# iC-JJ

POWER MANAGEMENT iC



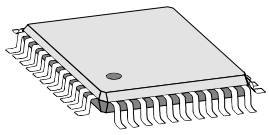
## FEATURES

- Supply voltage range of VBAT= 6 to 16.5V
- Autarky function to maintain temporarily output voltages with breakdown of supply voltage
- Adjustable 200mA boost converter (VA1= VBAT+2V to 48V)
- 6V step-down regulator with integrated 125kHz oscillator
- Two downstream 5V linear regulators with 200mA/60mA output current
- 12V/30mA tri-state output
- Low standby current of typ. 30µA
- Integrated high/low-side drivers e.g. to attach indicator lamps
- Overtemperature shutdown of high- and low-side drivers
- Undervoltage detection
- Serial single-wire communication interface
- Watchdog for monitoring of the external µ-controller
- CMOS-compatible inputs
- TTL-/CMOS-compatible outputs
- ESD protection

## APPLICATIONS

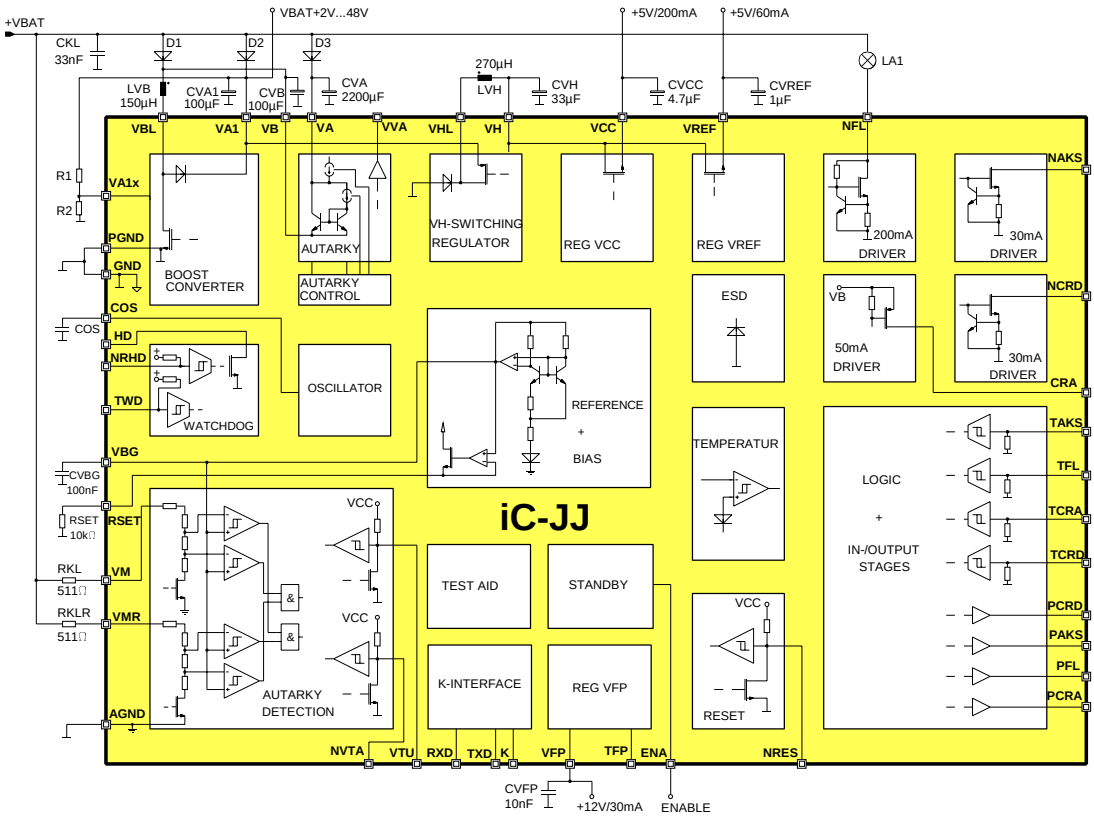
- Universal voltage supply iC with monitoring and autarky function for the voltage supply of automotive and industrial applications

## PACKAGE



MFQ44

## BLOCK DIAGRAM



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## GENERAL DESCRIPTION

Monolithic device iC-JJ supplies electronic systems from a single input voltage VBAT (6V to 16.5V) with voltages which range from 5V to 48V. The autarky function guarantees that the output voltages are maintained for up to several hundred milliseconds, even after the input voltage has been aborted.

A step-up converter produces a voltage of VBAT+2V to 48V, whose setpoint is adjusted via two external resistors at VA1x. Two 5V linear regulators provide 200mA (VCC) and 60mA (VREF). Alternatively, 260mA are available from the 6V step-down converter (VH) whose switching frequency is generated by an integrated 120kHz oscillator. An additional tristate-competent output provides 12V to 30mA and can be activated via a control input for writing data to EEPROMs, for example.

The integrated low voltage and autarky detection function indicates at the error message outputs VTU and NVTA when the relevant low voltage thresholds are reached; there are two different error message outputs for this purpose. The error message is deleted by an external low signal and not when the supply voltage rises again. Information on temporary voltage drops is retained.
If the autarky voltage threshold is undershot, the iC automatically switches into autarky mode. This mode can also be simulated in order to test the autarky capacitor CVA.

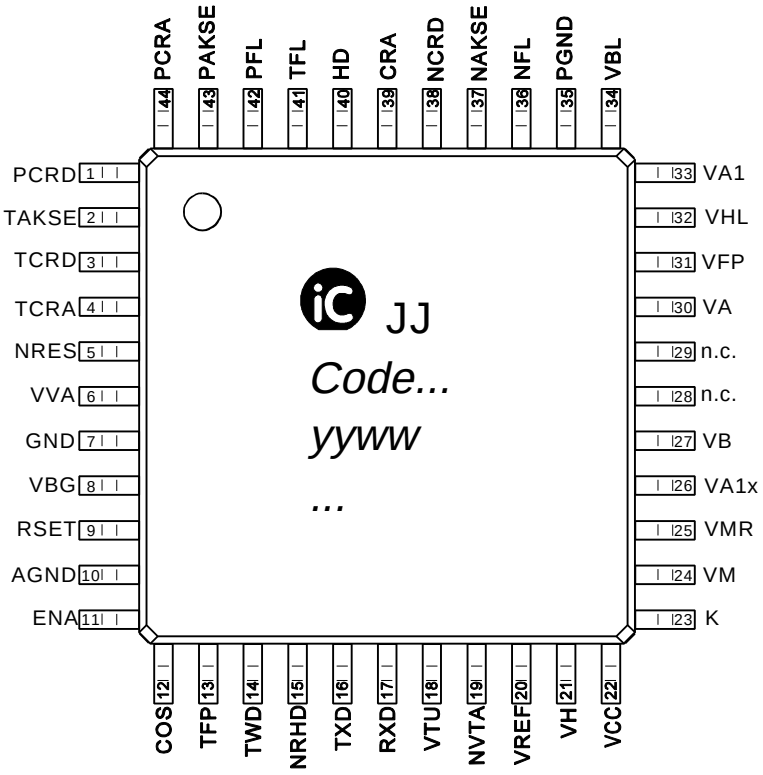
Integrated high- and low-side drivers permit various loads to be connected, such as panel indicators (visual monitors), for example. The drivers are switched via control inputs and status outputs are signaling the current switching state back to the controller.
iC-JJ monitors the chip temperature; with excessive temperature the high- and low-side drivers are switched off to reduce the power dissipation.

The integrated watchdog can monitor the correct operation of an external processor. If used, the bi-directional serial communication interface connects the chip with external diagnosis components. The iC can be switched to standby via the input ENA and then draws a low standby current of typically 30 µA.

The device is protected against destruction due to ESD.

**PACKAGE** MQFP44 according to the JEDEC standard

**PIN CONFIGURATION MQFP44** (top view)




**PIN FUNCTIONS**

| No. | Name | Function |
|---|---|---|
| 1 | PCRD | Message Output for Pin NCRD |
| 2 | TAKS | Trigger Input for Output NAKS |
| 3 | TCRD | Trigger Input for Output NCRD |
| 4 | TCRA | Trigger Input for Output CRA |
| 5 | NRES | Reset, low active |
| 6 | VVA | Capacitor Test Output |
| 7 | GND | Ground |
| 8 | VBG | Bandgap Reference Voltage |
| 9 | RSET | Attachment RSET |
| 10 | AGND | Analog Ground |
| 11 | ENA | Enable |
| 12 | COS | Capacitor for Oscillator Adjustment |
| 13 | TFP | Trigger Input for Output VFP |
| 14 | TWD | Trigger Input for Watchdog |
| 15 | NRHD | Trigger Input for Pin HD |
| 16 | TXD | Trigger Input K-Interface |
| 17 | RXD | Digital Output K-Interface |
| 18 | VTU | Message Output Undervoltage Detection |
| 19 | NVTA | Message Output Autarky Detection |
| 20 | VREF | +5V Output (60mA) |
| 21 | VH | +6V Output |
| 22 | VCC | +5V Output (200mA) |
| 23 | K | Bidirectional K-Interface |
| 24 | VM | Measurement Input Undervoltage- and Autarky Detection |
| 25 | VMR | Measurement Input Undervoltage- and Autarky Detection |
| 26 | VA1x | Setpoint Assignment VA1 |
| 27 | VB | Supply during autarky mode |
| 28 | n.c. | |
| 29 | n.c. | |
| 30 | VA | Voltage VA |
| 31 | VFP | +12V Tri-state Output (30mA) |
| 32 | VHL | Attachment Inductance for Step-down Regulator |
| 33 | VA1 | VBAT+2V...+48V Output |
| 34 | VBL | Attachment Inductance for Boost Converter |
| 35 | PGND | Ground |
| 36 | NFL | 200mA Low-side Driver Output |
| 37 | NAKS | 30mA Low-side Driver Output |
| 38 | NCRD | 30mA Low-side Driver Output |
| 39 | CRA | 50mA High-side Driver Output |
| 40 | HD | Tri-state Output, Low-side Driver |
| 41 | TFL | Trigger Input for Output NFL |
| 42 | PFL | Message Output for Pin NFL |
| 43 | PAKS | Message Output for Pin NAKS |
| 44 | PCRA | Message Output for Pin CRA |

## ABSOLUTE MAXIMUM RATINGS

Values beyond which damage may occur; device operation is not guaranteed.

| Item | Symbol | Parameter | Conditions | Fig. | Min. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| G001 | V() | Voltage at COS, TWD, VBG, RSET, RXD, TXD, TFP, TAKS, TFL, TCRD, TCRA, PFL, PAKS, PCRD, PCRA, NRES, NVTA, VTU, NRHD, VVA | V() ≤ VCC+ 0.3V | | -0.3 | 5.5 | V |
| G002 | I() | Current in Pins COS, TWD, VBG, RSET, RXD, TXD, TFP, TAKS, TFL, TCRD, TCRA, PFL, PAKS, PCRD, PCRA, NRES, NVTA, VTU, NRHD, VVA | | | -10 | 10 | mA |
| G003 | ESD | ESD Susceptibility at VM, VMR, VHL | MIL-STD-883, Method 3015.7 HBM 100pF discharged through 1.5kΩ | | | 0.8 | kV |
| G004 | ESD | ESD Susceptibility at all other Pins | MIL-STD-883, Method 3015.7 HBM 100pF discharged through 1.5kΩ | | | 1.4 | kV |
| G201 | V(NAKS) | Voltage at NAKS | | | -1.2 | 48 | V |
| G202 | I(AKS) | Current in NAKS | | | -30 | 30 | mA |
| G401 | V(ENA) | Voltage at ENA | | | -0.3 | 48 | V |
| G402 | I(ENA) | Current in ENA | | | -4 | 4 | mA |
| G501 | V(VHL) | Voltage at VHL | V(VHL) ≤ V(VA1) | | -1.4 | 48 | V |
| G502 | I(VHL) | Current in VHL | | | -600 | 10 | mA |
| G503 | V(VH) | Voltage at VH | V(VH) ≥ V(VCC)<br>V(VH) ≥ V(VREF) | | -0.3 | 7 | V |
| G504 | I(VH) | Current in VH | | | -6 | 600 | mA |
| G505 | V(VH) | Voltage at VH | V(VH) ≥ V(VCC)<br>V(VH) ≥ V(VREF), I < 50mA | | -0.3 | 10 | V |
| G601 | V(VCC) | Voltage at VCC | V(VCC) ≤ V(VH) | | -0.3 | 5.5 | V |
| G602 | I(VCC) | Current in VCC | | | -300 | 10 | mA |
| G701 | V(VREF) | Voltage at VREF | V(VREF) ≤ V(VH) | | -0.3 | 5.5 | V |
| G702 | I(VREF) | Current in VREF | | | -100 | 10 | mA |
| G901 | V(VFP) | Voltage at VFP | | | -0.3 | 12.5 | V |
| G902 | I(VFP) | Current in VFP | | | -40 | 6 | mA |
| GA01 | V(VA1) | Voltage at VA1 | | | -0.3 | 48 | V |
| GA02 | I(VA1) | Current in VA1 | | | -1600 | 10 | mA |
| GA03 | V(VA1x) | Voltage at VA1x | | | -0.3 | 7 | V |
| GA04 | I(VA1x) | Current in VA1x | | | -4 | 4 | mA |
| GA05 | V(VBL) | Voltage at VBL | | | -0.3 | 48 | V |
| GA06 | I(VBL) | Current in VBL | | | -10 | 1600 | mA |
| GB01 | V(K) | Voltage at K | | | -8.8 | 48 | V |
| GB02 | I(K) | Current in K | | | -6 | 200 | mA |
| GC01 | V(HD) | Voltage at HD | | | -0.3 | 48 | V |
| GC02 | I(HD) | Current in HD | | | -4 | 4 | mA |
| GD01 | V(NFL) | Voltage at NFL | applied via lamp of 2W | | -1.2 | 48 | V |
| GD02 | I(NFL) | Current in NFL | | | -200 | 200 | mA |
| GG01 | V(VA) | Voltage at VA | | | -0.3 | 48 | V |
| GG02 | I(VA) | Current in VA | V(VA, VB)< 3V, t< 2s | | -20 | 500 | mA |

All voltages are referenced to ground unless otherwise noted.
All currents into the device pins are positive; all currents out of the device pins are negative.

## ABSOLUTE MAXIMUM RATINGS

Values beyond which damage may occur; device operation is not guaranteed.

| Item | Symbol | Parameter | Conditions | Fig. | Min. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| GG03 | V(VB) | Voltage at VB | | | -0.3 | 48 | V |
| GG04 | I(VB) | Current in VB | V(VA, VB)< 3V, t< 2s | | -500 | 50 | mA |
| GG05 | Imax(VB) | Max. Current Load at VB during Autarky Case | VA1< 30.6V, CVB< 120µF, RVB> 9.5Ω | | -200 | 0 | mA |
| GH01 | V(NCRD) | Voltage at NCRD | | | -1.2 | 48 | V |
| GH02 | I(NCRD) | Current in NCRD | | | -30 | 30 | mA |
| GI01 | V(CRA) | Voltage at CRA | | | -8.8 | 48 | V |
| GI02 | I(CRA) | Current in CRA | | | -50 | 50 | mA |
| GP01 | V(VM) | Voltage at VM | via 511Ω | | -1.5 | 48 | V |
| GP02 | I(VM) | Current in VM | | | -55 | 20 | mA |
| GP03 | V(VMR) | Voltage at VMR | via 511Ω | | -1.5 | 48 | V |
| GP04 | I(VMR) | Current in VMR | | | -55 | 20 | mA |
| GP05 | I(VM) | Current in VM | t < 100ms | | -160 | 20 | mA |
| GP06 | I(VMR) | Current in VMR | t < 100ms | | -160 | 20 | mA |
| TG1 | Tj | Junction Temperature | | | -40 | 125 | °C |
| TG2 | Ts | Storage Temperature Range | | | -40 | 125 | °C |
| TG3 | Tl | Lead Temperature | soldering, 10sec | | | 260 | °C |

## THERMAL DATA

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|
| T001 | Ta | Operating Ambient Temperature Range | | | -40 | | 95 | °C |
| T002 | Rthja | Thermal Resistance Chip / Ambient | | | | 40 | | K/W |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Total Device** | | | | | | | | | |
| 1 | I(VA1) | Supply Current in VA1 | outputs passive, VA1= 30V, VH= 6V | | | 8 | 3 | 52 | mA |
| 002 | I(VH) | Supply Current in VH | in-/outputs passive, VA1= 30V, VH= 6V | | | 25 | 5 | 75 | mA |
| 003 | I(KL, KLR) | Supply Current in KL, KLR | in-/outputs passive, switching regulator active, V(KL, KLR)= 12V | | | 8 | 12 | 16 | mA |
| 004 | I(KL, KLR) | Supply Current in KL, KLR | in-/outputs passive, switching regulator active, V(KL, KLR)= 6.5V | | | 20 | 25 | 32 | mA |
| 5 | I(KL, KLR) | Supply Current in KL, KLR | no external capacitance at VA1, VA, VB; ENA= lo, V(KL, KLR) < 18V | | | | | 100 | µA |
| 006 | Rpu() | Pull-up Resistor to VCC at Inputs TWD, TXD, NRHD, NRES, NVTA, VTU | | 27 | | 5.4 | 9.1 | 15.4 | kΩ kΩ |
| 7 | Rpd() | Pull-down Resistor to GND at Inputs TFP, TAKS, TFL, TCRD, TCRA | for TFP test mode= lo | 27 | | 8.8 | 14.7 | 24.6 | kΩ kΩ |
| 8 | Vpu() | Pull-up Voltage to VCC at Inputs TWD, TXD, NRHD, NRES, NVTA, VTU | Vpu()= V()- VCC; I()= -10..10µA | | | -0.3 | | | V |
| 9 | Vpd() | Pull-down Voltage to GND at Inputs TFP, TAKS, TFL, TCRD, TCRA | I()= -10..10µA, for TFP test mode= lo | | | | | 0.3 | V |
| 10 | Vt()hi | Threshold Voltage hi at Inputs TWD, TXD, TFP, TAKS, TFL, TCRD, TCRA, NRHD, NRES, NVTA, VTU | | | | | | 67 | %VCC |
| 11 | Vt()lo | Threshold Voltage lo at Inputs TWD, TXD, TFP, TAKS, TFL, TCRD, TCRA, NRHD, NRES, NVTA, VTU | | | | 33 | | | %VCC |
| 12 | Vt()hys | Hysteresis at Inputs TWD, TXD, TFP, TAKS, TFL, TCRD, TCRA, NRHD, NRES, NVTA, VTU | Vt()hys= Vt()hi- Vt()lo | | | 500 | | | mV |
| 13 | Vs()lo | Saturation Voltage lo at Outputs NRES, NVTA, VTU, RXD, PFL, PAKS, PCRD, PCRA | I()= 1.6mA, outputs lo | | | | | 0.4 | V |
| 14 | Vs()hi | Saturation Voltage hi vs. VCC at Outputs RXD, PFL, PAKS, PCRD, PCRA | Vs()= V()- VCC; I()= -1mA, outputs hi | | | -0.8 | | | V |
| 15 | Isc() | Short-circuit Current in Outputs NRES, NVTA, VTU, HD | V()= VCC, pins= lo, V(HD)= VA1 | 27 | | | 10 | 30 | mA mA |
| 16 | tsup() | Permissible Spurious Pulse Width at Inputs TWD, TXD, TFP, TAKS, TFL, TCRD, TCRA, NRHD, NRES, NVTA, VTU | no switching triggered | | | | | 40 | ns |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Total Device (continued)** | | | | | | | | | |
| 17 | Vc()lo | ESD Clamp Voltage lo at COS, TWD, VBG, RSET, AGND, RXD, TXD, NRES, NVTA, VTU, VM, VMR, TFP, TFL, PFL, VH, VREF, VCC, ENA, TAKS, PAKS, TCRD, TCRA, PCRD, PCRA, NRHD, VVA, HD, VA1x, VA, VB | against GND, I()= -10mA | | | -1.4 | | -0.3 | V |
| 18 | Vc()lo | ESD Clamp Voltage lo at NFL, VHL, VFP, VA1, VBL, NCRD, NAKS | against PGND, I()= -10mA | | | -1.4 | | -0.3 | V |
| 19 | Vc()lo | ESD Clamp Voltage lo at K | against GND, I()= -10mA | | | -15 | | -5.5 | V |
| 20 | Vc()lo | ESD Clamp Voltage lo against PGND at CRA | against PGND, I()= -10mA | | | -15 | | -5.5 | V |
| 21 | Vc()hi | ESD Clamp Voltage hi at COS, TWD, VBG, RSET, AGND, RXD, TXD, NRES, NVTA, VTU, VREF, VCC, VH, VA1x, VVA, TAKS, PAKS, TFL, PFL, TCRD, TCRA, PCRD, PCRA, NRHD | against GND, I()= 10mA | | | 5.5 | | 14 | V |
| 22 | Vc()hi | ESD Clamp Voltage hi at TFP | against GND, I()= 10mA | | | 5.5 | | 16 | V |
| 023 | Vc()hi | ESD Clamp Voltage hi at VFP | against PGND, I()= 10mA | | | 12.5 | | 28 | V |
| 24 | Vc()hi | ESD Clamp Voltage hi at CRA, NCRD, K, VM, VMR, NFL, NAKS, VHL, VA1, VBL, VA, VB, ENA, HD | against PGND, I()= 10mA | 27 | | 48 | 52 | 60 | V |
| 25 | tTHL | Fall Time at RXD, PFL, PAKS, PCRD, PCRA, NRES, NVTA, VTU | CL= 75pF<br>V(): hi= 80% → lo= 20% VCC | | | | | 60 | ns |
| 026 | tTHL | Rise Time at<br>RXD, PFL, PAKS, PCRD, PCRA | CL= 75pF<br>V(): lo= 20% → hi= 80% VCC | | | | | 80 | ns |
| 27 | V() | Permissible Voltage at VA1, VA, VB, VBL | | | | | | 48 | V |
| **Reference and Bias** | | | | | | | | | |
| 101 | V(VBG) | Voltage at VBG | CVBG= 10..200nF | 27 | | 2.36 | 2.44 | 2.52 | V<br>V |
| 102 | V(RSET) | Voltage at RSET | R(RSET/AGND)= 10kΩ ±1% | 27 | | 2.36 | 2.44 | 2.52 | V<br>V |
| **30mA Low-side Driver** | | | | | | | | | |
| 201 | VsNAKS | Saturation Voltage at NAKS | I(NAKS)= 30mA, T < Tab,<br>TAKS= hi, NAKS= lo | | | | | 1 | V |
| 202 | IscNAKS | Short-circuit Current in NAKS | V(NAKS) < 18V, T < Tab,<br>TAKS= hi, NAKS= lo | 27 | | | 65 | 200 | mA<br>mA |
| 203 | IpdNAKS | Pull-down Current in NAKS | V(NAKS)= 2..16.5V,<br>TAKS= lo | | | 25 | | 100 | µA |
| 204 | VtNAKS | Switching Threshold at NAKS for PAKS | | | | 2.25 | | 2.75 | V |
| 205 | VfNAKS | Free-wheeling Voltage at NAKS | I(NAKS)= 10mA,<br>TAKS= lo, NAKS= hi | | | 48 | | | V |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Thermal Shutdown** | | | | | | | | | |
| 301 | Toff | Thermal Shutdown Threshold for NFL, NAKS, CRA, NCRD, K | | | | 135 | | 160 | °C |
| 302 | Ton | Thermal Lock-on Threshold for NFL, NAKS, CRA, NCRD, K | | | | 110 | | 145 | °C |
| 303 | Thys | Temperature Hysteresis Thys= Toff- Ton | | | | | 12 | | °C |
| **Standby** | | | | | | | | | |
| 401 | V(ENA)lo | Lower Enable Threshold | | | | 2 | | | V |
| 402 | V(ENA)hi | Upper Enable Threshold | | | | | | 4 | V |
| 403 | VENAhys | Hysteresis Enable Input | | | | 80 | | 800 | mV |
| 404 | V(ENA) | Permissible Voltage at ENA | | | | | | 48 | V |
| 405 | Ipd(ENA) | Pull-down Current in ENA | V(ENA)= 2..48V | | | 5 | | 50 | µA |
| **VH-Switching Regulator** | | | | | | | | | |
| 501 | VHn | Voltage at VH | LVH= 150µH±20%..470µH±20%, CVH= 33µF ±20%, Ri(LVH) < 1.1Ω, I(VH)= -200..0mA | 27 | | 5.6 | 6 | 6.3 | V V |
| 502 | Ia(VHL) | Max. DC cutoff Current in VHL | VH < VHn | | | -800 | -500 | | mA |
| 503 | Vs(VHL) | Saturation Voltage at VHL | Vs()= V(VA1)- V(VHL); I(VHL)= -300mA | | | | | 1.3 | V |
| 504 | Vf(VHL) | Free-wheeling Diode Forward Voltage | Vf()= V(GND)- V(VHL); I(VHL)= -300mA | | | | | 1.4 | V |
| 505 | Ilk(VHL) | Leakage Current in VHL | VHL= lo, V(VHL)= 0V..VA1 | | | -100 | | 100 | µA |
| 506 | ηVH | VH-Switching Regulator Efficiency | I(VH)= -200..-20mA | | | 70 | | | % |
| **Regulator VCC** | | | | | | | | | |
| 601 | VCCn | Voltage at VCC | I(VCC)= -200..0mA, VH= 5.6..6.3V, CVCC ≥ 4.7µF ±30% | | | 4.85 | | 5.15 | V |
| 602 | CVCC | Permissible Capacitance at VCC to AGND | Tolerance ±30% | | | 3.3 | | | µF |
| 603 | RiCVCC | Permissible Internal Resistance of Capacitor at VCC | | | | | | 10 | Ω |
| 604 | dVCCoff | Turn-off Threshold Over- and Undervoltage \|VCCoff - VCCn\| for NRES= lo | | | | | | 200 | mV |
| 605 | dVCCon | Turn-on Threshold Over- and -Undervoltage | dVCCon= \|VCCon - VCCn\|, NRES= hi | | | 40 | | | mV |
| 606 | dVCCres | Hysteresis of Turn-un and Turn-off Threshold at VCC | dVCCres= \|VCCon - VCCoff\| | | | 40 | | | mV |
| 607 | tl(NRES) | Reset Pulse Width lo at NRES | Triggered by VCC | | | 6.8 | | | µs |
| 608 | Vr(VCC) | Voltage Ratio VCC / VREF | I(VCC)= 0..200mA | | | 0.99 | | 101 | |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Regulator VREF** | | | | | | | | | |
| 701 | VREFn | Voltage at VREF | I(VREF)= -60..0mA,<br>VH= 5.6..6.3V,<br>CVREF ≥ 1µF ±30% | | | 4.9 | | 5.1 | V |
| 702 | CVREF | Permissible Capacitor at VREF to AGND | tolerance ±30% | | | 1 | | | µF |
| 703 | RiCVREF | Permissible Internal Resistance of Capacitor at VREF | | | | | | 10 | Ω |
| 704 | dVREFoff | Turn-off Threshold Over- and Undervoltage | dVREFoff= \|VREFoff - VREFn\|,<br>NRES= lo | | | | | 200 | mV |
| 705 | dVREFon | Turn-on Threshold Over- and Undervoltage | dVREFon= \|VREFon - VREFn\|,<br>NRES= hi | | | 40 | | | mV |
| 706 | dVREFres | Hysteresis of Turn-on and Turn-off Threshold at VREF | dVREFres= \|VREFon-VREFoff\| | | | 20 | | | mV |
| 707 | tl(NRES) | Reset Pulse Width lo at NRES | Triggered by VREF | | | 6.8 | | | µs |
| 708 | Vf | Forward Voltage Discharging Diode between VREF and VCC | I()= 20mA | | | | | 1.2 | V |
| **VFP-Regulator** | | | | | | | | | |
| 901 | V(VFP) | Voltage at VFP | I(VFP) ≤ -30mA,<br>VA1 > 15V, TFP= hi | <br>27 | | 11.5 | <br>12 | 12.5 | V<br>V |
| 902 | Isc(VFP) | Short-circuit Current in VFP | V(VFP) < 11.5V, TFP= hi | <br>27 | | -200 | <br>-90 | | mA<br>mA |
| 903 | Ilk(VFP) | Leakage Current in VFP | V(VFP)= 0..10V, TFP= lo | | | -10 | | 10 | µA |
| 904 | Ilk(VFP) | Leakage Current in VFP | V(VFP)= 10..12.5V, TFP= lo | | | -10 | | 250 | µA |
| 905 | tsu(VFP) | Settle Time at VFP | V(VFP)= 12V ±0.5V | | | | | 10 | µs |
| **Boost Converter** | | | | | | | | | |
| A01 | VA1n | Voltage at VA1 | VB= 14V, LVB= 150µH ±20%,<br>Ri(LVB) < 1Ω, I(VA1)= -200..0mA | | | 28.4 | | 30.6 | V |
| A02 | VA1n | Voltage at VA1 | VB= 5V, I(VA1)= -25..0mA | | | 28.4 | | 30.6 | V |
| A03 | VA1n | Voltage at VA1 | VB= 6.5V, I(VA1)= -60mA | | | 284 | | 306 | V |
| A04 | VA1 | Voltage at VA1 | VB= 6.5V, I(VA1)= -120mA | | | 190 | | 306 | V |
| A05 | VA1 | Voltage at VA1 | VB= 6.5V, I(VA1)= -200mA | | | 14.0 | | 30.6 | V |
| A06 | Ico(VBL) | DC Cutoff Current in VBL | V(VA1) < 28.5V | | | | 1 | | A |
| A07 | Vs(VBL) | Saturation Voltage at VBL | VBL= lo, I(VBL)= 600mA | | | | | 1 | V |
| A08 | Vf(VBL) | Forward Voltage Free-wheeling Diode | Vf()= V(VBL) - V(VA1);<br>VBL= hi, I(VBL)= 20mA | | | | | 1.1 | V |
| A09 | Vf(VBL) | Forward Voltage Free-wheeling Diode | Vf()= V(VBL) - V(VA1);<br>VBL= hi, I(VBL)= 600mA | | | | | 1.4 | V |
| A10 | ηVA1 | Efficiency of VA1-Regulator | VB= 5V, V(VA1) > 28.5V | | | 50 | | | % |
| A11 | ηVA1 | Efficiency of VA1-Regulator | VB= 6.5V, V(VA1) > 28.5V | | | 65 | | | % |
| A12 | ηVA1 | Efficiency of VA1-Regulator | VB= 18V, V(VA1) > 28.5V | | | 80 | | | % |
| A13 | Ilk(VBL) | Leakage Current in VBL | V(VBL)= 0V..VA1, VBL= hi | | | -100 | | 100 | µA |
| A14 | Vr(VA1) | Voltage Ratio V(VA1) / V(VREF) | internal VA1-voltage divider | <br>27 | | 5.7 | <br>5.9 | 6.1 | |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Boost Converter (continued)** | | | | | | | | | |
| A15 | Ipu(VA1x) | Pull-Up Current in VA1x | V(VA1x) < 1V | 27 | | -25 | -5 | -1 | µA µA |
| A16 | Vr(VA1x) | Transformation Ratio with external Voltage Divider R(VA1/VA1x) / R(VA1x/AGND) | V(VA1)= (1+R(VA1/VA1x) / R(VA1x/AGND)) × V(VBG), R(VA1x/AGND)= 1..5k, V(VA1)= V(VB)..48V | | | 2 | | 18 | |
| **K-Interface** | | | | | | | | | |
| B01 | Vs(K) | Saturation Voltage at K | I(K)= 15.7mA, TXD= lo, T < Tab | | | | | 1.4 | V |
| B02 | Vs(K) | Saturation Voltage at K | I(K)= 32.4mA, TXD= lo, T < Tab | | | | | 1.7 | V |
| B03 | Isc(K) | Short-circuit Current in K | V(K)= 2..27V, TXD= lo, t < 100ms | 27 | | | 60 | 150 | mA mA |
| B04 | C(K) | Permissible Input Capacitance K | | | | | | 25 | pF |
| B05 | Ipu(K) | Pull-Up Current in K | V(KL, KLR)= 8..16.5V, V(K)= 0.2V..V(KL, KLR)-1V V(VA1) > V(VM) + 2V, TXD= hi | | | -80 | | -20 | µA |
| B06 | Vt(K) | Switching Threshold at K related to Maximum V(KL, KLR) | V(KL, KLR)= 6..16.5V, TXD= hi | | | 45 | | 55 | % |
| B07 | Vt(K) | Switching Threshold at K during Autarky | V(KL, KLR) < 5.5V | 27 | | 54 | 60 | 66 | %VCC %VCC |
| B08 | Vhys(K) | Hysteresis at K | V(KL, KLR)= 6..16.5V or Autarky | | | 50 | | 300 | mV |
| B09 | tf(K) | Fall Time at K | R(KLR/K)= 511Ω, CK < 5nF, V(K) from hi= 80% → lo= 20% V(KLR), TXD from hi to lo | | | | | 2 | µs |
| B10 | In(K) | Current in K | V(K)= -3V, TXD= hi | | | -8 | | | mA |
| B11 | Ilk(K) | Leakage Current in K | V(K) > KL, KLR, TXD = hi, V(K) < 27V, VM, VMR > 0V | | | -20 | | 20 | µA |
| B12 | Vf(K) | Free-wheeling Voltage at K | I(K)= 10mA, TXD= hi | | | 48 | | | V |
| B13 | Vpu(K) | Pull-up Current at K against V(VM, VMR) | I(K)= -20µA, TXD= hi, V(VM), V(VMR)= 8..16.5V V(VA1) > V(VM) + 2V | | | -0.3 | | 0.3 | V |
| B14 | tp(K) | Transmission Delay K → RXD | f ≤ 200kHz, V(K) from 25% → 75% V(VM, VMR) | | | | 6 | 2 | µs |
| B15 | tp(K) | Transmission Delay TXD→K | f ≤ 200kHz, V(K) from 75% → 25% V(VM, VMR) | | | | 4 | 2 | µs |
| B16 | dtp(K) | Transmission Delay Difference K → RXD, K lo → hi to K hi → lo | f ≤ 200kHz, V(K) from 25% → 75% V(VM, VMR) | | | | | 1 | µs |
| B17 | tf(K) | Fall Time at K | R(KLR/K)= 511Ω,, CK< 10nF, V(K) from hi= 80% → lo= 20% V(KLR), TXD from hi to lo | | | | | 1 | µs |
| **Watchdog** | | | | | | | | | |
| C01 | tl(NRES) | Reset Pulse Width lo at NRES | triggered by watchdog | | | 6.5 | | 8.9 | µs |
| C02 | Tu(TWD) | Lower TWD Period for Reset | | 27 | | 404 | 480 | 558 | µs µs |
| C03 | To(TWD) | Upper TWD Period for Reset | | 27 | | 652 | 770 | 885 | ms ms |
| C04 | tp(TWD) | Permissible Pulse Width at TWD | TWD detection at lo pulse | | | 18 | | 649.9 | ms |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Watchdog (continued)** | | | | | | | | | |
| C05 | tt(TWD) | Permissible Spurious Pulse Width at TWD | no TWD detection at lo pulse | | | | | 6.5 | µs |
| C06 | Ilk(HD) | Leakage Current in HD | V(HD)= 0V..VA1, NRHD= lo | | | -10 | | 10 | µA |
| C07 | Vs(HD)lo | Saturation Voltage lo at Output HD | I()= 1.6mA, output lo | | | | | 0.5 | V |
| **200mA Low-side Driver** | | | | | | | | | |
| D01 | Vs(NFL) | Saturation Voltage at NFL | I(NFL)= 100mA, TFL= hi, NFL= lo, T < Tab | | | | | 1 | V |
| D02 | Vs(NFL) | Saturation Voltage at NFL | I(NFL)= 200mA, TFL= hi, NFL= lo, T < Tab | | | | | 2 | V |
| D03 | Isc(NFL) | Short-circuit Current in NFL | V(NFL) < 18V, TFL= hi, NFL= lo, T < Tab | 27 | | | 300 | 500 | mA mA |
| D04 | Isc(NFL) | Short-circuit Current in NFL | V(NFL) < 18V, T < Tab, no supply voltage | 27 | | | 300 | 500 | mA mA |
| D05 | Vt(NFL) | Threshold Voltage at NFL | | | | 2.25 | | 2.75 | V |
| D06 | Ipd(NFL) | Pull-down Current in NFL | V(NFL)= 2..16.5V,TFL= lo, NFL= hi | | | 0.25 | | 1 | mA |
| D07 | Vs(NFL) | Saturation Voltage at NFL | I(NFL)= 100mA, T < Tab, without supply voltage | | | | | 3.5 | V |
| D08 | Vs(NFL) | Saturation Voltage at NFL | I(NFL)= 200mA, T < Tab, without supply voltage | | | | | 4 | V |
| D09 | Vf(NFL) | Free-wheeling Voltage at NFL | I(NFL)= 10mA, TFL= lo, NFL= hi | | | 48 | | | V |
| D10 | Vf(NFL) | Free-wheeling Voltage at NFL | I(NFL)= 200mA, TFL= lo, NFL= hi | | | 48 | | | V |
| **Autarky** | | | | | | | | | |
| G01 | II(VA) | Charging Current from VA1 to VA | V(VA)= 0..V(VA1)- 2V | 27 | | -33 | -30 | -27 | mA mA |
| G02 | Vs(VA) | Saturation Voltage at VA | I(VA)= -2mA, V(VA1) - V(VA) | | | | | 0.2 | V |
| G03 | Vs(VB) | Saturation Voltage VB referred to VA | Vs()= V(VA)- V(VB); I(VB)= -500..0mA, LSA= on | | | | | 3 | V |
| G04 | Ilk(VB) | Leakage Current in VB | V(VA) > V(VB), LSA= off | | | -100 | | | µA |
| G05 | Iilk(VB) | Inverse Leakage Current in VB | V(VB)- V(VA)= 0..5V, LSA= off | | | | | 40 | mA |
| G06 | V(VVA) | Output Voltage at VVA related to V(VA) | I(VVA)= -10..10µA, V(VVA)= 0.6V..VREF- 0.1V | 27 | | 12 | 12.5 | 13 | % % |
| G07 | Isc(VVA) | Short-circuit Current in VVA | V(VVA)= 0V..VREF | | | -1 | | 10 | mA |
| G08 | VAmini | Minimal Discharge Voltage at VA at Test-Discharging by NVTA | internal VA1-voltage divider, VA1x against GND | 27 | | 20 | 21 | 22 | V |
| G09 | Vvalo | Lower Turn-off Threshold of Converter | | | | 5.5 | | | V |
| G10 | Vvahi | Upper Turn-off Threshold of Converter | | | | | | 7 | V |
| G11 | Vhys | Hysteresis Turn-off Threshold | Vhys= Vvahi- Vvalo | | | 0.2 | | 1 | V |
| G12 | VAminx | Minimal Discharge Voltage at VA at Test-Discharging by NVTA | external VA1-voltage divider | 27 | | 66 | 71 | 76 | %VA1 %VA1 |
| G13 | Imax (VA,VB) | Maximal Current Load at VA during Autarky | VA1 < 30.6V, CVB < 120µF, RVB > 9.5 | | | | | 200 | mA |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **30mA Low-side Driver** | | | | | | | | | |
| H01 | Vs(NCRD) | Saturation Voltage at NCRD | I(NCRD)= 10mA, TCRD= hi, T < Tab | | | | | 0.5 | V |
| H02 | Vs(NCRD) | Saturation Voltage at NCRD | I(NCRD)= 30mA, TCRD= hi, T < Tab | | | | | 1.5 | V |
| H03 | IscNCRD | Short-circuit Current in NCRD | V(NCRD) < 18V, TCRD= hi, T < Tab | 27 | | | 65 | 200 | mA mA |
| H04 | IpdNCRD | Pull-down Current in NCRD | V(NCRD)= 2..16.5V, TCRD= lo | | | 25 | | 100 | µA |
| H05 | Vt(NCRD) | Switching Threshold at NCRD | | | | 2.25 | | 2.75 | V |
| H06 | Vf(NCRD) | Free-wheeling Voltage at NCRD | I(NCRD)= 10mA, TCRD= lo, NCRD= hi | | | 48 | | | V |
| H07 | tlh(NCRD) | Rise Time at NCRD | R(KLR/NCRD)= 1k, V(NCRD) from lo= 10% → hi= 90% V(KL, KLR) | | | | | 10 | µs |
| H08 | thl(NCRD) | Fall Time at NCRD | R(KLR/NCRD)= 1k, CNCRD < 50nF, V(NCRD) from lo= 90% → hi= 10%, V(KL, KLR) | | | | | 20 | µs |
| H09 | tf(NCRD) | Requested Turn-on Duration at NCRD | TCRD= hi, T > Tab, Vs(NCRD) > 2.75V | | | 16.2 | | 31.2 | µs |
| **50mA High-side Driver** | | | | | | | | | |
| I01 | Vs(CRA) | Saturation Voltage hi at CRA against VB | Vs()= V(VB)- V(CRA), I(CRA)= -50mA, V(KL, KLR)= 6..16.5V, TCRA= hi, T < Tab | | | | | 2 | V |
| I02 | Vt(CRA) | Switching Threshold at CRA related to Maximum V(KL, KLR) | V(KL, KLR)= 6..16.5V, TCRA= lo | | | 45 | | 55 | % |
| I03 | Vt(CRA) | Switching Threshold at CRA during Autarky | V(KL, KLR) < 5.5V | 27 | | 54 | 60 | 66 | %VCC %VCC |
| I04 | VhysCRA | Hysteresis at CRA | V(KL, KLR)= 6..16.5V or autarky | | | 50 | | 300 | mV |
| I05 | Vf(CRA) | Free-wheeling Voltage at CRA | I(CRA)= 10mA, TCRA= lo, VB open | | | 48 | | | V |
| I06 | Ipu(CRA) | Pull-up Current in CRA | V(CRA) < VB- 2V, TCRA= lo | | | -100 | | -25 | µA |
| I07 | Isc(CRA) | Short-circuit Current in CRA | V(CRA) < 18V, TCRA= hi, T < Tab | 27 | | -200 | -100 | | mA mA |
| I08 | Ir(CRA) | Inverse Current in CRA | V(CRA) > V(B), TCRA= lo | | | | | 50 | mA |
| I09 | tf(CRA) | Requested Turn-on Duration at CRA | TCRA= hi, Vs(CRA) > 2V, T > Tab | | | 16.2 | | 31.2 | µs |
| **Oscillator** | | | | | | | | | |
| J01 | fos | Oscillator Frequency | COS= 680pF ±5%, VA1 > 4.2V | 27 | | 110.5 | 130 | 149.5 | kHz kHz |

## ELECTRICAL CHARACTERISTICS

Operating conditions: +VBAT= 6..16.5V, PGND= GND, COS= 680pF,
RSET= 10kΩ, RKL= 511Ω, RKLR= 511Ω, Tj= -40..125°C, unless otherwise noted

| Item | Symbol | Parameter | Conditions | Tj °C | Fig. | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| **Autarky Detection** | | | | | | | | | |
| P01 | Ri() | Input Resistance at VM, VMR | | 27 | | 50 | 100 | 220 | kΩ kΩ |
| P02 | Vvtulo | Lower Undervoltage Threshold at KL, KLR | RKL= RKLR= 511Ω ±1% | 27 | | 8.75 | 9 | | V V |
| P03 | Vvtuhi | Upper Undervoltage Threshold at KL, KLR | RKL= RKLR= 511Ω ±1% | 27 | | | 10 | 10.3 | V V |
| P04 | Vhys | Hysteresis Undervoltage Detection | Vhys= Vvtuhi- Vvtulo | 27 | | 0.8 | 1 | 1.2 | V V |
| P05 | Vautlo | Lower Autarky Threshold at KL, KLR | RKL= RKLR= 511Ω ±1% | | | 5.5 | | | V |
| P06 | Vauthi | Upper Autarky Threshold at KL, KLR | RKL= RKLR= 511Ω ±1% | | | | | 6 | V |
| P07 | Vhys | Hysteresis Autarky Detection | Vhys= Vauthi- Vautlo | | | 80 | | 300 | mV |
| P08 | V(VM, VMR) | Permissible Voltage at KL, KLR | | | | | | 48 | V |
| P09 | tt(VM, VMR) | Permissible Spurious Pulse Width at VM, VMR | no undervoltage detection, no autarky detection | | | | | 6.5 | µs |

## DESCRIPTION OF FUNCTIONS

### BOOST CONVERTER

If VA1x is connected to ground, a voltage of 30V becomes available at VA1. An external voltage divider can be used to adjust voltages at VA1 from VBAT+2V to +48V. In this case the band gap voltage of 2.44V is present

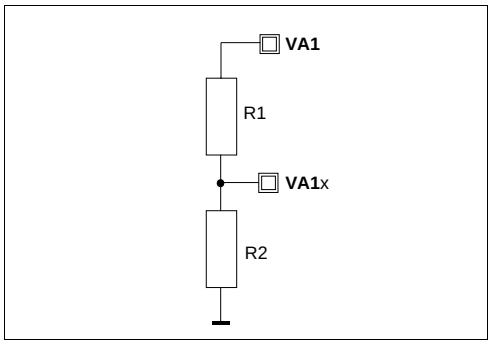



Figure 1: Adjustment V(VA1)

at VA1x. The voltage at VA1 can be calculated via VA1= 2.44V ( (R1+R2)/R2).

### AUTARKY / LOW VOLTAGE DETECTION

To create a system with a redundant voltage supply, measurement inputs VM and VMR are connected to KL15 and KL15R respectively via a 511Ω resistor. If both supply inputs are used they need to be connected with 511Ω to VBAT. If only one of the two inputs (VM or VMR) is used the unused inputs must be connected to GND.
The system is checked for low voltage and autarky via the internal voltage dividers (at 100kΩ each). The voltage dividers are shut off in standby mode. The outputs of the two comparators for low voltage and autarky are AND-gated, meaning that a message at VTU or NVTA delayed by one clock pulse (8us) is only generated when the relevant voltage thresholds are undershot at both measurement inputs. A reset of the outputs VTU and/or NVTA via the microcontroller with a rising edge at VTU is only possible if low voltage or autarky is no longer detected.

### AUTARKY CIRCUIT / MEASUREMENT OF AUTARKY CAPACITANCE

The switch between VA and VB is closed for at least 5 clock cycles after autarky has been detected. With this, the voltage of the autarky capacitor is connected to the input of the VA1 up converter; a stable VA1 voltage can thus be maintained during autarky. At the same time the 30mA current source, which supplies current for charging the autarky capacitor, is switched off.

The voltage of the autarky capacitor can be measured at output VVA (V(VVA)= 1/8 V(VA). This serves to check whether the capacitor is charged to a suitably high voltage to sustain the system during autarky. The capacitance of the capacitor can be determined while the capacitor is being charged. The system's energy consumption can be determined during autarky.

Autarky can be simulated using NVTA as an input. If V(VA) > 21V, then the switch between VA and VB can be closed via a rising edge at NVTA. The 30mA current source is then shut down and the autarky capacitor is discharged to the level of the threshold voltage (V(VA)= 21V). This is automatically followed by the switch being opened and the current source switched on again. A second falling edge at NVTA will stop discharging the capacitor if V (VA) >21V.

**WATCHDOG**
If the watchdog is not activated within the stipulated period (500µs..800ms), a reset is triggered via NRES. The watchdog counter restarts with each falling edge at TWD. Reset pulses from the microcontroller or V(VCC) or V(VREF) not included in the specifications also reset the watchdog counter.
NRHD and HD activate external hardware in conjunction with the watchdog.
**NRDH:** CMOS input with a pull-up resistor to activate output HD**.**
**HD:** after 128 correct watchdog cycles and when pin NRHD = high, the open-drain transistor is activated (HD = low). Via NRHD = low, a reset (NRES) or false operation of the watchdog, the output is switched to tristate and can only become low again when 128 correct watchdog cycles have again occurred.

**RESET**
If V(VCC) or V(VREF) are not within specifications range or if the watchdog is operated incorrectly a reset is triggered via the open-drain output NRES. The microcontroller can also trigger a reset externally, thus resetting the watchdog and switching the indicator lamp on via NFL.

**VFP REGULATOR**
The VFP regulator provides the microcontroller with 12V programming supply voltage. When TFP= high, output VFP is activated; otherwise this output is switched to tristate.

**STANDBY**
Via input ENA a sleep mode can be set; current consumption is reduced to a minimum of 30µA approximately.

**K-Interface**
The K-Interface uses two pins that can be connected with the serial interface of the microcontroller.
TXD is used to send data via the interface. If TXD is switched from high to low then K switches from V (VM) to low. RXD switches to low if V(RXD) < V (VM)/2 (in Autarky mode RXD < 3V). If TXD is open then RXD will reflect the external voltage at K.

**TEMPERATURE MONITORING**
The K interface, indicator lamp output and NAKS output are shut off in the event of excessive temperature. The two driver outputs can be forcibly switched on with excessive temperature for a short period if they are the cause of this excessive temperature. If the level falls below that of the shutdown temperature (hysteresis) the drivers can be switched on again.

**OSCILLATOR**
The oscillator provides an internal frequency of ca. 125kHz for the switching converters, watchdog counter and autarky control.

**30mA LOW-SIDE DRIVER (NCRD)**
The low-side driver is switched on by the microcontroller via TCRD = high. A comparator at output PCRD signals the state of the digital crash output to the microcontroller.

| TCRD | PCRD | State of the Driver Output NCRD |
|---|---|---|
| low | low | Output off |
| low | high | Short circuit to ground or broken wire |
| high | low | Short circuit to KL15, KL15R |
| high | high | Output on |

**50mA HIGH-SIDE DRIVER (CRA)**
The high-side driver is switched on by the microcontroller via TCRA = high. A comparator at output PCRA signals the state of the analog crash output to the microcontroller.

| TCRA | PCRA | State of the Driver Output CRA |
|---|---|---|
| low | low | Output off |
| low | high | Short circuit vs. VBAT or broken wire |
| high | low | Short circuit to ground |
| high | high | Output on |

**200mA LOW-SIDE DRIVER (NFL)**
The low-side driver which is switched on by the microcontroller via TFL = high. It is also switched on by a flip-flop which mirrors the reset state. This flip-flop can be reset via a falling edge at TFL after the reset has ended. A comparator at output PFL signals the state of the indicator lamp output to the microcontroller. The driver is normally on when no supply voltage is available at the iC.

| TFL | PFL | State of the Driver Output |
|---|---|---|
| low | low | Output off, lamp off |
| low | high | Short circuit to ground or broken wire |
| high | low | Short circuit to KL15, KL15R |
| high | high | Output on, lamp on |

**30mA LOW-SIDE DRIVER (NAKS)**

The NAKS output is a low-side driver which is switched on by the microcontroller via TAKS= high. A comparator at output PAKS signals the state of the NAKS output to the microcontroller.

| TAKS | PAKS | State of NAKS Output |
|---|---|---|
| low | low | Output off, lamp off |
| low | high | Short circuit to ground or broken wire |
| high | low | Short circuit vs. VBAT |
| high | high | Output on |

## ORDERING INFORMATION

| Type | Package | Order designation |
|---|---|---|
| iC-JJ | MQFP44 | iC-JJ MQFP44 |

For information about prices, terms of delivery, options for other case types ec., please contact:

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