ | V_{VOUT} overvoltage protection | DCDC Converter Overvoltage Protection | 5.0 | 5.25 | 5.5 | V |
| I_{LIMIT} | Current Limit for coil LDCDC (Pin SW) measured at 50% PWM duty cycle ² | maximum 40000s lifetime operation in overcurrent limit | 0.7 | 0.8 | 0.9 | A |
| V_{LED_SHORT} | Flash LED short circuit detection voltage | Voltage measured on pin LED_OUT | | 1.45 | 1.65 | V |

Table 3. Electrical Characteristics (Continued)

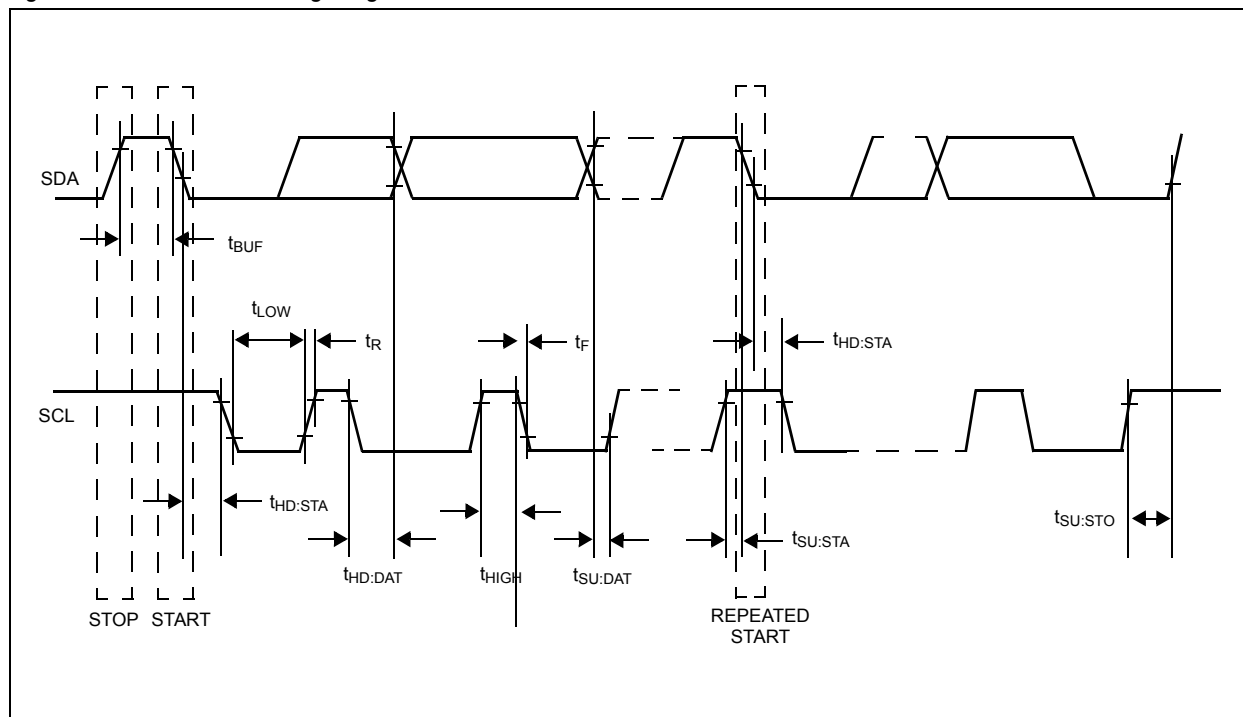
| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--|---|---|-------------------------|------------------------|-------------------------|------|
| T _{OVTEMP} | Overtemperature Protection | Junction temperature | | 144 | | °C |
| T _{OVTEMPHYST} | Overtemperature Hysteresis | | | 5 | | °C |
| t _{FLASHTIMER} | Flash Timer | Can be adjusted by register flash_timer (see page 18) | -7.5% | 30 to 480 | +7.5% | ms |
| V _{UVLO} | Undervoltage Lockout ³ | Falling V _{VIN} | 2.3 | 2.4 | 2.5 | V |
| | | Rising V _{VIN} | V _{UVLO} +0.05 | V _{UVLO} +0.1 | V _{UVLO} +0.15 | V |
| Digital Interface | | | | | | |
| V _{IH} | High Level Input Voltage | Pins SCL, SDA ⁴ | 1.26 | | V _{VIN} -0.2 | V |
| V _{IL} | Low Level Input Voltage | | 0.0 | | 0.54 | V |
| V _{OL} | Low Level Output Voltage | Pin SDA with pullup >1kΩ to digital supply <2V, V _{VIN} >2.7V | | | 0.3 | V |
| I²C interface timings - see Figure 3 on page 6 | | | | | | |
| t _{WAKEUP} | Wakeup Time | Minimum time from SDA or SCL going high to first I ² C start command | 500 | | | μs |
| t _{TIMEOUT} | I ² C timeout time | In flash, assist light and indicator mode if SCL and SDA are L for t _{TIMEOUT} , the AS3642 enters automatically shutdown mode | | 35 | | ms |
| f _{SCLK} | SCL Clock Frequency | | 1/t _{TIMEOUT} | | 400 | kHz |
| t _{BUF} | Bus Free Time Between a STOP and START Condition | | 1.3 | | | μs |
| t _{HD:STA} | Hold Time (Repeated) START Condition ⁵ | | 0.6 | | | μs |
| t _{LOW} | LOW Period of SCL Clock | | 1.3 | | | μs |
| t _{HIGH} | HIGH Period of SCL Clock | | 0.6 | | | μs |
| t _{SU:STA} | Setup Time for a Repeated START Condition | | 0.6 | | | μs |
| t _{HD:DAT} | Data Hold Time ⁶ | | 0 | | 0.9 | μs |
| t _{SU:DAT} | Data Setup Time ⁷ | | 100 | | | ns |
| t _R | Rise Time of Both SDA and SCL Signals | | 20 + 0.1C _B | | 300 | ns |
| t _F | Fall Time of Both SDA and SCL Signals | | 20 + 0.1C _B | | 300 | ns |
| t _{SU:STO} | Setup Time for STOP Condition | | 0.6 | | | μs |
| C _B | Capacitive Load for Each Bus Line | C _B — total capacitance of one bus line in pF | | | 400 | pF |

Table 3. Electrical Characteristics (Continued)

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|-----------|----------------------------|-----------|-----|-----|-----|------|
| $C_{I/O}$ | I/O Capacitance (SDA, SCL) | | | | 10 | pF |

1. Limited to max. 5V due to overvoltage protection circuit on pin VOUT
2. Due to slope compensation of the current limit, I_{LIMIT} changes with duty cycle - see Figure 16 on page 9.
3. Due to the architecture (the supply of the AS3642 is connected to the output VOUT), the undervoltage lockout is only detected when the DCDC converter is not switching
4. The logic input levels V_{IH} and V_{IL} allow for 1.8V supplied driving circuit (70%/30% of 1.8V)
5. After this period, the first clock pulse is generated.
6. A device must internally provide a hold time of at least 300ns for the SDA signal (referred to the V_{IHMIN} of the SCL signal) to bridge the undefined region of the falling edge of SCL.
7. A fast-mode device can be used in a standard-mode system, but the requirement $t_{SU:DAT} =$ to 250ns must then be met. This is automatically the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line $t_R \text{ max} + t_{SU:DAT} = 1000 + 250 = 1250\text{ns}$ before the SCL line is released.

Timing Diagrams

Figure 3. I²C interface Timing Diagram

7 Typical Operating Characteristics

$V_{IN} = 3.7V$, $T_A = +25^\circ C$ (unless otherwise specified)

Figure 4. DCDC Efficiency vs. V_{IN}

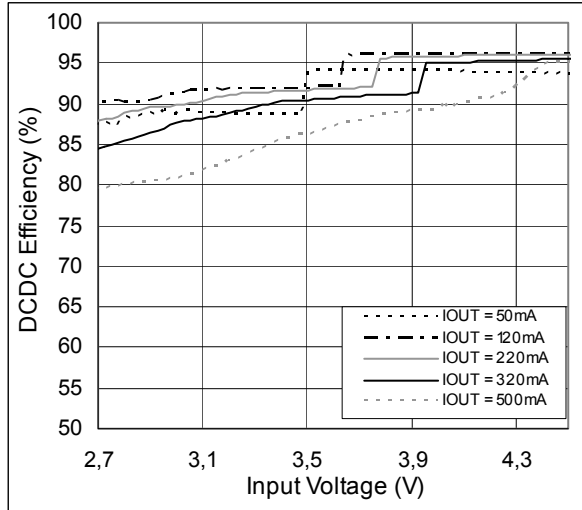


Figure 5. Application Efficiency (P_{LED}/P_{VIN}) vs. V_{IN}

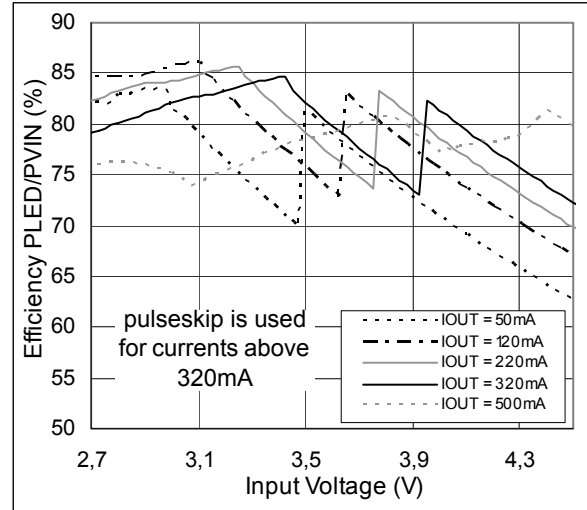


Figure 6. I_{LED_OUT} Startup ($I_{LED_OUT}=300mA$)

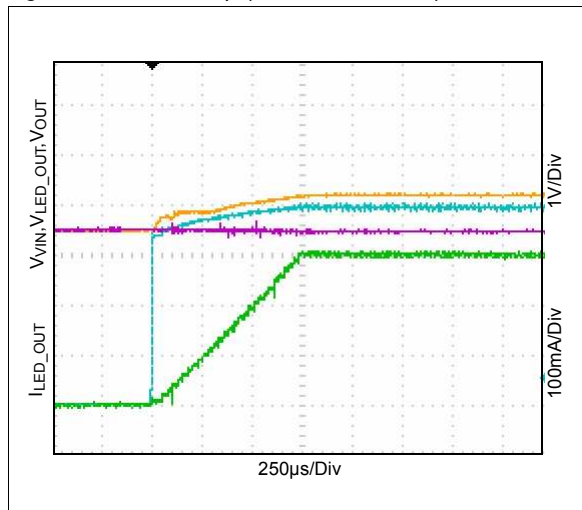


Figure 7. I_{VIN} Startup ($I_{LED_OUT}=300mA$)

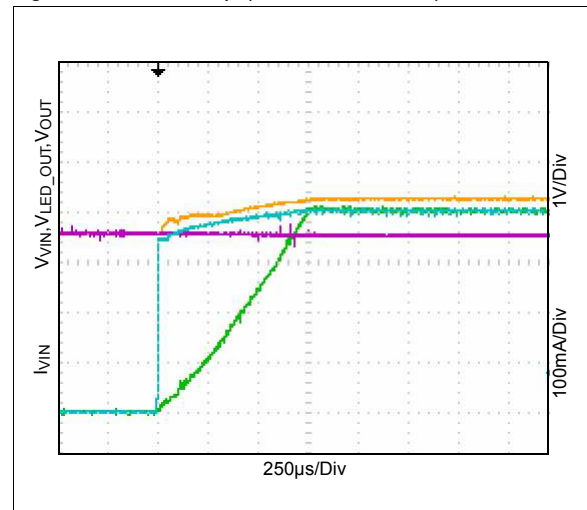


Figure 8. I_{LED_OUT} Startup ($I_{LED_OUT}=51.6mA$)

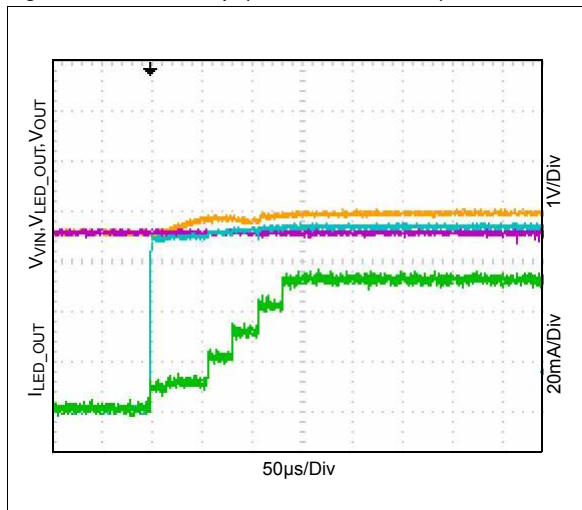


Figure 9. V_{OUT} / I_{LED_OUT} ripple, $I_{LED_OUT} = 300mA$

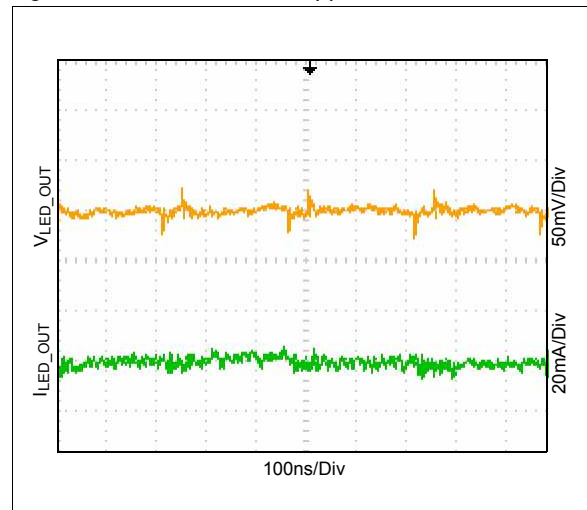


Figure 10. ILED_Rampdown (ILED_OUT=300mA)

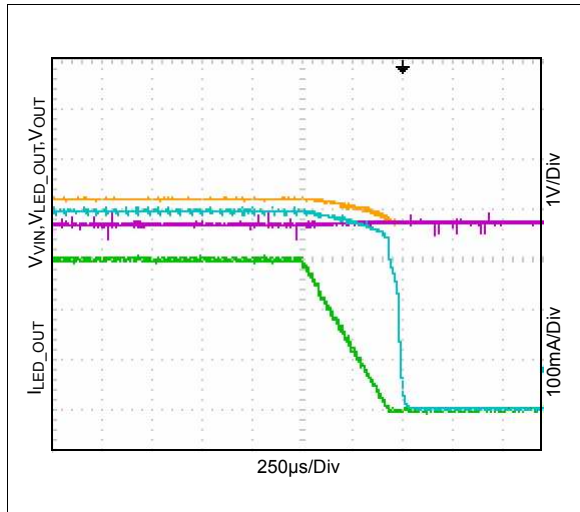


Figure 11. ILED_OUT Linearity of current sink

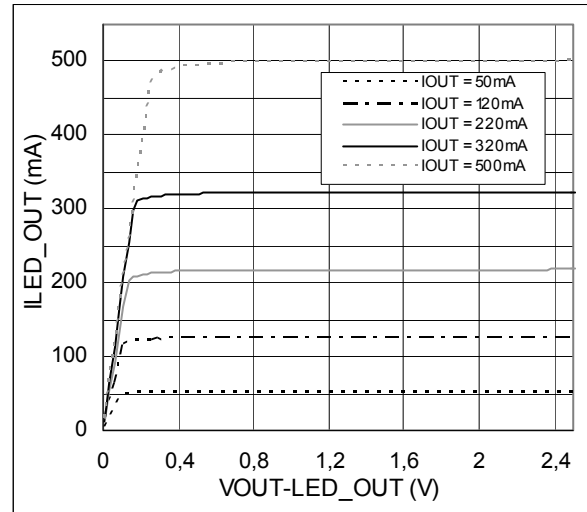


Figure 12. ILED_OUT vs. TAMB

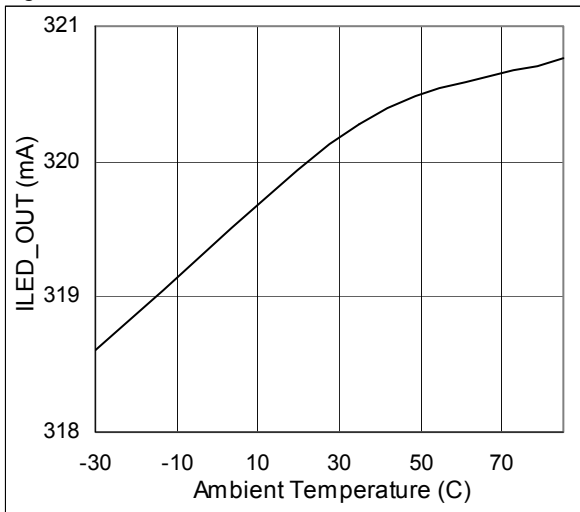


Figure 13. Oscillator frequency fCLK vs. TAMB

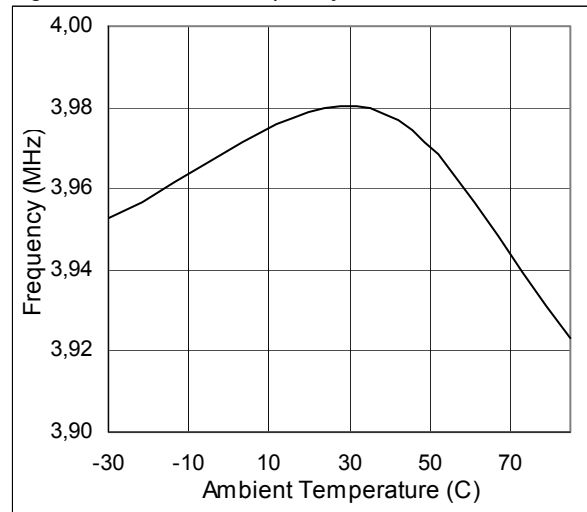


Figure 14. DCDC fCLK change 4MHz->1MHz(300mA)

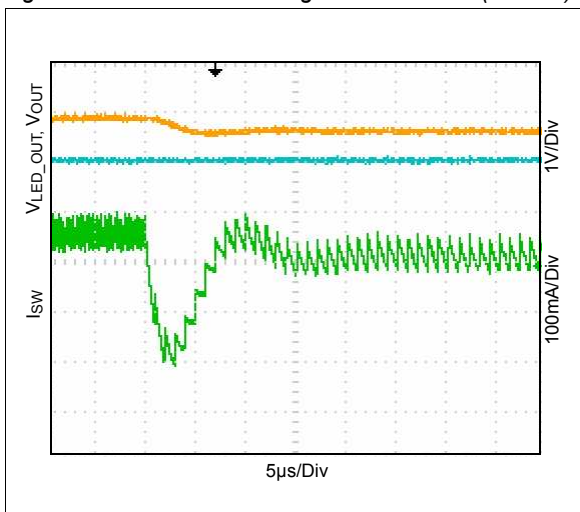
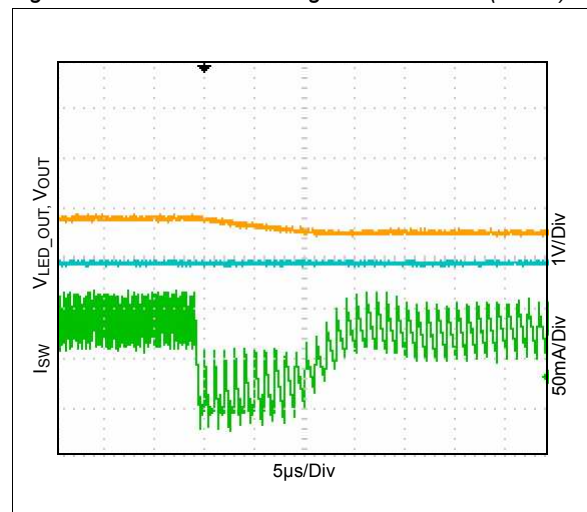


Figure 15. DCDC fCLK change 4MHz->1MHz(51mA)



8 Detailed Description

The AS3642 is a high performance DCDC step up converter with internal PMOS and NMOS switches. The switching frequency of 4MHz allows the use of tiny coils. Its output is connected to a flash LED by an internal current source.

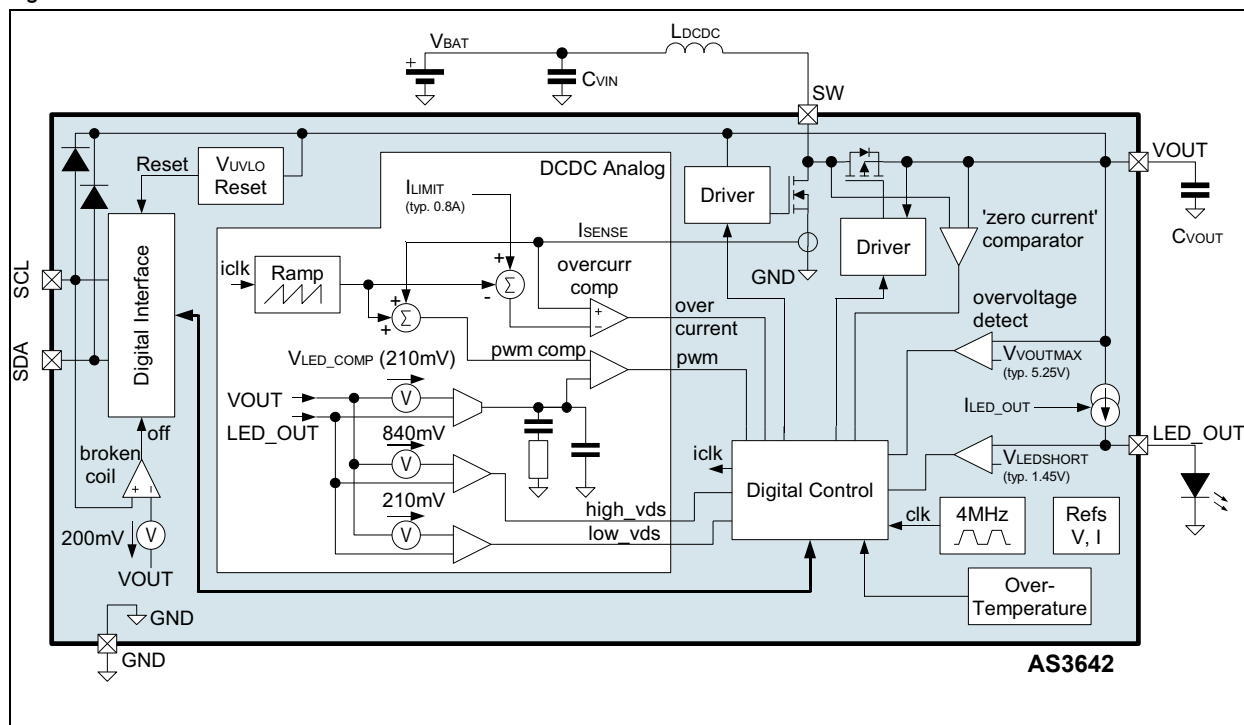
The AS3642 is controlled by an I²C interface. All timings and currents can be accurately adjusted by this interface. It support following operating modes:

1. Flash mode (enabled by `mode=11`):
The LED current is defined by register `flash_current`. A timer defines the output flash duration (30ms...480ms in 30ms steps defined by register `flash_timer`). The flash is started immediately after the end of the I²C command.
If SCL and SDA are L for more than `tTIMEOUT`, shutdown mode is automatically entered.
2. Assist light mode (=video or torch light mode) (enabled by `mode=10`):
The LED current is defined by register `assist_current`. The current is enabled until another mode is chosen by the interface.
If SCL and SDA are L for more than `tTIMEOUT`, shutdown mode is automatically entered.
3. Indicator light mode (enabled by `mode=01`):
The LED current is PWM modulated¹ by 1/32, 2/32, 3/32 or 4/32 (defined by register `ind_current` resulting in a effective current of 1.35mA / 2.9mA / 4.4mA or 6.0mA. The current is enabled until another mode is chosen by the interface.
If SCL and SDA are L for more than `tTIMEOUT`, shutdown mode is automatically entered
4. Shutdown mode (`mode=00`), `SCL=0V`, `SDA=0V`:
The DCDC and the current source is disabled and the AS3642 is configured to draw minimum current.

Internal Circuit

The AS3642 includes a fixed frequency DCDC step-up with accurate startup control. Together with the output current source (on LED_OUT) it includes protection and safety functions as shown in the following internal blockdiagram:

Figure 16. AS3642 internal circuit

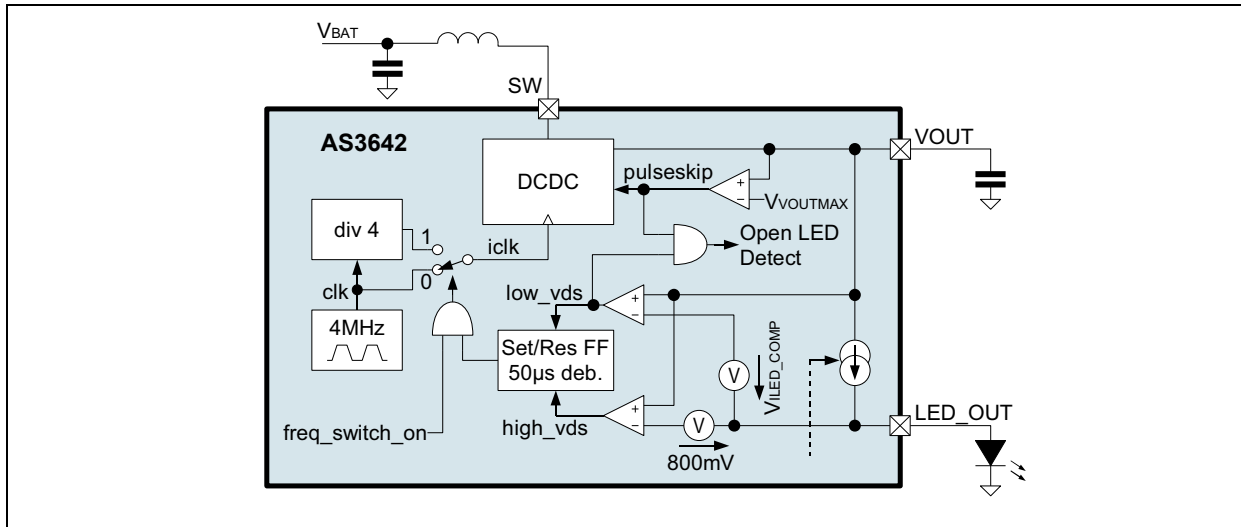


1. The PWM modulation frequency is 31.25kHz to avoid audible noise on the external capacitors.

The DCDC converter always operates in PWM mode (exception: PFM mode is allowed during startup) to reduce EMI in EMI sensitive systems. For flash and assist light mode and high duty cycles close to 100% on-time (maximum duty cycle) of the PMOS, the DCDC converter can switch into a 1MHz operating mode and maximum duty cycle to improve efficiency for this load condition. The DCDC converter returns back to its normal 4MHz operating frequency when load or supply conditions change. Due to this switching between two fixed frequencies the noise spectrum of the system is exactly defined and predictable. If improved efficiency is required, the fixed switching between 1MHz / 4MHz can be disabled by `freq_switch_on` (see page 16)=0². In this case pulseskip will be used.

The internal circuit for switching between these two frequencies is shown in Figure 17:

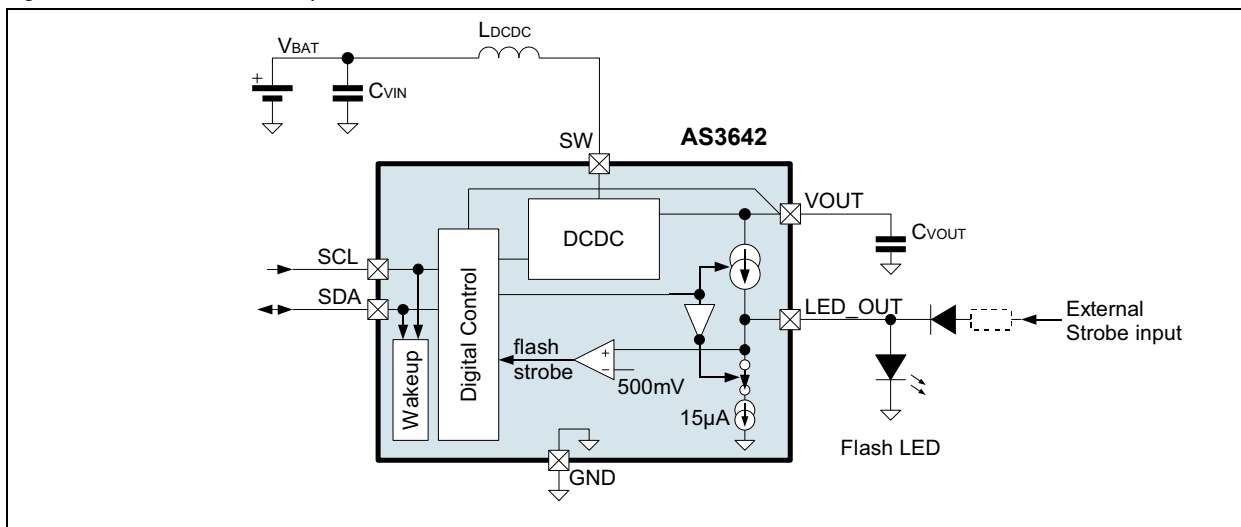
Figure 17. Internal circuit of 4MHz/1Mhz selection



External Strobe Input

To start the flash operation by an hardware input using an external strobe input, use schematic shown in Figure 18:

Figure 18. External strobe input



To enable this function, program the flash timer with the exact flash duration (by programming `flash_timer`) and set `external_strobe=1`. The AS3642 waits for an external strobe signal on pin LED_OUT and starts the flash pulse with a duration defined by `flash_timer`.

2. If `current_mode=11` (500mA operating mode), the AS3642 will always use only 4Mhz.

Protection and Fault Detection Functions

The protection functions protect the AS3642 and the LED(s) against physical damage. In most cases a register bit is set, which can be readout with the interface. The fault bits are cleared³ by a readout of the fault register.

DCDC Overvoltage Protection

In case of no or a broken LED at the pin LED_OUT and an enabled DCDC converter, the voltage on VOUT rises until it reaches VVOUTMAX (overvoltage condition) and the voltage across the current source does not reach regulation ($V_{OUT} - V_{LED} < V_{ILED_COMP}$). If this condition is detected, the DCDC converter is stopped, the current sources are disabled and the bit `fault_ovp` (see page 19)⁴ is set.

DCDC Broken Coil Detection

If the coil LDCDC is broken, the AS3642 is not powered by the pin SW connected to VOUT by the internal switch. Due to the protection diodes between SCL to VOUT and SDA to VOUT, the AS3642 can be powered through these diodes. The AS3642 detects this error condition by comparing the voltage on SCL and VOUT. If the voltage on VOUT is lower compared to the voltage on SCL, the AS3642 will ignore any I²C write commands. Therefore the application can simply detect this condition.

Note: Due to the broken coil detection, the high levels of SDA and SCL should be always below the supply voltage.

LED Short Circuit Protection

After the startup of the DCDC converter, the voltage on LED_OUT is continuously monitored and compared against VLEDSHORT. If the voltage stays below VLEDSHORT, the DCDC is stopped (as a shorted LED is assumed), the current sources are disabled and the bit `fault_led_short` (see page 19) is set.

Overtemperature Protection

The junction temperature of the AS3642 is continuously monitored. If the temperature exceeds TOVTEMP, the DCDC is stopped, the current sources are disabled and the bit `fault_overtemp` (see page 19) is set. The driver cannot be re-enabled unless the junction temperature drops below TOVTEMP-TOVTEMPHYST.

Flash Timer

The duration of the flash is defined by the register `flash_timer` (see page 18). After the timer expires, the DCDC is stopped and the flash current source (on pin LED_OUT) is disabled.

Supply undervoltage Protection

If the voltage on the pin VOUT (=battery voltage) is or falls below VUVLO, the AS3642 is kept in shutdown state and in all registers are set to their default state.

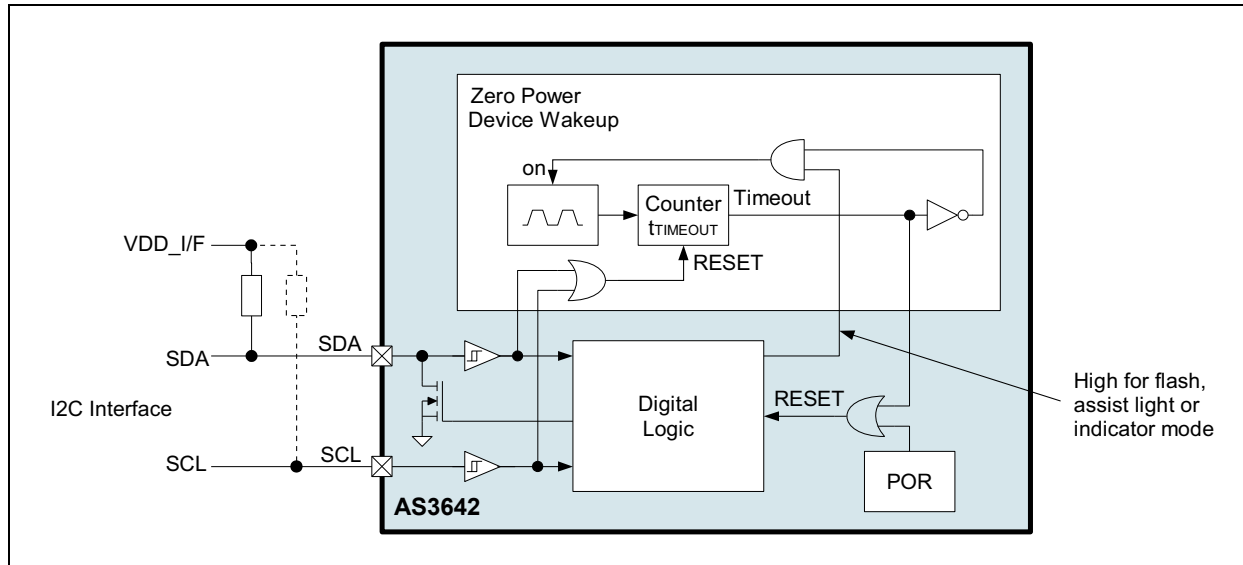
Note: During operation of the DCDC converter, the supply undervoltage protection will still monitor the DCDC output voltage only. Therefore the supply undervoltage protection will only monitor the battery voltage if the DCDC converter is switched off and the output capacitor is discharged down to the supply voltage.

Wakeup Circuit - Power off detection

In flash, assist light and indicator mode (register `mode` (page 18)=01, 10 or 11), if SCL and SDA are L for more than TIMEOUT, shutdown mode is automatically entered. This feature automatically detects a power-off of the controlling circuit driving SCL and SDA (VDD_I/F goes to 0V) - the internal circuit is shown in Figure 19:

-
3. Except overtemperature protection bit `fault_overtemp`: This bit can be cleared once the temperature drops below TOVTEMP-TOVTEMPHYST.
 4. In indicator mode (`mode`=01) the register `fault_ovpi` is never set (the overvoltage protection is nevertheless operating)

Figure 19. Device Shutdown and Wakeup



I²C Serial Data Bus

The AS3642 supports the I²C bus protocol. A device that sends data onto the bus is defined as a transmitter and a device receiving data as a receiver. The device that controls the message is called a master. The devices that are controlled by the master are referred to as slaves. A master device that generates the serial clock (SCL), controls the bus access, and generates the START and STOP conditions must control the bus. The AS3642 operates as a slave on the I²C bus. Within the bus specifications a standard mode (100kHz maximum clock rate) and a fast mode (400kHz maximum clock rate) are defined. The AS3642 works in both modes. Connections to the bus are made through the open-drain I/O lines SDA and SCL.

The following bus protocol has been defined (Figure 20):

- Data transfer may be initiated only when the bus is not busy.
- During data transfer, the data line must remain stable whenever the clock line is HIGH. Changes in the data line while the clock line is HIGH are interpreted as control signals.

Accordingly, the following bus conditions have been defined:

Bus Not Busy

Both data and clock lines remain HIGH.

Start Data Transfer

A change in the state of the data line, from HIGH to LOW, while the clock is HIGH, defines a START condition.

Stop Data Transfer

A change in the state of the data line, from LOW to HIGH, while the clock line is HIGH, defines the STOP condition.

Data Valid

The state of the data line represents valid data when, after a START condition, the data line is stable for the duration of the HIGH period of the clock signal. The data on the line must be changed during the LOW period of the clock signal. There is one clock pulse per bit of data.

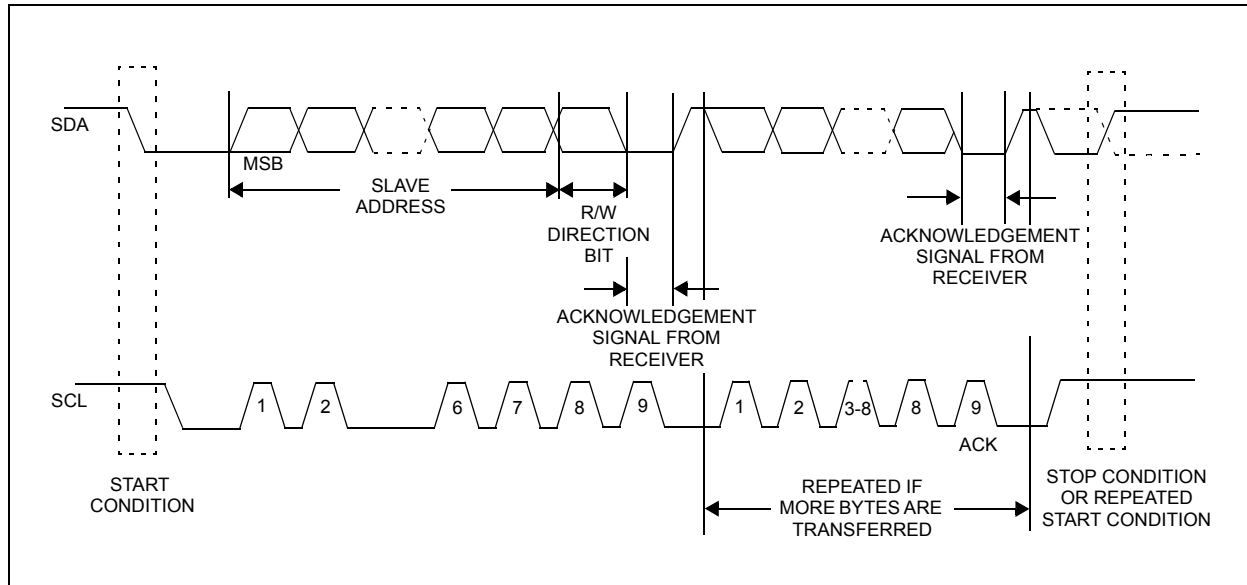
Each data transfer is initiated with a START condition and terminated with a STOP condition. The number of data bytes transferred between START and STOP conditions are not limited, and are determined by the master device. The information is transferred byte-wise and each receiver acknowledges with a ninth bit.

Acknowledge

Each receiving device, when addressed, is obliged to generate an acknowledge after the reception of each byte. The master device must generate an extra clock pulse that is associated with this acknowledge bit.

A device that acknowledges must pull down the SDA line during the acknowledge clock pulse in such a way that the SDA line is stable LOW during the HIGH period of the acknowledge-related clock pulse. Of course, setup and hold times must be taken into account. A master must signal an end of data to the slave by not generating an acknowledge bit on the last byte that has been clocked out of the slave. In this case, the slave must leave the data line HIGH to enable the master to generate the STOP condition.

Figure 20. Data Transfer on I²C Serial Bus



Depending upon the state of the R/W bit, two types of data transfer are possible:

1. **Data transfer from a master transmitter to a slave receiver.** The first byte transmitted by the master is the slave address. Next follows a number of data bytes. The slave returns an acknowledge bit after each received byte. Data is transferred with the most significant bit (MSB) first.
2. **Data transfer from a slave transmitter to a master receiver.** The master transmits the first byte (the slave address). The slave then returns an acknowledge bit, followed by the slave transmitting a number of data bytes. The master returns an acknowledge bit after all received bytes other than the last byte. At the end of the last received byte, a "not acknowledge" is returned. The master device generates all of the serial clock pulses and the START and STOP conditions. A transfer is ended with a STOP condition or with a repeated START condition. Since a repeated START condition is also the beginning of the next serial transfer, the bus is not released. Data is transferred with the most significant bit (MSB) first.

The AS3642 can operate in the following two modes:

1. **Slave Receiver Mode (Write Mode):** Serial data and clock are received through SDA and SCL. After each byte is received an acknowledge bit is transmitted. START and STOP conditions are recognized as the beginning and end of a serial transfer. Address recognition is performed by hardware after reception of the slave address and direction bit (see Figure 21). The slave address byte is the first byte received after the master generates the START condition. The slave address byte contains the 7-bit AS3642 address, which is 0110000, followed by the direction bit (R/W), which, for a write, is 0.⁵ After receiving and decoding the slave address byte the device outputs an acknowledge on the SDA line. After the AS3642 acknowledges the slave address + write bit, the master transmits a register address to the AS3642. This sets the register pointer on the AS3642. The master may then transmit zero or more bytes of data, with the AS3642 acknowledging each byte received.

5. The address for writing to the AS3642 is 60h = 01100000b

The address pointer will increment after each data byte is transferred. The master generates a STOP condition to terminate the data write.

- Slave Transmitter Mode (Read Mode):** The first byte is received and handled as in the slave receiver mode. However, in this mode, the direction bit indicates that the transfer direction is reversed. Serial data is transmitted on SDA by the AS3642 while the serial clock is input on SCL. START and STOP conditions are recognized as the beginning and end of a serial transfer (Figure 22 and Figure 23). The slave address byte is the first byte received after the master generates a START condition. The slave address byte contains the 7-bit AS3642 address, which is 0110000, followed by the direction bit (R/W), which, for a read, is 1.⁶ After receiving and decoding the slave address byte the device outputs an acknowledge on the SDA line. The AS3642 then begins to transmit data starting with the register address pointed to by the register pointer. If the register pointer is not written to before the initiation of a read mode the first address that is read is the last one stored in the register pointer. The AS3642 must receive a “not acknowledge” to end a read.

Figure 21. Data Write - Slave Receiver Mode

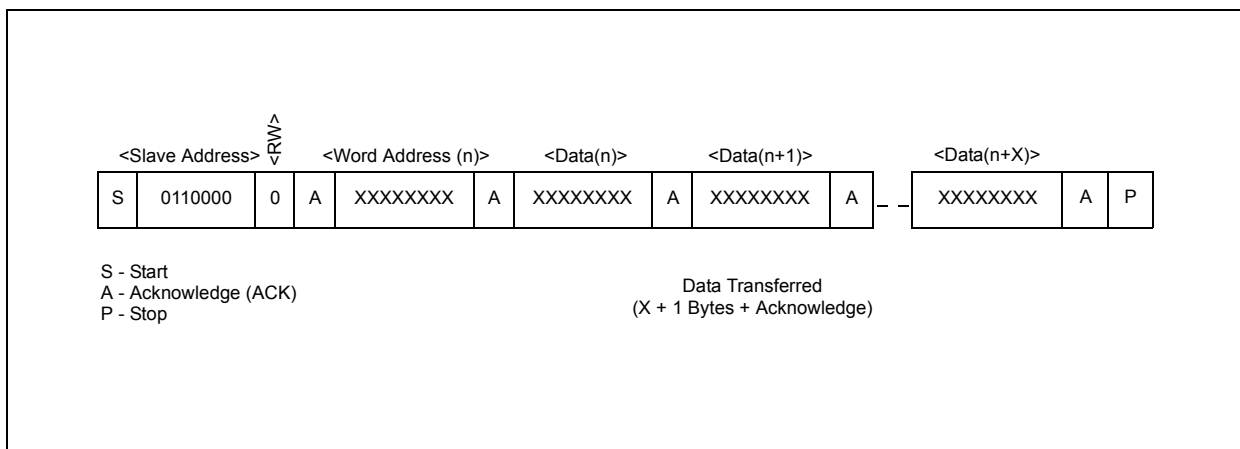
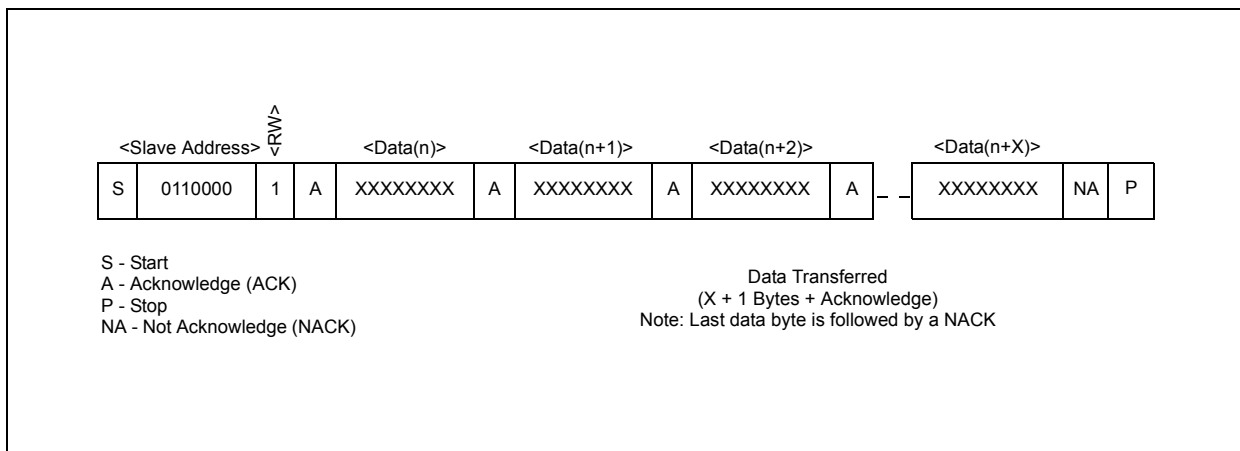
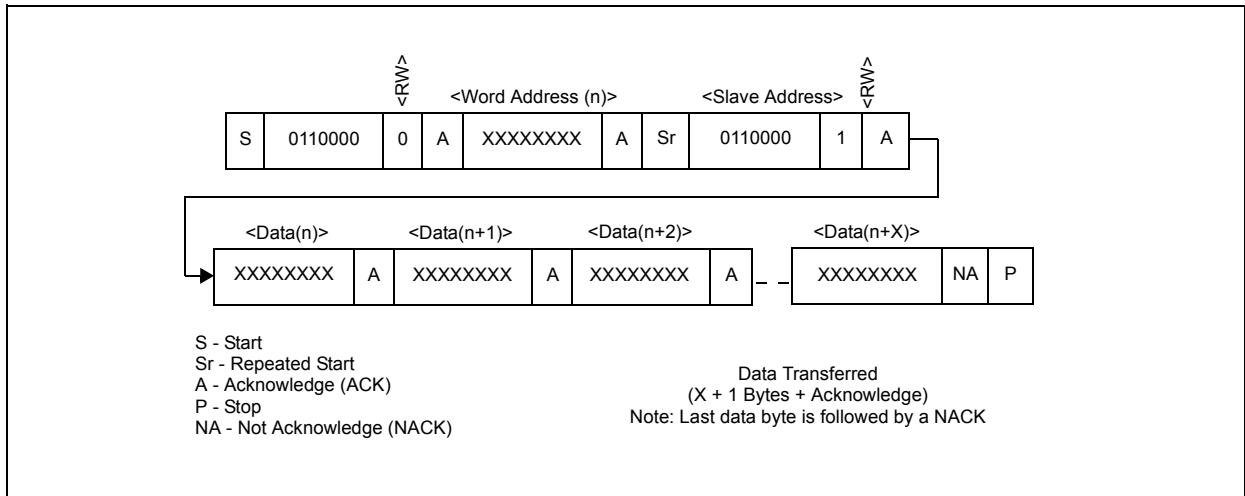


Figure 22. Data Read (from Current Pointer Location) - Slave Transmitter Mode



6. The address for read mode from the AS3642 is 61h = 01100001b

Figure 23. Data Read (Write Pointer, Then Read) - Slave Receive and Transmit



Register Description

Table 4. *Design Info Register*

| Addr: 0 | | Design Info Register | | |
|------------------------------|----------|----------------------|--------|--|
| This register has a fixed ID | | | | |
| Bit | Bit Name | Default | Access | Description |
| 7:0 | fixed_id | 13h | R | This is a fixed identification (e.g. to verify the I ² C communication) |

Table 5. *Version Control Register*

| Addr: 1 | | Version Control Register | | |
|---------------------------------------|----------|--------------------------|--------|-----------------------|
| This register defines design versions | | | | |
| Bit | Bit Name | Default | Access | Description |
| 3:0 | version | Xh | R | AS3642 version number |
| 7:4 | reserved | Xh | R | reserved - don't use |

Table 6. *Current Set Register*

| Addr: 2 | | Current Set Register | | | |
|--|-----------------------------|----------------------|--------|---|---|
| This register defines the Current Settings | | | | | |
| Bit | Bit Name | Default | Access | Description | |
| 1:0 | current_mode ¹ | 00 | R/W | Define the current on pin LED_OUT | |
| | | | | 00 | LED_OUT current is defined by <code>ind_current</code> , <code>assist_current</code> and <code>flash_current</code> |
| | | | | 01 | LED_OUT current is defined by register 2, bits <7:3> LSB = 10mA, full range = 320mA |
| | | | | 11 | LED_OUT current is defined by register 2, bits <7:3> LSB = 15.625mA, full range = 500mA |
| 2 | freq_switch_on ² | 1 | R/W | Exact frequency switching between 4MHz/1MHz for assist and flash modes for operation close to maximum pulsewidth - see Figure 17 on page 10 | |
| | | | | 0 | Pulseskip operation is allowed for all modes - results in better efficiency |
| | | | | 1 | In flash and assist light mode, the DCDC is running at 4MHz or 1MHz (pulseskip is disabled) - results in improved noise performance |
| 4:3 | ind_current | 10 | R/W | Define the current on pin LED_OUT in indicator mode if <code>current_mode=00</code> or <code>10</code> | |
| | | | | 00 | I _{LED_OUT} = 1.35mA (PWM with 1/32 duty cycle) |
| | | | | 01 | I _{LED_OUT} = 2.9mA (PWM with 2/32 duty cycle) |
| | | | | 10 | I _{LED_OUT} = 4.4mA (PWM with 3/32 duty cycle) |
| | | | | 11 | I _{LED_OUT} = 6.0mA (PWM with 4/32 duty cycle) |
| 5 | assist_current | 1 | R/W | Define the current on pin LED_OUT in assist light mode if <code>current_mode=00</code> or <code>10</code> | |
| | | | | 0 | I _{LED_OUT} = 51.6mA |
| | | | | 1 | I _{LED_OUT} = 72.3mA |

Table 7. Control Register

| Addr: 3 | | Control Register | | | |
|---------|--|---|--------|--|--|
| | | This register defines the operating mode and different protection functions in I ² C interface | | | |
| Bit | Bit Name | Default | Access | Description | |
| 3:0 | flash_timer | 4h | R/W | Define the duration of the flash timer | |
| | | | | 0h | 30ms |
| | | | | 1h | 60ms |
| | | | | 2h | 90ms |
| | | | | 3h | 120ms |
| | | | | 4h | 150ms default value |
| | | | | 5h | 180ms |
| | | | | 6h | 210ms |
| | | | | 7h | 240ms |
| | | | | 8h | 270ms |
| | | | | 9h | 300ms |
| | | | | Ah | 330ms |
| | | | | Bh | 360ms |
| | | | | Ch | 390ms |
| | | | | Dh | 420ms |
| Eh | 450ms | | | | |
| Fh | 480ms | | | | |
| 5:4 | mode | 00 | R/W | AS3642 operating mode selection | |
| | | | | 00 | Shutdown mode |
| | | | | 01 | Indicator light mode with ind_current ¹ |
| | | | | 10 | Assist light mode ² with assist_current |
| 11 | Flash mode with duration flash_timer with flash_current (if current_mode =00b or 10b) or current (if current_mode =10b or 11b) | | | | |
| 6 | reserved | 0 | R | reserved - don't use | |
| 7 | external_strobe ³ | 0 | R/W | External strobe signal from pin LED_OUT | |
| | | | | 0 | no external strobe |
| | | | | <p>1</p> <p>A flash pulse with current defined by flash_current (if current_mode=00b or 10b) or current (if current_mode=10b or 11b) register is triggered on a rising edge on LED_OUT (e.g. due to an external signal pulling it high). At the same time this register is automatically cleared. After the flash pulse (duration defined by flash_timer) the AS3642 returns to shutdown mode.</p> <p>Note: Setting this bit automatically sets mode (see page 18)=11 (flash mode)</p> <p>A ongoing flash started with external_strobe can be stopped by writing '0' to external_strobe and '00' to mode.</p> | |

1. Before changing `mode` register to 01, write 0xA1 to register 0x80h (password protection).
2. Torch mode and assist light mode share the same operating mode and identical currents.
3. Before changing `external_strobe` register to 01, write 0xA1 to register 0x80h (password protection).

Table 8. *Fault Register*

| Addr: 4 | | Fault Register | | | |
|---|-----------------|----------------|--------|---|---|
| This register identifies all the different fault conditions and provide information about the LED detection | | | | | |
| Bit | Bit Name | Default | Access | Description | |
| 4:0 | reserved | 0 | R | reserved - don't use | |
| 5 | fault_overtemp | 0 | R | see Overtemperature Protection on page 11 | |
| | | | | 0 | No fault |
| | | | | 1 | Junction temperature limit has been exceeded |
| 6 | fault_led_short | 0 | R | see LED Short Circuit Protection on page 11 | |
| | | | | 0 | No fault |
| | | | | 1 | A shorted LED is detected (pin LED_OUT) |
| 7 | fault_ovp | 0 | R | see DCDC Overvoltage Protection on page 11 | |
| | | | | 0 | No fault |
| | | | | 1 | An overvoltage condition is detected (pin VOUT) |

Register Map

Table 9. *Register Map*

| Register Definition | Addr | Default | Content | | | | | | | |
|---------------------|------|---------|----------------------------------|-----------------|----------------|----------|----------------|--------------|----|----|
| | | | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| Design Info | 0 | 13h | fixed_id | | | | | | | |
| Version Control | 1 | XXh | reserved | | | | version | | | |
| Current Set | 2 | B4h | flash_current | assist_current | ind_current | | freq_switch_on | current_mode | | |
| | | | current if current_mode=10 or 11 | | | | | | | |
| Control | 3 | 04h | external_strobe | reserved | mode | | flash_timer | | | |
| Fault | 4 | 00h | fault_ovp | fault_led_short | fault_overtemp | reserved | | | | |

9 Application Information

The AS3642 can be directly connected to an (existing) I²C bus (e.g. from the baseband or camera processor). All functions are accessible by this interface. An strobe input can be done by adding a diode (with an optional resistor in series) to the LED_OUT pin. Setting the register bit `external_strobe=1` enable this input as a strobe input. The duration of the flash is programmed by the I²C interface, but the exact starting time is defined by this input- see [External Strobe Input on page 10](#).

External Components

Input Capacitor C_{VIN}

Low ESR input capacitors reduce input switching noise and reduce the peak current drawn from the battery. Ceramic capacitors are required for input decoupling and should be located as close to the device as is practical.

Table 10. Recommended Input Capacitor

| Part Number | C | TC Code | ESR | Rated Voltage | Size | Manufacturer |
|-----------------|---|---------|-------|---------------|------|---|
| CL05A395MQ5NQKL | 4.7µF +/-10% >1.6µF @ V _{VIN} | X5R | <20mΩ | 6V3 | 0402 | Samsung Electro-Mechanics www.sem.samsung.co.kr |

If a different input capacitor is chosen, ensure similar ESR value and at least 1.6µF capacitance at the maximum input supply voltage. Larger capacitor values (C) may be used without limitations.

Output Capacitor C_{VOUT}

Low ESR capacitors should be used to minimize V_{OUT} ripple. Multi-layer ceramic capacitors are recommended since they have extremely low ESR and are available in small footprints. The capacitor should be located as close to the device as is practical.

X5R dielectric material is recommended due to their ability to maintain capacitance over wide voltage and temperature range.

Table 11. Recommended Output Capacitor

| Part Number | C | TC Code | ESR | Rated Voltage | Size | Manufacturer |
|-----------------|----------------|---------|-------|---------------|-----------------|---|
| ECJUNBPJ155K | 2x1.5µF +/-15% | X5R | <10mΩ | 6V3 | 0405 2-array | Panasonic www.panasonic.com |
| CL14A185MQ8SAKL | | | | | | Samsung Electro-Mechanics www.sem.samsung.co.kr |

If a different output capacitor is chosen, ensure similar ESR values and at least 1.0µF capacitance at maximum output voltage.

Inductor L_{DCDC}

The fast switching frequency (4MHz) of the AS3642 allows for the use of small SMDs for the external inductor. The inductor should have low DC resistance (DCR) to reduce the I²R power losses - high DCR values will reduce efficiency.

Table 12. Recommended Inductor

| Part Number | L | DCR | L @ 0.9A | Size | Manufacturer |
|---------------|-------|-------|----------|--------------|---|
| LQM21PN1R0NGC | 1.1µH | 100mΩ | >0.7µH | 2x1.25x0.9mm | Murata www.murata.com |
| ELGTEA1R0SN | 1.0µH | | >0.7µH | 2x1.25x0.9mm | Panasonic www.panasonic.com |

Table 12. Recommended Inductor (Continued)

| Part Number | L | DCR | L @ 0.9A | Size | Manufacturer |
|-----------------|--------------|---------------|--------------|--------------|---|
| CIG21K1R0SCE | 1.17 μ H | 135m Ω | >0.7 μ H | 2x1.25x0.9mm | Samsung Electro-Mechanics www.sem.samsung.co.kr |
| CKP2012N1R0M | 1.0 μ H | 110m Ω | >0.7 μ H | 2x1.25x0.9mm | Taiyo Yuden www.t-yuden.com |
| MLP2012L1R0MT | 1.0 μ H | | >0.7 μ H | 2x1.25x0.9mm | TDK www.tdk.com |
| MDT2012-CR1R0AN | 1.0 μ H | 110m Ω | >0.7 μ H | 2x1.25x0.9mm | Toko www.toko.co.jp |

If a different inductor is chosen, ensure similar DCR values and at least 0.7 μ H inductance at 0.9A input current.

LED

Use LED and optics as required by the system.

Table 13. Recommended LEDs

| Part Number | Name | Lumen @ 300mA | Size | Manufacturer |
|------------------|-------------|---------------|------------------|--|
| CERAMOS LUW C9SM | Ceramos | 55 | 2.04x1.64x0.75mm | Osram Opto Semiconductors www.osram-os.com |
| LXCL-PWF3 | Luxeon PWF3 | 30 | 2.04x1.64x0.7mm | Philips Lumileds www.philipslumileds.com |

PCB Layout Guideline

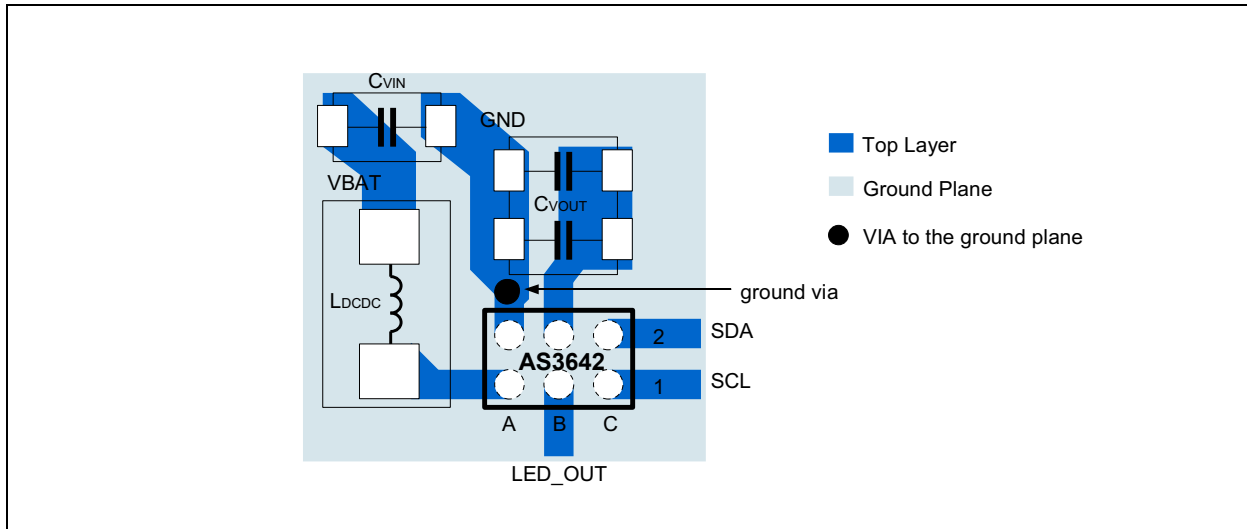
The high speed operation requires proper layout for optimum performance. Route the power traces first and try to minimize the area and wire length of the two high frequency/high current loops:

Loop1: CVIN - LDCDC - pin SW - pin GND - CVIN

Loop2: CVIN - LDCDC - pin SW - pin VOUT - CVOUT - pin GND - CVIN

At the pin GND a single via (or more vias, which are closely combined) connects to the common ground plane. This via(s) will isolate the DCDC high frequency currents from the common ground (as most high frequency current will flow between Loop1 and Loop2 and will not pass the ground plane) - see the 'ground via' in Figure 24.

Figure 24. Layout recommendation



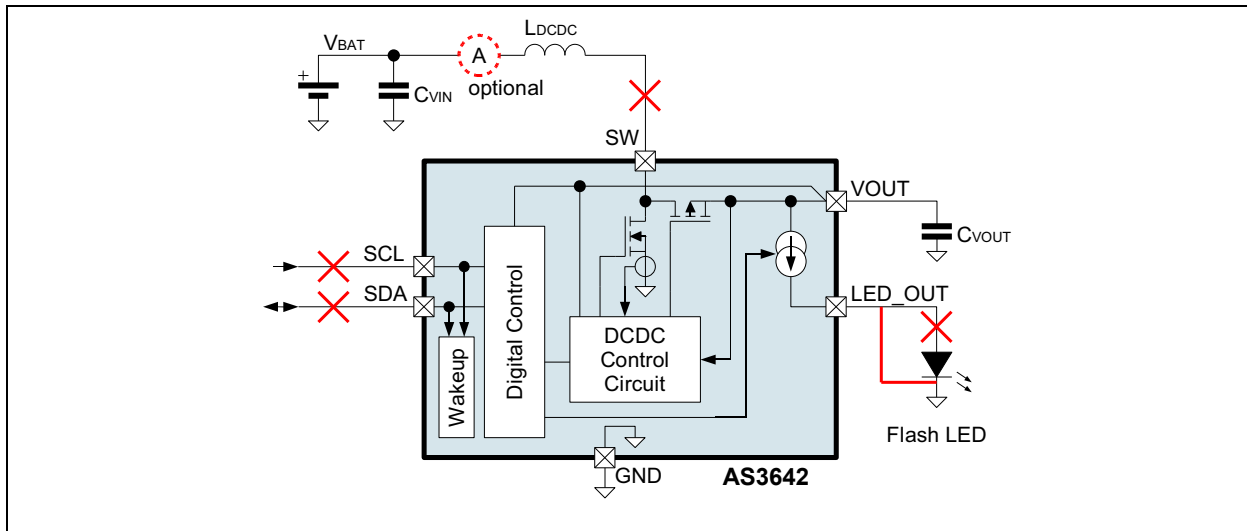
Note: If component placement rules allow, move all components close to the AS3642 to reduce the area and length of Loop1 and Loop2.

The recommended PCB pad size for the AS3642 is 250µm.

Application Self Testing Guideline

Using the in-built self testing features of the AS3642, the errors as shown in Figure 25 during the assembling and soldering of the AS3642, can be detected - this simplifies and can reduce cost during manufacturing:

Figure 25. Self Testing - Detecting Assembling and Soldering Errors



The self testing procedure is simple:

1. Write 0x20 into register 0x03 (**Control** register) [Enable assist light with default 72mA].
2. Read back⁷ register 0x03 - must return 0x20, otherwise LDCDC or I²C (SCL or SDA) is broken
3. Write 0x00 into register 0x03 [Power off]
4. Read register 0x04 (**Fault** register) - must return 0x00, otherwise the LED is open or shorted

See [Table 14](#) to identify the different possible soldering errors:

Table 14. How-to identify errors

| Error | Identified by |
|-------------------|--|
| SCL or SDA broken | writing 0x20 to 0x03 and read back of register 0x03 does not return 0x20 |
| LDCDC broken | writing 0x20 to 0x03 and read back of register 0x03 does not return 0x20 - see DCDC Broken Coil Detection on page 11 |
| Flash LED shorted | register <code>fault_led_short</code> (see page 19) is set |
| Flash LED open | register <code>fault_ovp</code> (see page 19) is set |

Typical I²C programming example

A typical use case for the AS3642 is to generate a 480ms, 500mA flash pulse. The programming example is shown in [Table 15](#):

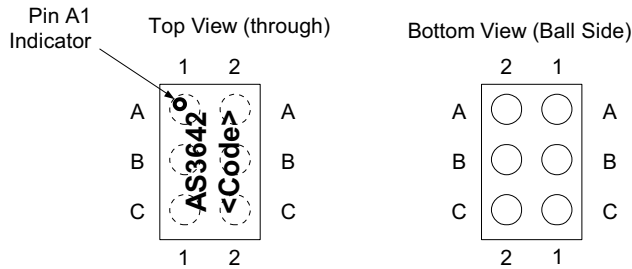
Table 15. I²C Programming Example - 500mA, 480ms flash pulse

| Sequence | C-Syntax | Purpose/Action |
|--------------------------------|--|--|
| write 0xA1 to register 0x80h | <code>AMSWriteByte(0x80, 0xA1);</code> | Use password to unlock next I ² C write |
| write 0xFF to register 0x02h | <code>AMSWriteByte(0x02, 0xFF);</code> | Set 500mA mode (<code>current_mode</code> (page 16)=11b) and <code>current</code> (page 17) to 500mA |
| write 0x3F to register 0x03h | <code>AMSWriteByte(0x03, 0x3F);</code> | Set <code>flash_timer</code> (page 18) to 480ms and <code>mode</code> (page 18) to flash (which automatically fires the flash and stops it after <code>flash_timer</code> expired) |
| - no further action required - | | the AS3642 automatically returns to shutdown mode |

7. Alternative testing method: Instead of reading the internal registers, the current into the AS3642 can be measured. During assist light mode, the supply current must increase by at least 60mA. If an error is detected, the current source and the DCDC is automatically switched off - see [Protection and Fault Detection Functions on page 11](#)

10 Package Drawings and Markings

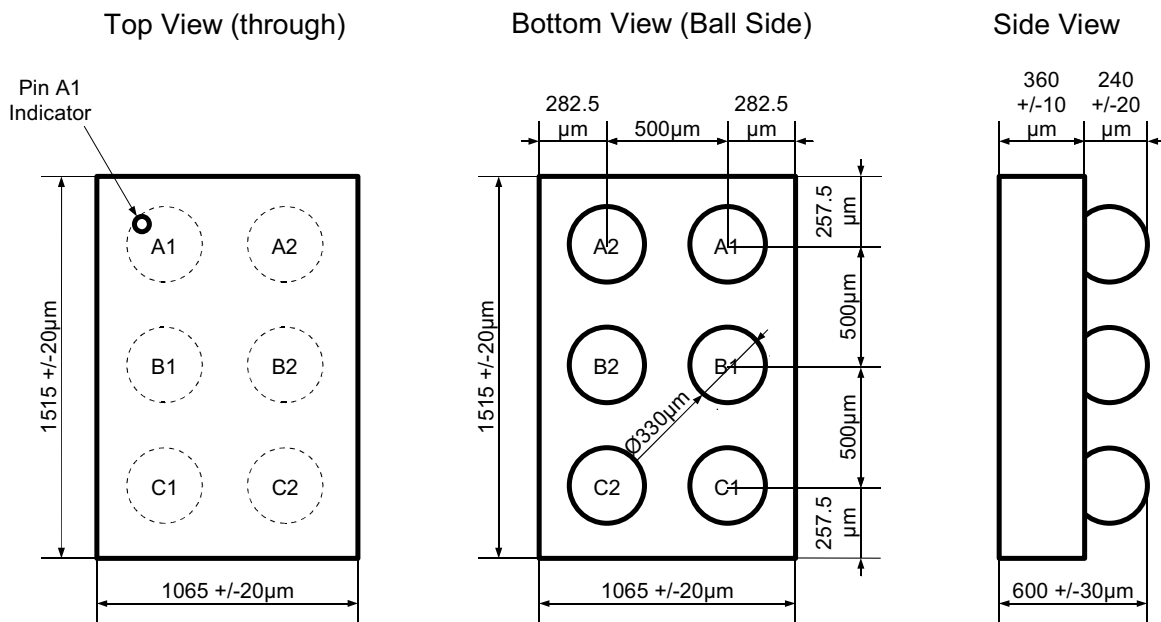
Figure 26. 6pin WL-CSP Marking



Note:

- Line 1: AS3642
- Line 2: <Code>
 Encoded Datecode (4 characters)

Figure 27. 6pin WL-CSP Package Dimensions



The coplanarity of the balls is 40 μm.



11 Ordering Information

The devices are available as the standard products shown in [Table 16](#).

Table 16. Ordering Information

| Model | Description | Delivery Form | Package |
|-------------|--|---------------|---|
| AS3642-ZWLT | Ultra Small 500mA Inductive White LED Flash Driver | Tape & Reel | 6-pin WL-CSP (1.5mm x 1.1mm x 0.6mm) RoHS compliant / Pb-Free / Green |

Note: All products are RoHS compliant and austriamicrosystems green.

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or find your local distributor at <http://www.austriamicrosystems.com/distributor>

Note: AS3642-ZWLT

AS3642-

Z ... Temperature Range: -30°C - 85°C

WL ... Wafer Level Chip Scale Package (WL-CSP)

T ... Delivery Form: Tape & Reel

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Contact Information

Headquarters

austriamicrosystems AG

Tobelbaderstrasse 30

Schloss Premstaetten

A-8141 Austria

Tel: +43 (0) 3136 500 0

Fax: +43 (0) 3136 525 01

For Sales Offices, Distributors and Representatives, please visit:

<http://www.austriamicrosystems.com/contact>