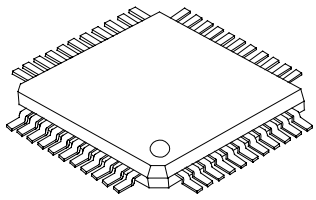
# 4-CH MOTOR DRIVER FOR PORTABLE CD PLAYERS



QFP-44-0.8

## DESCRIPTION

The UTC MM1538 contains a 4ch H bridge driver and DC-DC converter control circuit on one chip, and was developed for use in portable CD players.

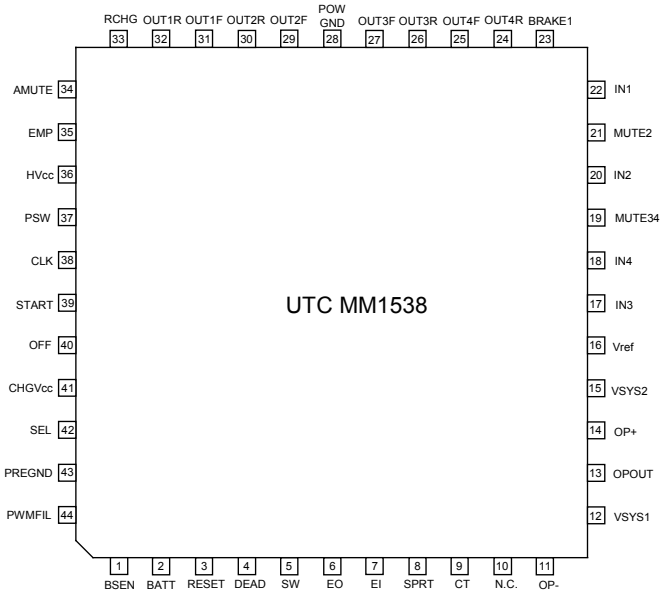
## FEATURES

*Built-in 4ch H bridge driver, and PWM control of load drive voltage is made possible by external components.
*DC-DC converter control circuit on chip.
*With reset output inversion output pin.
*Empty detection level can be switched between rechargeable battery and dry battery.
*Constant current charging; current value can be varied using external resistor.
*Built-in power transistor for charging.
*Built-in independent thermal shutdown circuit.

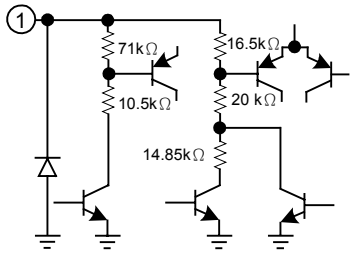
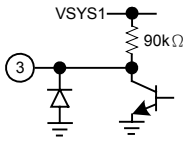
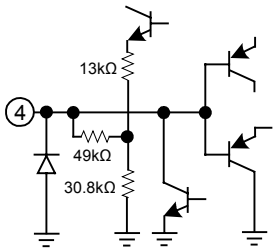
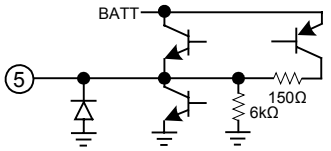
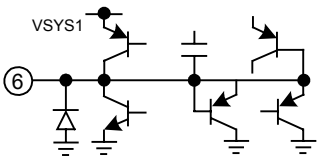
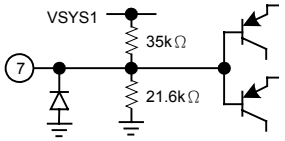
## APPLICATIONS

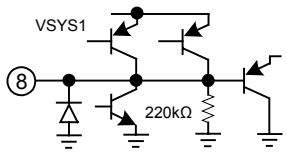
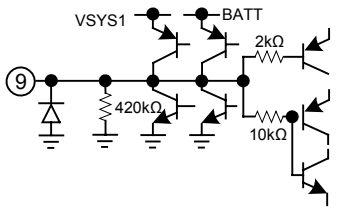
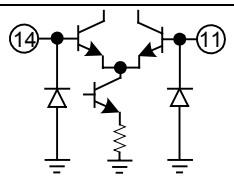
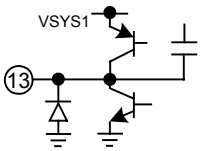
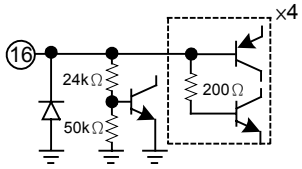
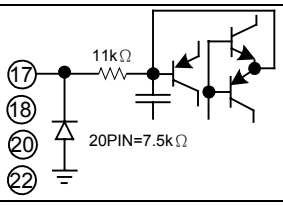
*Portable CD radio cassette recorders

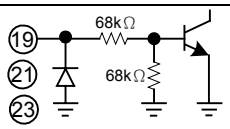
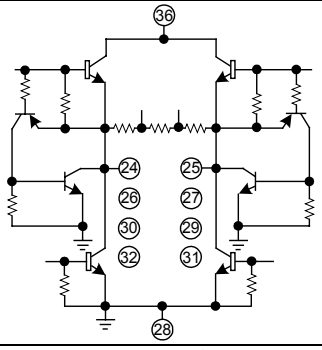
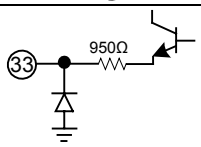
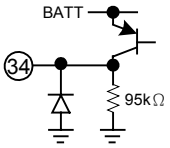
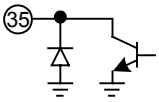
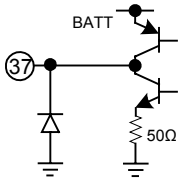
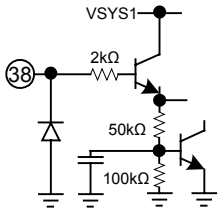
## PIN CONFIGURATION

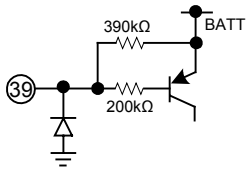
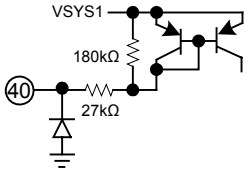
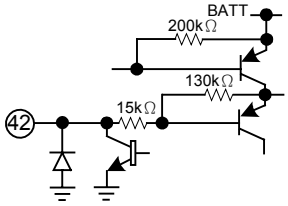
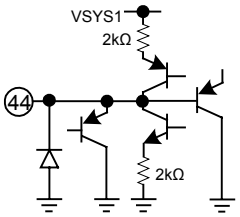


PIN DESCRIPTION

| PIN NO. | PIN NAME | INPUT/OUTPUT | FUNCTION | INTERMAL EQUIVALENT CIRCUIT |
|---|---|---|---|---|
| 1 | BSEN | Input | Battery Voltage Monitor |  |
| 2 | BATT | Input | Battery Power Supply Input | Power Supply |
| 3 | RESET | Output | Reset Detect Output |  |
| 4 | DEAD | Input | DEAD Time Setting |  |
| 5 | SW | Output | Transistor Drive For Voltage Multiplier |  |
| 6 | EO | Output | Error Amplifier Output |  |
| 7 | EI | Input | Error Amplifier Input |  |

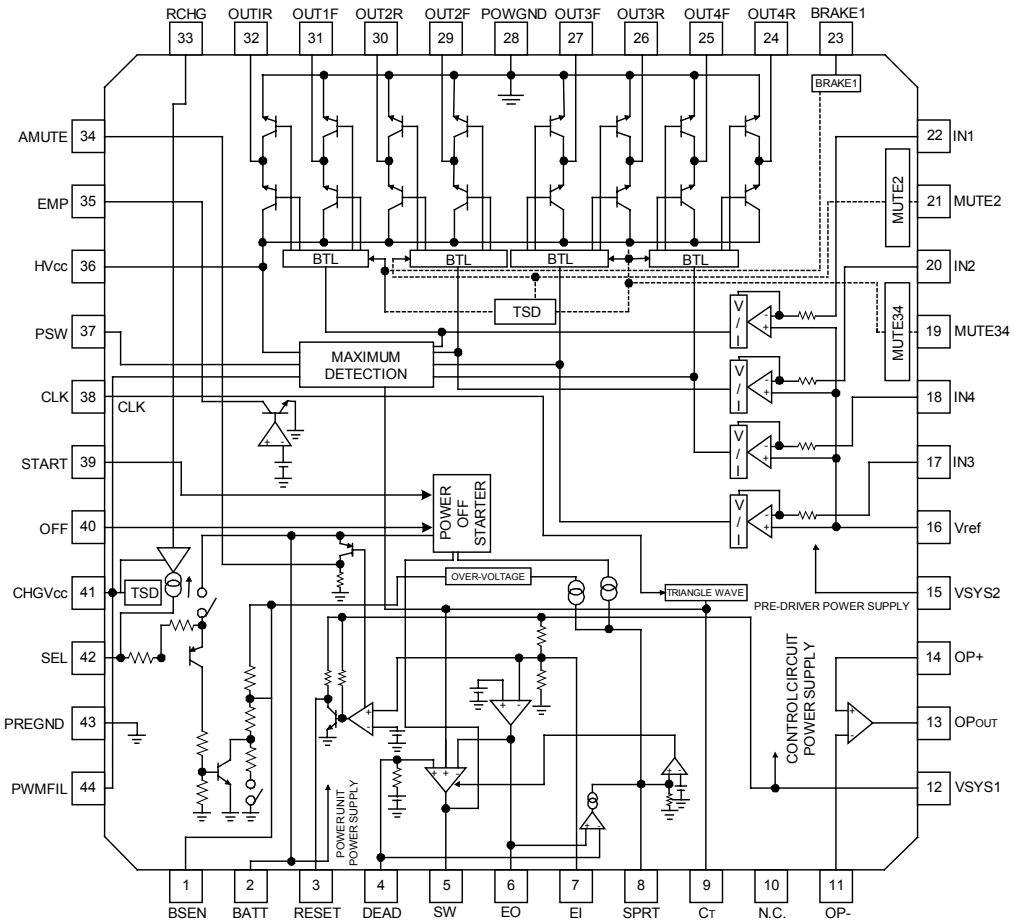
| PIN NO. | PIN NAME | INPUT/OUTPUT | FUNCTION | INTERMAL EQUIVALENT CIRCUIT |
|---|---|---|---|---|
| 8 | SPRT | Output | Short Circuit Protection Setting |  |
| 9 | CT | Output | Triangular-Wave Output |  |
| 10 | N.C. | | | |
| 11<br>14 | OP-<br>OP+ | Input | Op Amp Negative Input<br>Op Amp Positive Input |  |
| 12 | VSYS1 | Input | Control Circuit Power Supply Input | Control Circuit Power Supply |
| 13 | OPOUT | Output | Op Amp Output |  |
| 15 | VSYS2 | Input | Driver Pre-step Power Supply | Pre-Drive Power Supply |
| 16 | Vref | Input | Reference Voltage Input |  |
| 17<br>18<br>20<br>22 | IN3<br>IN4<br>IN2<br>IN1 | Input | ch3 Control Signal Input<br>ch4 Control Signal Input<br>ch2 Control Signal Input<br>ch1 Control Signal Input |  |

| PIN NO. | PIN NAME | INPUT/OUTPUT | FUNCTION | INTERMAL EQUIVALENT CIRCUIT |
|---|---|---|---|---|
| 19<br>21<br>23 | MUTE34<br>MUTE2<br>BRAKE1 | Input | Ch3 and 4 Mute<br>Ch2 Mute<br>Ch1 Brake |  |
| 24<br>25<br>26<br>27<br>29<br>30<br>31<br>32 | OUT4R<br>OUT4F<br>OUT3R<br>OUT3F<br>OUT2F<br>OUT2R<br>OUT1F<br>OUT1R | Output | Ch4 Negative Output<br>Ch4 Positive Output<br>Ch3 Negative Output<br>Ch3 Positive Output<br>Ch2 Positive Output<br>Ch2 Negative Output<br>Ch1 Positive Output<br>Ch1 Negative Output |  |
| 28 | POWGND | | Power Block Power Supply Ground | |
| 36 | HVcc | Input | H-Bridge Power Supply Input | |
| 33 | RCHG | Input | Charge Current Setting |  |
| 34 | AMUTE | Output | Reset Invert Output |  |
| 35 | EMP | Output | Empty Detect Output |  |
| 37 | PSW | Output | PWM Transistor Drive |  |
| 38 | CLK | Input | External Clock Synchronizing Input |  |

| PIN NO. | PIN NAME | INPUT/OUTPUT | FUNCTION | INTERMAL EQUIVALENT CIRCUIT |
|---|---|---|---|---|
| 39 | START | Input | Voltage Multiplier DC-DC Converter Start |   |
| 40 | OFF | Input | Voltage Multiplier DC-DC Converter OFF |   |
| 41 | CHGVcc | Input | Charging Circuit Power Supply Input | Charging Circuit Power Supply |
| 42 | SEL | Input/Output | Empty Detect Level Switch |   |
| 43 | PREGND | | Pre Section Power Supply Ground | Pre Section Power Supply Ground |
| 44 | PWMFIL | Input | PWM Phase Compensation |   |

*The positive and negative outputs are the polarity with respect to the input

BLOCK DIAGRAM



## ABSOLUTE MAXIMUM RATINGS (Ta=25°C )

| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| Supply Voltage | Vcc *1 | 13.5 | V |
| Driver Output Current | Io | 500 | mA |
| Power Dissipation | $P_D$ | 625 | mW |
| Operating Temperature | $T_{OPR}$ | -30~+85 | °C |
| Storage Temperature | $T_{STG}$ | -55~+150 | °C |

*1: Vcc shows input voltage of VSYS1,VSYS2, HVcc, BATT,and CHGVcc.

## RECOMMENDED OPERATING CONDITIONS

| PARAMETER | SYMBOL | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| Control Circuit Power Supply Voltage | VSYS1 | 2.7 | 3.2 | 5.5 | V |
| Pre-Driver Circuit Power Supply Voltage | VSYS2 | 2.7 | 3.2 | 5.5 | V |
| H-Bridge Power Supply Voltage | HVcc | | PWM | BATT | V |
| Power Supply Voltage | BATT | 1.5 | 2.4 | 8.0 | V |
| Charging circuit Power supply Voltage | CHGVcc | 3.0 | 4.5 | 8.0 | V |
| Operating Temperature | Ta | -10 | 25 | 70 | °C |

## ELECTRICAL CHARACTERISTICS

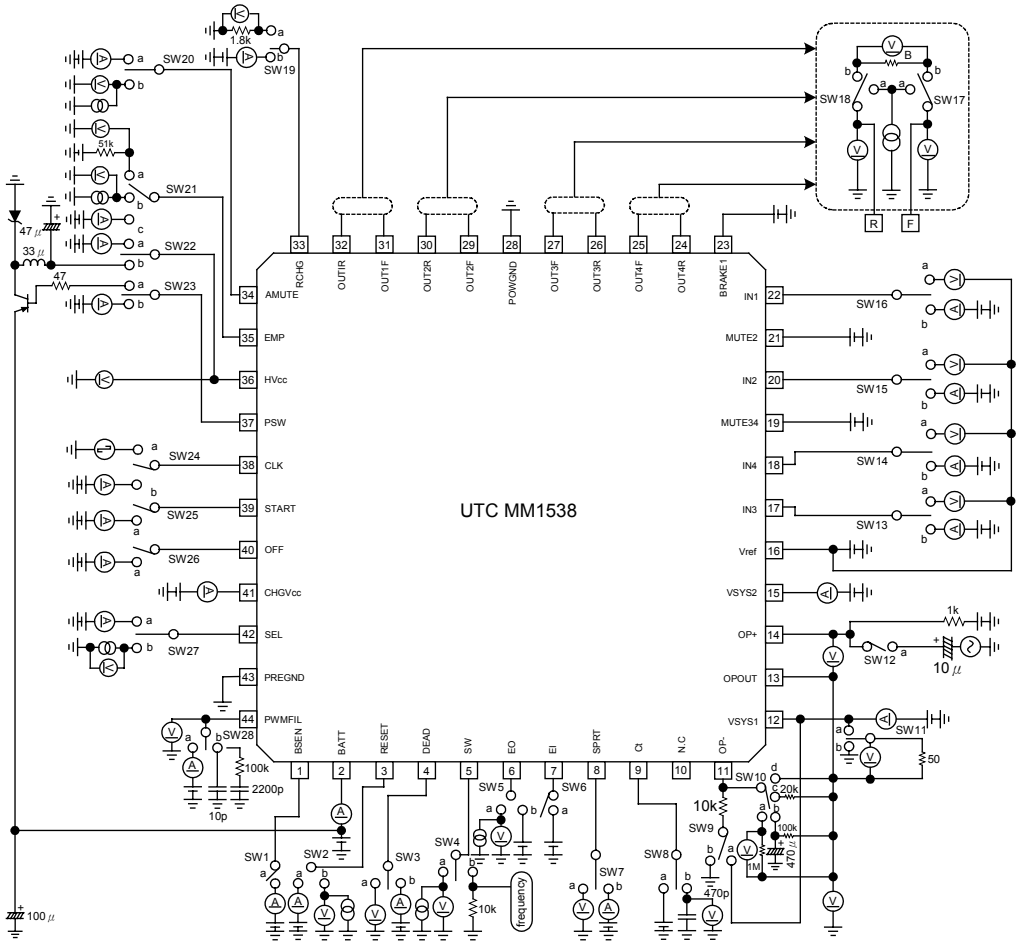
(Ta=25°C, BATT=2.4V,VSYS1=VSYS2=3.2V,Vref=1.6V,CHGVcc=0V,fCLK=88.2kHz, unless otherwise specified)

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| Common Section | | | | | | |
| BATT Stand-by Current | $I_{ST}$ | BATT=9.0V, VSYS1=VSYS2=Vref=0V | | 0 | 3 | μA |
| BATT Supply Current (No load) | $I_{BAT}$ | HVcc=0.45V, MUTE34=3.2V | | 2.5 | 4.0 | mA |
| VSYS1 Supply Current (No load) | $I_{SYS1}$ | HVcc=0.45V, MUTE34=3.2V, EI=0V | | 4.7 | 6.4 | mA |
| VSYS2 Supply Current (No load) | $I_{SYS2}$ | HVcc=0.45V, MUTE34=3.2V | | 4.1 | 5.5 | mA |
| CHGVcc Supply Current (No load) | $I_{CGVCC}$ | $CHGV_{CC}$=4.5V, $R_{OUT}$=OPEN | | 0.65 | 2.00 | mA |
| H-Bridge Driver Part | | | | | | |
| Voltage Gain ch1,ch3.ch4 | $G_{VC134}$ | | 12 | 14 | 16 | dB |
| Voltage Gain ch2 | $G_{VC2}$ | | 21.5 | 23.5 | 24.5 | dB |
| Gain Error By Polarity | $\Delta G_{VC}$ | | -2 | 0 | 2 | dB |
| Input pin resistance ch1,ch3,ch4 | $R_{IN134}$ | IN=1.7V and 1.8V | 9 | 11 | 13 | kΩ |
| Input pin resistance ch2 | $R_{IN2}$ | IN=1.7V and 1.8V | 6 | 7.5 | 9 | kΩ |
| Maximum Output Voltage | $V_{OUT}$ | $R_L$=8Ω ,HVcc=BATT=4.0V, IN=0-3.2V | 1.9 | 2.1 | | V |
| Saturation Voltage (Lower) | $V_{satL}$ | Io=-300mA, IN=0 and 3.2V | | 240 | 400 | mV |
| Saturation Voltage (Upper) | $V_{satU}$ | Io=-300mA, IN=0 and 3.2V | | 240 | 400 | mV |
| Input Offset Voltage | $V_{OI}$ | | -8 | 0 | 8 | mV |
| Output Offset Voltage ch1,ch3,ch4 | $V_{OO134}$ | Vref=IN=1.6V | -50 | 0 | 50 | mV |
| Output Offset Voltage ch2 | $V_{OO2}$ | Vref=IN=1.6V | -130 | 0 | 130 | mV |
| Dead Zone | $V_{DB}$ | | -10 | 0 | 10 | mV |
| BRAKE1ON Threshold Voltage | $V_{BRON}$ | IN1=1.8V | 2.0 | | | V |
| BRAKE1OFF Threshold Voltage | $V_{BROFF}$ | IN1=1.8V | | | 0.8 | V |
| MUTE2 ON Threshold Voltage | $V_{M2ON}$ | IN2=1.8V | 2.0 | | | V |
| H-Bridge Driver Part | | | | | | |
| MUTE2 OFF Threshold Voltage | $V_{M2OFF}$ | IN2=1.8V | | | 0.8 | V |
| MUTE34 ON Threshold Voltage | $V_{M34ON}$ | IN3=IN4=1.8V | | | 0.8 | V |
| MUTE34 OFF Threshold Voltage | $V_{M34OFF}$ | IN3=IN4=1.8V | 2.0 | | | V |
| Vref ON Threshold Voltage | $V_{refON}$ | IN1=IN2=IN3=IN4=1.8V | 1.2 | | | V |
| Vref OFF Threshold Voltage | $V_{refOFF}$ | IN1=IN2=IN3=IN4=1.8V | | | 0.8 | V |

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| BRAKE1 Brake Current | $I_{BRAKE1}$ | Current difference between BRAKE pin "H" time and "L" time. | 4 | 7 | 10 | mA |
| PWM Power Supply Driving | | | | | | |
| PSW Sink Current | $I_{PSW}$ | IN1=2.1V | 10 | 13 | 17 | mA |
| HVcc Level Shift Voltage | $V_{SHIF}$ | IN1=1.8V, HVcc-OUT1F | 0.35 | 0.45 | 0.55 | V |
| HVcc Leak Current | $I_{HLK}$ | HVcc=9.0V, VSYS1=VSYS2=BATT=0V | | 0 | 5 | μA |
| PWM Amp Transfer Gain | $G_{PWM}$ | IN1=1.8V, HVcc=1.2 ~ 1.4V | 1/60 | 1/50 | 1/40 | 1/kΩ |
| DC-DC Converter | | | | | | |
| Error Amp | | | | | | |
| VSYS1 Threshold Voltage | $V_{S1TH}$ | | 3.05 | 3.20 | 3.35 | V |
| EO Pin Output Voltage "H" | $V_{EOH}$ | EI=0.7V, Io=-100μA | 1.4 | 1.6 | | V |
| EO Pin Output Voltage "L" | $V_{EOL}$ | EI=1.3V, Io=100μA | | | 0.3 | V |
| Short Circuit Protection | | | | | | |
| SPRT Pin Voltage | $V_{SPR}$ | EI=1.3V | | 0 | 0.1 | V |
| EO=H SPRT Pin Current1 | $I_{SPR1}$ | EI=0.7V | 6 | 10 | 16 | μA |
| OFF=L SPRT Pin Current2 | $I_{SPR2}$ | EI=1.3V, OFF=0V | 12 | 20 | 32 | μA |
| SPRT Pin Current3 Over-Voltage | $I_{SPR3}$ | EI=1.3V, BATT=9.5V | 12 | 20 | 32 | μA |
| SPRT Pin Impedance | $R_{SPR}$ | | 175 | 220 | 265 | kΩ |
| SPRT Pin Threshold Voltage | $V_{SPTH}$ | EI=0.7V, $C_T$=0V | 1.10 | 1.20 | 1.30 | V |
| Over-Voltage Protection Detect | $V_{HVPR}$ | BSEN Pin Voltage | 8.0 | 8.4 | 9.0 | V |
| Transistor Driving | | | | | | |
| SW Pin Output Voltage1 "H" | $V_{SW1H}$ | BATT=$C_T$=1.5V, VSYS1=VSYS2=0V, Io=-2mA Starting Time | 0.78 | 0.98 | 1.13 | V |
| SW Pin Output Voltage2 "H" | $V_{SW2H}$ | $C_T$=0V, Io=-10mA, EI=0.7V, SPRT=0V | 1.00 | 1.50 | | V |
| SW Pin Output Voltage2 "L" | $V_{SW2L}$ | $C_T$=2.0V, Io=10mA | | 0.30 | 0.45 | V |
| SW Pin Oscillating Frequency1 | $f_{SW1}$ | $C_T$=470pF, VSYS1=VSYS2=0V Starting Time | 65 | 80 | 95 | kHz |
| SW Pin Oscillating Frequency2 | $f_{SW2}$ | $C_T$=470pF, CLK=0V | 60 | 70 | 82 | kHz |
| SW Pin Oscillating Frequency3 | $f_{SW3}$ | $C_T$=470pF | | 88.2 | | kHz |
| SW Pin Minimum Pulse Width | $T_{SWmin}$ | $C_T$=470pF, EO=0.5V→0.7V Sweep | 0.01 | | 0.60 | μs |
| Pulse Duty Start | $D_{SW1}$ | $C_T$=470pF, VSYS1=VSYS2=0V | 40 | 50 | 60 | % |
| Max. Pulse Duty At Self-Running | $D_{SW2}$ | $C_T$=470pF, EI=0.7V, CLK=0V | 70 | 80 | 90 | % |
| Max. Pulse Duty At CLK Synchronization | $D_{SW3}$ | $C_T$=470pF, EI=0.7V | 65 | 75 | 85 | % |
| Interface | | | | | | |
| OFF Pin Threshold Voltage | $V_{OFTH}$ | EI=1.3V | | | VSYS1-2.0 | V |
| OFF Pin Bias Current | $I_{OFF}$ | OFF=0V | 75 | 95 | 115 | μA |
| START Pin ON Threshold Voltage | $V_{STATH1}$ | VSYS1=VSYS2=0V, $C_T$=2.0V | | | BATT-1.0 | V |
| START Pin OFF Threshold Voltage | $V_{STATH2}$ | VSYS1=VSYS2=0V, $C_T$=2.0V | BATT-0.3 | | | V |
| START Pin Bias Current | $I_{START}$ | START=0V | 10<br>13 | 20<br>16 | 30<br>19 | μA |
| CLK Pin Threshold Voltage "H" | $V_{CLKTHH}$ | | 2.0 | | | V |
| CLK Pin Threshold Voltage "L" | $V_{CLKTHL}$ | | | | 0.8 | V |
| CLK Pin Bias Current | $I_{CLK}$ | CLK=3.2V | | | 10 | μA |
| Dead Time | | | | | | |
| DEAD Pin Impedance | $R_{DEAD}$ | | 52 | 65 | 78 | kΩ |
| DEAD Pin Output Voltage | $V_{DEAD}$ | | 0.78 | 0.88 | 0.98 | V |
| Starter Circuit | | | | | | |

| PARAMETER | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| Starter Switching Voltage | $V_{STNM}$ | VSYS1=VSYS2=0→3.2V, START=0V | 2.3 | 2.5 | 2.7 | V |
| Starter Switching Hysteresis Width | $V_{SNHS}$ | START=0V | 130 | 200 | 300 | mV |
| Discharge Release | $V_{DIS}$ | | 1.63 | 1.83 | 2.03 | V |
| Empty Detection | | | | | | |
| EMP Detection Voltage 1 | $V_{EMPT1}$ | VSEL=0V | 2.1 | 2.2 | 2.3 | V |
| EMP Detection Voltage 2 | $V_{EMPT2}$ | ISEL=- 2μA | 1.7 | 1.8 | 1.9 | V |
| EMP Detection Hysteresis Voltage 1 | $V_{EMHS1}$ | VSEL=0V | 25 | 50 | 100 | mV |
| EMP Detection Hysteresis Voltage 2 | $V_{EMHS2}$ | ISEL=- 2μA | 25 | 50 | 100 | mV |
| EMP Pin Output Voltage | $V_{EMP}$ | Io=1mA, BSEN=1V | | | 0.5 | V |
| EMP Pin Output Leak Current | $I_{EMPL}$ | BSEN=2.4V | | | 1.0 | μA |
| BSEN Pin Input Resistance | $R_{BSEN}$ | VSEL=0V | 17 | 23 | 27 | kΩ |
| BSEN Pin Leak Current | $I_{BSENL}$ | VSYS1=VSYS2=0V, BSEN=4.5V | | | 1.0 | V |
| SEL Pin Detection Voltage | $V_{SELTH}$ | $V_{SELTH}$=BATT-SEL, BSEN=2.0V | 1.5 | | | V |
| SEL Pin Detection Current | $I_{SELT}$ | | -2 | | | μA |
| Reset Circuit | | | | | | |
| VSYS1 RESET Threshold Voltage Ratio | $H_{SRT}$ | Comparison with error amplifier threshold voltage | 85 | 90 | 95 | % |
| RESET Detection Hysteresis Width | $V_{RSTHS}$ | | 25 | 50 | 100 | mV |
| RESET Pin Output Voltage | $V_{RST}$ | Io=1mA, VSYS1=VSYS2=2.8V | | | 0.5 | V |
| RESET Pin PULL UP Resistance | $R_{RST}$ | | 72 | 90 | 108 | kΩ |
| AMUTE Pin Output Voltage 1 | $V_{AMT1}$ | Io=-1mA, VSYS1=VSYS2=2.8V | BATT -0.4 | | BATT | V |
| AMUTE Pin Output Voltage 2 | $V_{AMT2}$ | Io=-1mA, START=0V, VSYS1=VSYS2=0V | BATT -0.4 | | BATT | V |
| AMUTE Pin PULL DOWN Resistance | $R_{AMT}$ | | 77 | 95 | 113 | kΩ |
| Op Amp | | | | | | |
| Input Bias Current | $I_{BIAS}$ | OP+=1.6V | | | 300 | nA |
| Input Offset Voltage | $V_{OIOP}$ | | -5.5 | 0 | 5.5 | mV |
| High Level Output Voltage | $V_{OHOP}$ | $R_L$=OPEN | 2.8 | | | V |
| Low level Output Voltage | $V_{OLOP}$ | $R_L$=OPEN | | | 0.2 | V |
| Output Drive Current (Source) | $I_{SOU}$ | 50Ω GND | | -6.5 | -3.0 | mA |
| Output Drive Current (Sink) | $I_{SIN}$ | 50Ω VSYS1 | 0.4 | 0.7 | | mA |
| Open Loop Voltage Gain | GVO | $V_{IN}$=-75dBV, f=1kHz | | 70 | | dB |
| Slew Rate | SR | | | 0.5 | | V/μs |
| Battery Charging Circuit | | | | | | |
| RCHG Pin Bias Voltage | $V_{RCHG}$ | CHGVcc=4.5V, RCHG=1.8kΩ. | 0.71 | 0.81 | 0.91 | V |
| RCHG Pin Output Resistance | $R_{RCHG}$ | CHGVcc=4.5V, RCHG=0.5 and 0.6V | 0.75 | 0.95 | 1.20 | kΩ |
| SEL Pin Leak Current 1 | $I_{SELLK1}$ | CHGVcc=4.5V, RCHG=OPEN, BATT=4.5V | | | 1.0 | μA |
| SEL Pin Leak Current 2 | $I_{SELLK2}$ | CHGVcc=0.6V, RCHG=1.8kΩ, BATT=4.5V | | | 1.0 | μA |
| SEL Pin Saturation Voltage | $V_{SELCG}$ | CHGVcc=4.5V, Io=300mA, RCHG=0Ω | | 0.45 | 1.00 | V |

MEASURING CIRCUIT



SWITCHING POSITION TABLE

| ITEM | SW NO. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 4 | 5 | 6 | 7 | 8 | 22 | 24 | 25 | 26 |
| BATT Stand-by Current | - | - | - | - | - | - | - | - | - | - |
| BATT Supply Current (No load) | - | - | - | - | - | - | a | - | a | - |
| VSYS1 Supply Current (No load) | - | - | - | a | - | - | a | - | a | - |
| VSYS2 Supply Current (No load) | - | - | - | - | - | - | a | - | a | - |
| CHGVcc Supply Current (No load) | - | - | - | - | - | - | - | - | - | - |
| VSYS1 Threshold Voltage | - | - | a | - | - | - | - | - | - | - |
| EO Pin Output Voltage “H” | - | - | a | a | - | - | - | - | - | - |
| EO Pin Output Voltage ”L” | - | - | a | a | - | - | - | - | - | - |
| SPRT Pin Voltage | - | - | - | a | a | - | - | - | - | - |
| SPRT Pin Current1 EO=”H” | - | - | - | a | b | - | - | - | - | - |
| SPRT Pin Current2 OFF=”L” | - | - | - | a | b | - | - | - | - | a |
| SPRT Pin Current3 Over-Voltage | a | - | - | a | b | - | - | - | - | - |
| SPRT Pin Impedance | - | - | - | - | b | - | - | - | - | - |
| SPRT Pin Threshold Voltage | - | - | - | a | a | a | - | - | - | - |
| Over-Voltage Protection Detect | a | - | - | - | a | - | - | - | - | - |
| SW Pin Output Voltage1”H” | - | a | - | - | - | a | - | - | a | - |
| SW Pin Output Voltage2”H” | - | a | - | a | b | a | - | - | - | - |
| SW Pin Output Voltage2”L” | - | a | - | - | - | a | - | - | - | - |
| SW Pin Oscillating Frequency 1 | - | b | - | - | - | b | - | - | a | - |
| SW Pin Oscillating Frequency 2 | - | b | - | - | - | b | - | b | - | - |
| SW Pin Oscillating Frequency 3 | - | b | - | - | - | b | - | a | - | - |
| SW Pin Minimum Pulse Width | - | b | b | - | - | b | - | - | - | - |
| Pulse Duty Start | - | b | - | - | - | b | - | b | a | - |
| Max Pulse Duty At Self-Running | - | b | - | - | - | b | - | b | - | - |
| Max Pulse Duty At CLK Synchronization | - | b | - | a | - | b | - | a | - | - |

-: Turn off switch

| ITEM | SW NO. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 6 | 7 | 8 | 20 | 24 | 25 | 26 |
| DEAD Pin Impedance | - | b | - | - | - | - | - | - | - | - |
| DEAD Pin Output Voltage | - | a | - | - | - | - | - | - | - | - |
| OFF Pin Threshold Voltage | - | - | - | a | a | - | - | - | - | a |
| OFF Pin Bias Current | - | - | - | - | - | - | - | - | - | a |
| START Pin ON Threshold Voltage | - | - | a | - | - | a | - | - | a | - |
| START Pin OFF Threshold Voltage | - | - | a | - | - | a | - | - | a | - |
| START Pin Bias Current | - | - | - | - | - | - | - | - | a | - |
| CLK Pin Threshold Voltage “H” | - | - | a | - | - | b | - | b | - | - |
| CLK Pin Threshold Voltage “L” | - | - | a | - | - | b | - | b | - | - |
| CLK Pin Bias Current | - | - | - | - | - | - | - | a | - | - |
| Starter Switching Voltage | - | - | a | - | - | - | - | - | a | - |
| Starter Switching Hysteresis Width | - | - | a | - | - | - | - | - | a | - |
| Discharge Release Voltage | - | - | - | - | a | - | - | - | - | - |
| VSYS1 Pin RESET Threshold Voltage Ratio | b | - | - | - | - | - | - | - | - | - |
| RESET Detection Hysteresis Width | b | - | - | - | - | - | - | - | - | - |
| RESET Pin Output Voltage | b | - | - | - | - | - | - | - | - | - |
| RESET Pin PULL UP Resistance | a | - | - | - | - | - | - | - | - | - |
| AMUTE Pin Output Voltage 1 | - | - | - | - | - | - | b | - | -- | - |
| AMUTE Pin Output Voltage 2 | - | - | - | - | - | - | b | - | a | - |
| AMUTE Pin PULL DOWN Resistance | - | - | - | - | - | - | a | - | - | - |

-: Turn off switch

| ITEM | SW NO. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 9 | 10 | 11 | 12 | 21 | 27 |
| EMP Detection Voltage 1 | a | - | - | - | - | a | a |
| EMP Detection Voltage 2 | a | - | - | - | - | a | b |
| EMP Detection Hysteresis Voltage 1 | a | a | - | - | - | a | a |
| EMP Detection Hysteresis Voltage 2 | a | - | - | - | - | a | b |
| EMP Pin Output Voltage | a | - | - | - | - | b | - |
| EMP Pin Output Leak Current | a | - | - | - | - | c | - |
| BSEN Pin Input Resistance | a | - | - | - | - | - | a |
| BSEN Pin Leak Current | a | - | - | - | - | - | - |
| SEL Pin Detection Voltage | a | - | - | - | - | a | a |
| SEL Pin Detection Current | a | - | - | - | - | a | b |
| Input Bias Current | - | - | a | - | - | - | - |
| Input Offset Voltage | - | - | d | - | - | - | - |
| “H” Level Output Voltage | - | b | c | - | - | - | - |
| “L” Level Output Voltage | - | a | c | - | - | - | - |
| Output Drive Current (Source) | - | - | d | b | - | - | - |
| Output Drive Current (Sink) | - | - | d | a | - | - | - |
| Open Loop Voltage Gain | - | - | b | - | a | - | - |
| Slew Rate | - | - | d | - | a | - | - |

-: Turn off switch

| ITEM | | SW NO. | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 13 | 14 | 15 | 16 | 17 | 18 | 22 |
| Voltage Gain | Ch1R | - | - | - | b | b | b | a |
| | Ch2R | - | - | b | - | b | b | a |
| | Ch3R | b | - | - | - | b | b | a |
| | Ch4R | - | b | - | - | b | b | a |
| Gain Error By Polarity | Ch1 | - | - | - | b | b | b | a |
| | Ch2 | - | - | b | - | b | b | a |
| | Ch3 | b | - | - | - | b | b | a |
| | Ch4 | - | b | - | - | b | b | a |
| Input Pin resistance | Ch1 | - | - | - | b | b | b | a |
| | Ch2 | - | - | b | - | b | b | a |
| | Ch3 | b | - | - | - | b | b | a |
| | Ch4 | - | b | - | - | b | b | a |
| Maximum Output Voltage | Ch1R | - | - | - | b | b | b | a |
| | Ch2R | - | - | b | - | b | b | a |
| | Ch3R | b | - | - | - | b | b | a |
| | Ch4R | - | b | - | - | b | b | a |
| Saturation Voltage (Lower) | Ch1F | - | - | - | b | a | - | a |
| | Ch1R | - | - | - | b | - | a | a |
| | Ch2F | - | - | b | - | a | - | a |
| | Ch2R | - | - | b | - | - | a | a |
| | Ch3F | b | - | - | - | a | - | a |
| | Ch3R | b | - | - | - | - | - | a |
| | Ch4F | - | b | - | - | a | - | a |
| | Ch4R | - | b | - | - | - | a | a |
| Saturation Voltage (Upper) | Ch1F | - | - | - | b | a | - | a |
| | Ch1R | - | - | - | b | - | a | a |
| | Ch2F | - | - | b | - | a | - | a |
| | Ch2R | - | - | b | - | - | a | a |
| | Ch3F | b | - | - | - | a | - | a |
| | Ch3R | b | - | - | - | - | a | a |
| | Ch4F | - | b | - | - | a | - | a |
| | Ch4R | - | b | - | - | - | a | a |
| Input Offset Voltage | Ch1 | - | - | - | a | - | - | a |
| | Ch2 | - | - | a | - | - | - | a |
| | Ch3 | a | - | - | - | - | - | a |
| | Ch4 | - | a | - | - | - | - | a |
| Output Offset Voltage | Ch1 | - | - | - | b | b | b | a |
| | Ch2 | - | - | b | - | b | b | a |
| | Ch3 | b | - | - | - | b | b | a |
| | Ch4 | - | b | - | - | b | b | a |
| Dead Zone | Ch1 | - | - | - | b | b | b | a |
| | Ch2 | - | - | b | - | b | b | a |
| | Ch3 | b | - | - | - | b | b | a |
| | Ch4 | - | b | - | - | b | b | a |

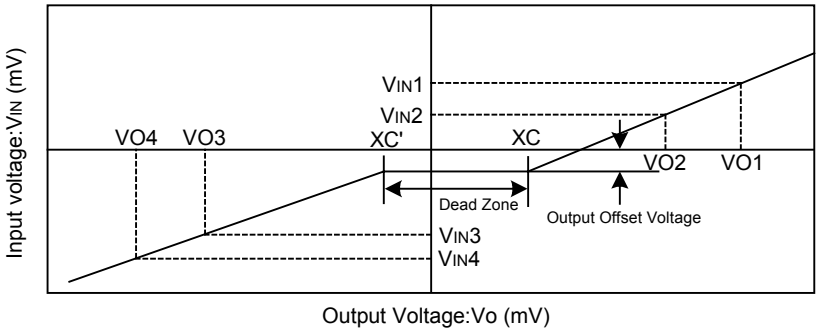
-: Turn off switch

| ITEM | | SW NO. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 13 | 14 | 15 | 16 | 17 | 18 | 22 | 23 | 28 |
| BRAKE1 ON Voltage | Ch1 | - | - | - | b | b | b | a | - | - |
| BRAKE1 OFF Voltage | Ch1 | - | - | - | b | b | b | a | - | - |
| MUTE2 ON Voltage | Ch2 | - | - | b | - | b | b | a | - | - |
| MUTE2 OFF Voltage | Ch2 | - | - | b | - | b | b | a | - | - |
| MUTE34 ON Voltage | Ch3 | b | - | - | - | b | b | a | - | - |
| | Ch4 | - | b | - | - | b | b | a | - | - |
| MUTE34 OFF Voltage | Ch3 | b | - | - | - | b | b | a | - | - |
| | Ch4 | - | b | - | - | b | b | a | - | - |
| Vref ON Voltage | Ch1 | - | - | - | b | b | b | a | - | - |
| | Ch2 | - | - | b | - | b | b | a | - | - |
| | Ch3 | b | - | - | - | b | b | a | - | - |
| | Ch4 | - | b | - | - | b | b | a | - | - |
| Vref OFF Voltage | Ch1 | - | - | - | b | b | b | a | - | - |
| | Ch2 | - | - | b | - | b | b | a | - | - |
| | Ch3 | b | - | - | - | b | b | a | - | - |
| | Ch4 | - | b | - | - | b | b | a | - | - |
| BREAK1 Brake Current | Ch1 | - | - | - | b | b | b | a | - | - |
| PWM Sink Current | | - | - | - | b | - | - | a | b | a |
| HVcc Level Shift Voltage | | - | - | - | b | b | b | b | a | b |
| HVcc Leak Current | | - | - | - | - | b | b | a | - | - |
| PWM Amp Transfer Gain | | - | - | - | b | b | b | a | - | - |

| ITEM | SW NO. | |
|---|---|---|
| | 19 | 27 |
| CHGSET Pin Bias Voltage | a | - |
| CHGSET Pin Output Resistance | b | - |
| SEL Pin Leak Current 1 | - | a |
| SEL Pin Leak Current 2 | a | a |
| SEL Pin Saturation Voltage | b | b |

-: Turn off switch

SWITCHING POSITION TABLE




* Voltage Gain

$$Gvc(+)=20\log\frac{VO1-VO2}{V_{IN}1-V_{IN}2}$$

$$Gvc(-)=20\log\frac{VO3-VO4}{V_{IN}3-V_{IN}4}$$

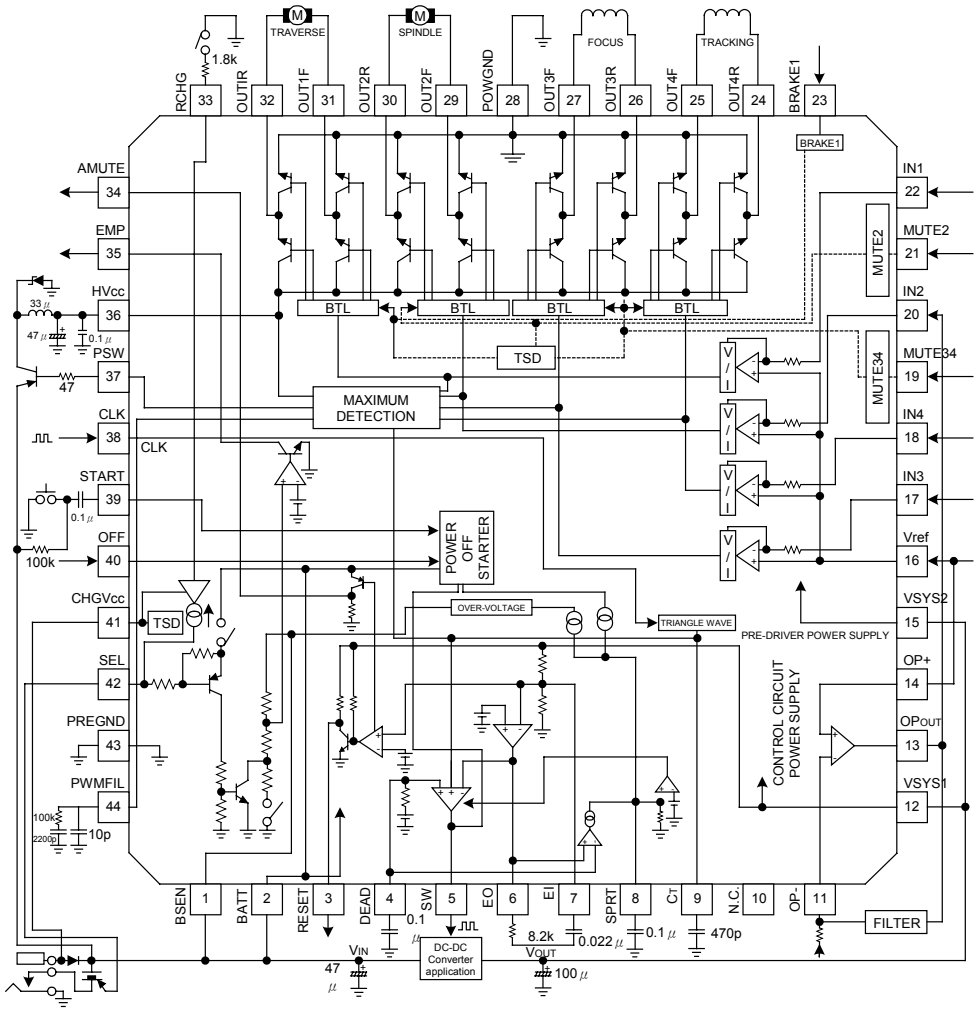
* Gain Error By Polarity

Gvc=Gvc (+)-Gvc (-)

* Dead Zone

$$XC-XC'=\frac{V_{IN}2\cdot VO1-V_{IN}1\cdot VO2}{VO1-VO2}-\frac{V_{IN}3\cdot VO4-V_{IN}4\cdot VO3}{VO3-VO4}$$

APPLICATION CIRCUIT




* We shall not be liable for any trouble or damege caused by using this circuit.
*In the evert a problem which may affect industrial property or any other rights of us or a third party is encountered during the use of information described in these circuit,Mitsumi Electric Co.,Ltd.shall not be liable for any such problem,nor grant a license therefor.

## CIRCUIT OPERATION

1 H-bridge driver block

(1) Gain setting

- The driver input resistance (ch 1,3 and 4) are 11kΩ typ. ,ch2 is 7.5kΩ typ. . Set the gain according to the following formula.

| | |
|---|---|
| ch1<br>ch2<br>ch3 | $GV=20\log\left\|\frac{55k}{11k+R}\right\|$ (db) |
| ch2 | $GV=20\log\left\|\frac{110k}{7.5k+R}\right\|$ (db) |

R:Externally-connected input

- The driver output stage power supply is HVcc (36PIN), and the bridge circuit power supply is VSYS2 (15PIN). Connect a bypass capacitor between these two power supplies (approximately 0.1μF).

(2) Mute function

- Of the four drivers,ch1 has a brake function, and the other channels have a mute function.
- When BRAKE1(23PIN)is set to high level, both ch1 outputs go low level, and the circuit enters brake mode.
- When MUTE2(21PIN)is set to high level, the ch2 output is muted.
- When MUTE34(19PIN)is set to high level, the ch3 and 4 outputs are muted.

(3) Vref drop mute

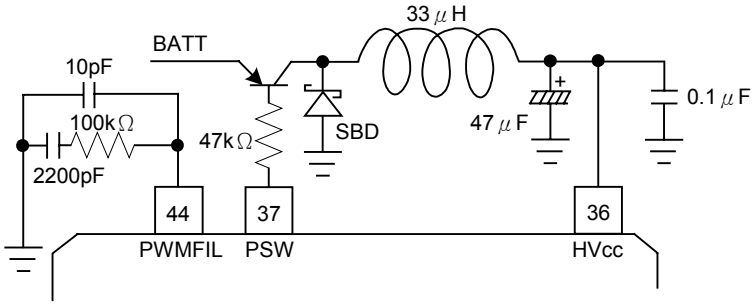
- When the voltage applied to Vref (16PIN)is 1.0V or less typ. , the driver outputs are set to high impedance.

(4) Thermal shutdown

- When the chip temperature reaches 150℃ typ. the output current is cut. The chip starts operating again at about 120℃ typ. .

2 PWM power supply drive block

- This detects the maximun output level from among the four channels, and supplies the load drive power supply (36PIN)for the PWM. The external components are a PNP transistor, coil, Schottky diode, and capacitor.

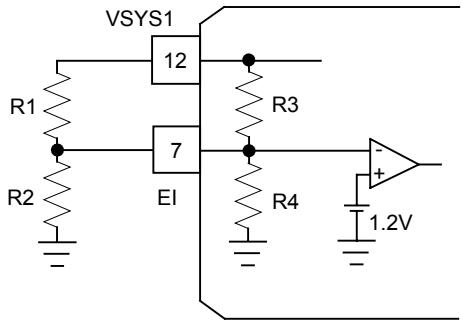


3 DC-DC converter block

(1) Output voltage

• 3.2V typ. voltage multiplier circuit can be constructed using external components. This voltage can be varied with the addition of an external resistor. The setting method is as follows.

$$VSYS1=1.2\times \frac{\frac{R1\cdot R3}{R1+R3}+\frac{R2\cdot R4}{R2+R4}}{\frac{R2\cdot R4}{R2+R4}} (V)$$




(2) Short protect function

• When the error amplifier output(6PIN)has switched to the high-level state, SPRT (8PIN)is charged, and when the voltage reaches 1.2V typ. , the SW(5PIN)switching stops. The time until switching stops is set by the capacitor connected to SPRT(8PIN)according to the following formula.

$$t=CSPRT\times\frac{V_{TH}}{ISPRT} (sec) (V_{TH}=1.2V, ISPRT=10\mu A)$$

(3) Soft start function

• The soft start function operates when a capacitor is connected between DEAD(4PIN)and GND. Also, the maximum duty can be varied by connecting a resistor to 4PIN.

$$t=CDEAD\times R(sec) \quad (R=65k\Omega)$$

(4) Power off function

• When low-level is applied to OFF(40PIN), SPRT(8PIN)is charged, and when the voltage reaches 1.2V typ. , the SW(5PIN)switching stops. The time until switching stops is set by the capacitor connected to SPRT (8PIN)according to the following formula.

$$t=CSPRT\times\frac{V_{TH}}{I_{OFF}} (sec) (V_{TH}=1.2V, I_{OFF}=20\mu A)$$

(5) Over voltage protection circuit

• When the voltage applied to BSEN(1PIN)reaches 8.4V typ. , SPRT (8PIN) is charged, and when the voltage reaches 1.2V typ. , theSW (5PIN)switching stops. The time until switching stops is set by the capacitor connected to SPRT(8PIN)according to the following formula.

$t=CSPRT\times\frac{V_{TH}}{IHV}$ (sec) ($V_{TH}$=1.2V, $I_{HV}$=20 $\mu$ A)

4 Empty detector block

(1) Output voltage

- When the voltage applied to the BSEN(1PIN)falls below the detector voltage, EMP(35PIN)goes from high level to low level(open-collector output). The detector voltage has 50mV typ. of hysteresis to prevent output chattering. Use SEL (42PIN) to switch the detection voltage as shown below.

| SEL | Detect Voltage | Return Voltage |
|---|---|---|
| L | 2.20V typ. | 2.25V typ. |
| High-Z | 1.80V typ. | 1.85V typ. |

5 Reset circuit block

- At about 90% typ. of the DC-DC converter output voltage, RESET(3PIN)goes from low level to high level, and AMUTE(34PIN)goes from high level to low level. The reset voltage has 50mV typ. of hysteresis to prevent output chattering.

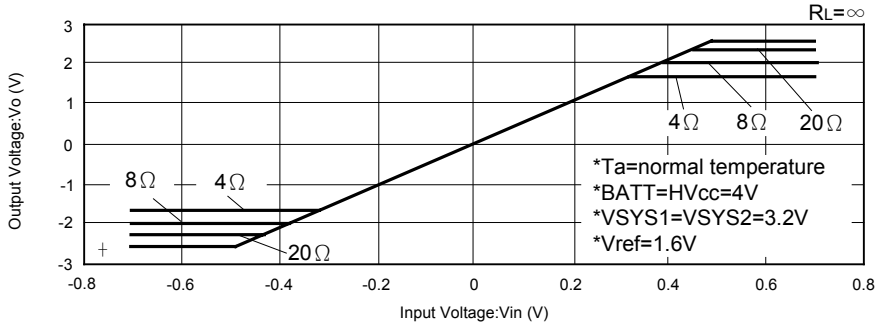
6 Charging circuit block

- The power supply for the charging circuit block is CHGVCC(41PIN), and is independent from the other circuits. The resistance between RCHG (33PIN) and GND sets the charging current. This current is drawn from SEL (42PIN).

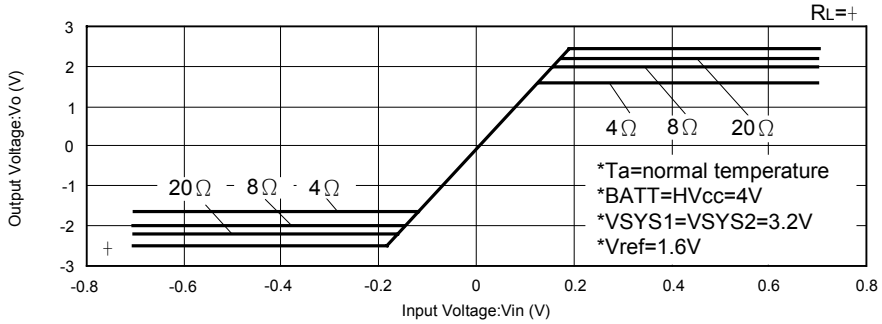
- A thermal shutdown circuit is provided, and when the chip temperature reaches 150℃ typ. the charging current is cut. The chip starts operating again at about 120℃ typ. .

## CHARACTERISTICS

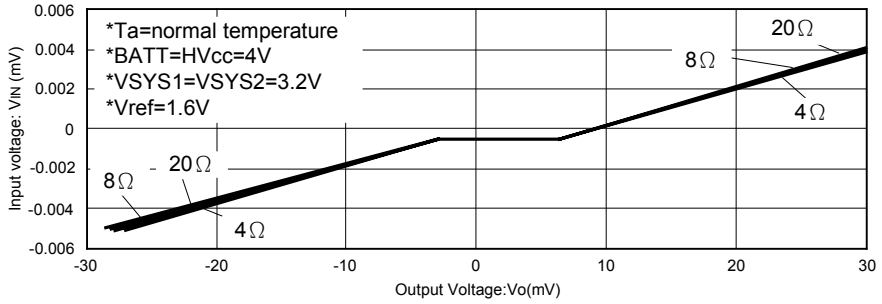
Input Load Fluctuation



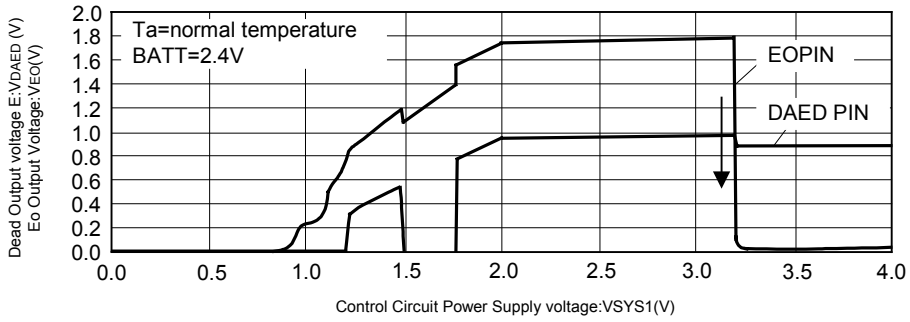
Input Load Fluctuation (ch2)




Dead Zone




Error Amp Output Voltage



Resete Pin Voltage