

## ICs for Communications

ISDN DC Converter Circuit  
IDCC

PEB 2023 Version 1.1  
PEF 2023 Version 1.1

Data Sheet 08.97

|                          |  |
|--------------------------|--|
| <b>PEB 2023</b>          |  |
| <b>PEF 2023</b>          |  |
| <b>Revision History:</b> | <b>Original Version:      Data Sheet 08.97</b>   |
| Previous Releases:       | Data Sheet 02.97   |
| <b>Page</b>              | <b>Subjects (changes since last revision)</b>  |
| all Pages                | Additional to the normal temperature range devices PEB 2023 also the extended temperature range devices PEF 2023 are specified in this Data Sheet. |
| 21                       | The ambient temperature under bias is separately defined for PEB 2023 and PEF 2023.  |
| 22                       | The maximum limit values for line regulation $V_{REF\ Line}$ and load regulation $V_{REF\ Load}$ are reduced. The typical values are adapted.      |
| 22                       | The maximum limit value for voltage stability of $f_{OSC}$ is reduced. The typical value is adapted.   |
| 22                       | The test condition ambient temperature range $T_A$ is extended for temperature stability of $V_{REF}$ and $f_{OSC}$ .                              |
| 23                       | The sense voltage $V_{Sense}$ of the current limit comparator is separately defined for PEB 2023 and PEF 2023.                                     |

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## 1 Overview

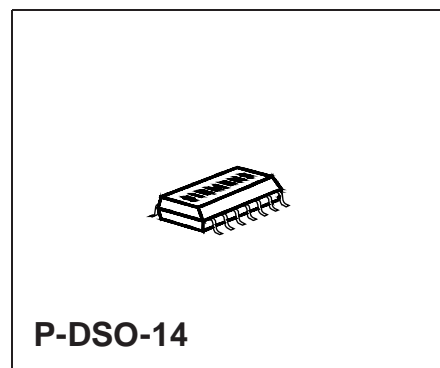
The PEB/F 2023 is a pulse width modulator circuit designed for fixed-frequency switching regulators with very low power consumption.

In telephone and ISDN-systems a high conversion yield is crucial to maintain functionality in all supply conditions via S- or U-interfaces. The PEB/F 2023 design and technology realizes high conversion efficiency and low power dissipation. The PEB/F 2023 is fully compatible with the ITU-power recommendations of the S-interface. For these reasons the PEB/F 2023 is especially suited for telephone and ISDN-environments.

Coupled with a few external components it can provide a stable 5V DC-supply for subscriber terminals (TE's) or network terminators (NT's). It can additionally be programmed for higher output voltages, e.g. to supply the S-lines.

It should be recognized that the PEB/F 2023 can also be used in numerous DC/DC-conversion systems other than ISDN-power supplies. For example, in a special supply voltage range the PEB/F 2023 can be supplied from a 12V battery.

For detailed technical information about "**Processing Guidelines**" and "**Quality Assurance**" for ICs, see our "**Product Overview**".



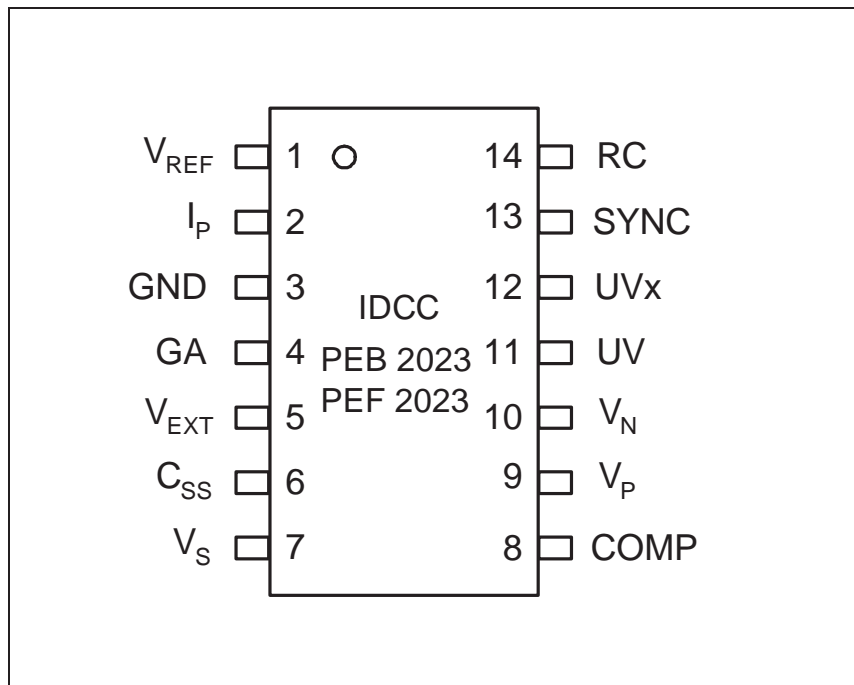
## 1.1 Features

- Switched Mode DC/DC Converter
- ITU ISDN Compatible
- Low Power Dissipation
- Supply Voltage Range 0: 8V to 16V  
Supply Voltage Range 1: 12V to 80V  
Supply Voltage Range 2: 22V to 90V  
(pin striping selects between range 1 and range 2)  
Supply Voltage Range 3, with shifting by an external zener diode:  $U_{ZD}+8V$  to  $U_{ZD}+90V$   
(minimum zener voltage  $U_{ZD} = 14V$ )
- Programmable Overcurrent Protection
- Soft Start
- Power Housekeeping Input
- Input Undervoltage Detection
- High Input Impedance ( $<10\mu A$ ) During Undervoltage Condition
- Oscillator Synchronization Input/Output
- High Voltage Smart Power Technology 75V
- P-DSO-14/1 Package

| Type     | Ordering Code | Package  |
|----------|---------------|----------|
| PEB 2023 | Q67100-H6830  | P-DSO-14 |
| PEF 2023 | Q67220-H1059  | P-DSO-14 |

## 1.2 Pin Configuration

(top view)



## 1.3 Pin Definitions and Functions

| Pin No. | Symbol    | Input (I)<br>Output (O) | Function   |
|---------|-----------|-------------------------|--|
| 1       | $V_{REF}$ | O                       | Output of the 4V reference voltage.  |
| 2       | $I_P$     | I                       | When the voltage difference between $I_P$ and GND exceeds 100mV, the digital current limiting becomes active and turns off the external FET for the rest of this oscillator period.  |
| 3       | GND       | I                       | All analog and digital signals are referred to this pin.   |
| 4       | GA        | O                       | Output of the FET-driver.  |
| 5       | $V_{EXT}$ | I/O                     | Output of the internal supply. Via $V_{EXT}$ the internal low-voltage-circuits can be supplied from an external DC-supply in order to reduce chip power dissipation. In supply voltage range 0 the positive supply voltage must be connected via a resistor to this pin. |
| 6       | $C_{SS}$  | I                       | The capacitor at this pin determines the soft-start characteristic.  |
| 7       | $V_S$     | I                       | $V_S$ is the positive input voltage for supply voltage range 1, 2 and 3. Must be connected to GND via a resistor when using supply voltage range 0.  |
| 8       | COMP      | O                       | Error amplifier output and <b>Pulse Width Modulator (PWM)</b> input for loop stabilization network.  |
| 9       | $V_P$     | I                       | Non-inverting input of the error amplifier.  |
| 10      | $V_N$     | I                       | Inverting input of the error amplifier.  |
| 11      | UV        | I                       | Input undervoltage lockout. The input undervoltage lockout level depends on the used supply voltage range. Must be connected to pin $V_S$ when using supply voltage range 0.   |
| 12      | UVx       | I                       | If this pin is connected to UV, then supply range 1 is selected. If this pin is not connected (floating), then supply range 2 or supply range 3 can be used. Must be connected to pin $V_{EXT}$ when using supply voltage range 0.                                       |
| 13      | SYNC      | I/O                     | Input for synchronization of the oscillator to an external frequency, or output to synchronize multiple devices.   |
| 14      | RC        | I                       | The external timing components of the ramp generator are attached to this pin.   |

1.4 Functional Block Diagram

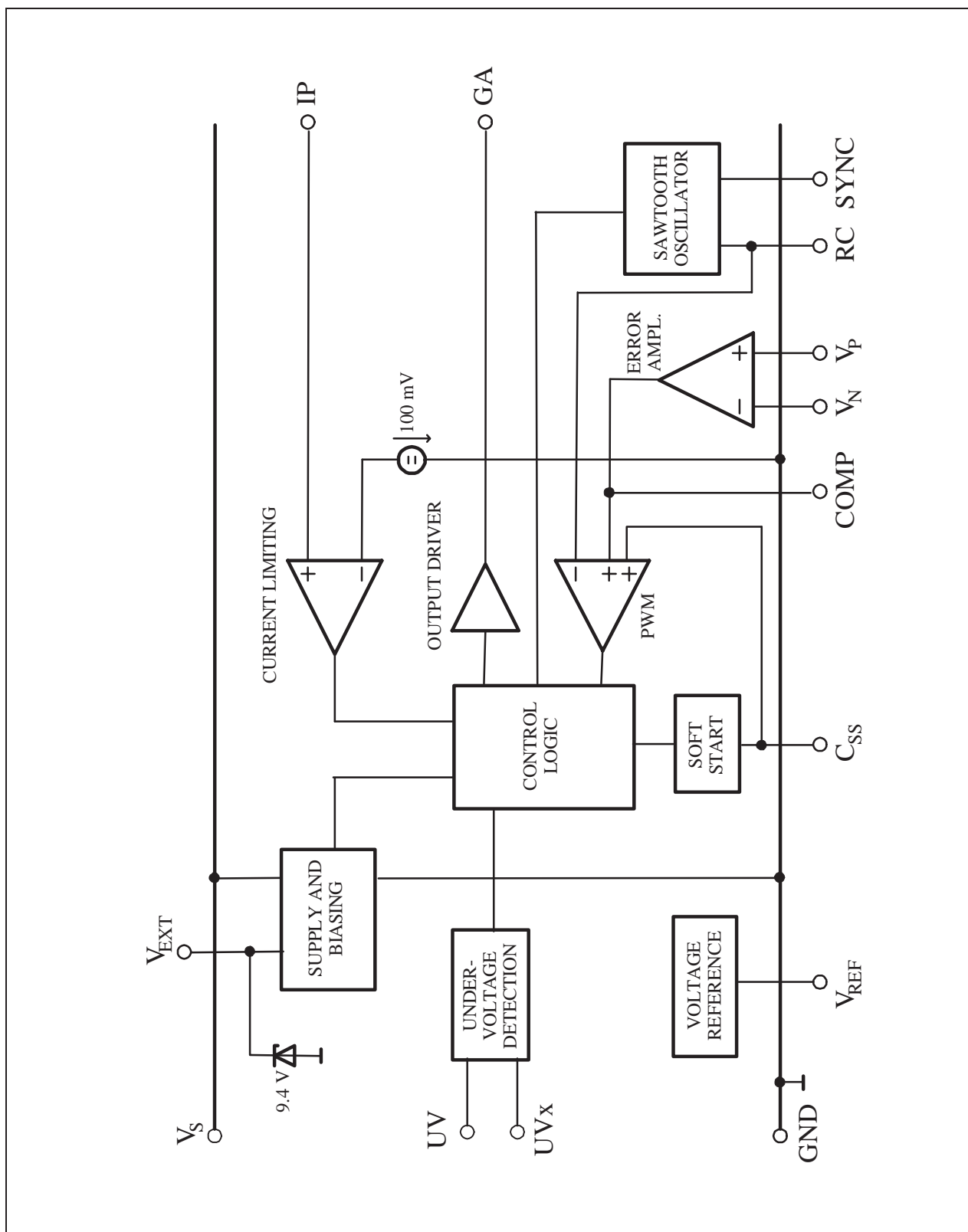


Figure 1  
Block Diagram

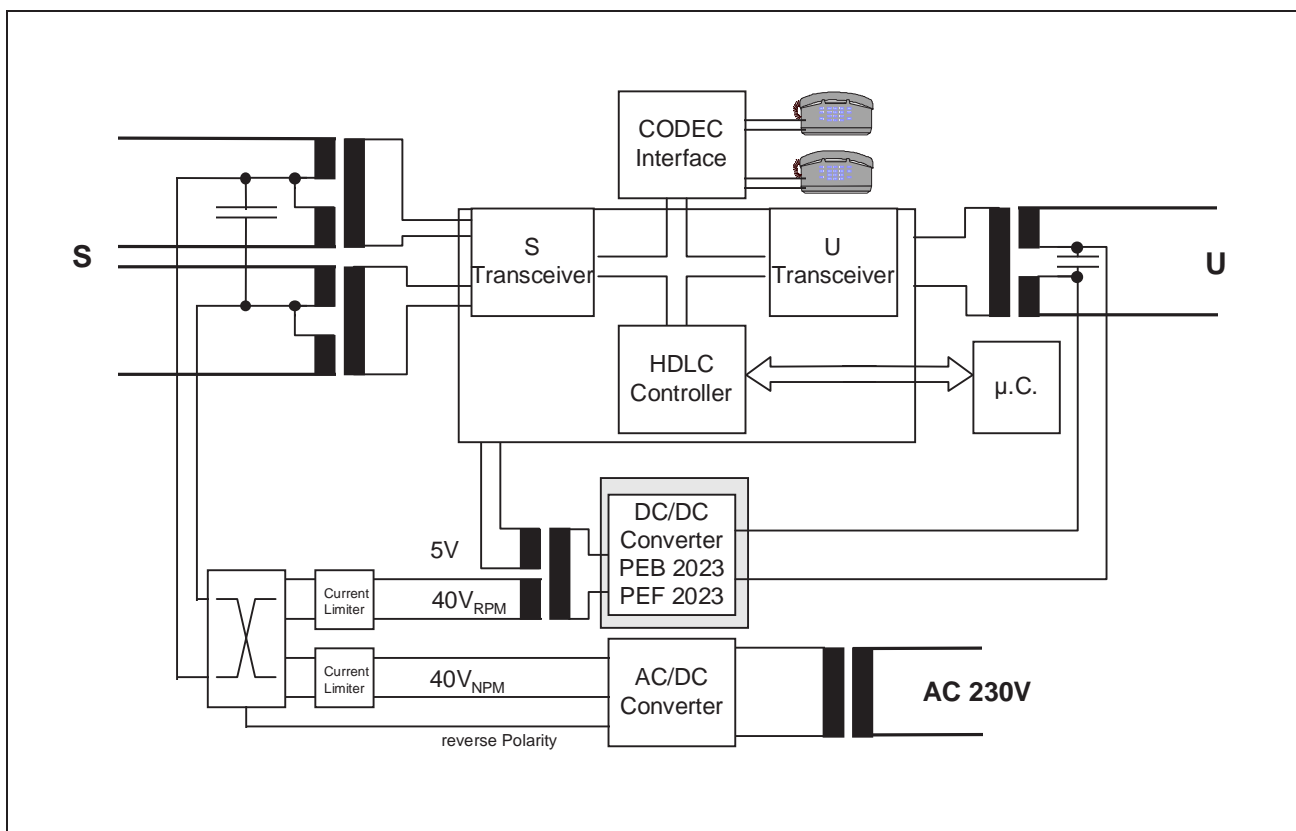


## 1.5 System Integration

**Figure 2** and **3** showing examples out of the wide application field of the PEB/F 2023. In network termination applications, the PEB/F 2023 supplies the internal IC's directly from the U-interface. If the local main supply of the NT is out of order, then the PEB/F 2023 will also supply the S-interface (restricted power mode).

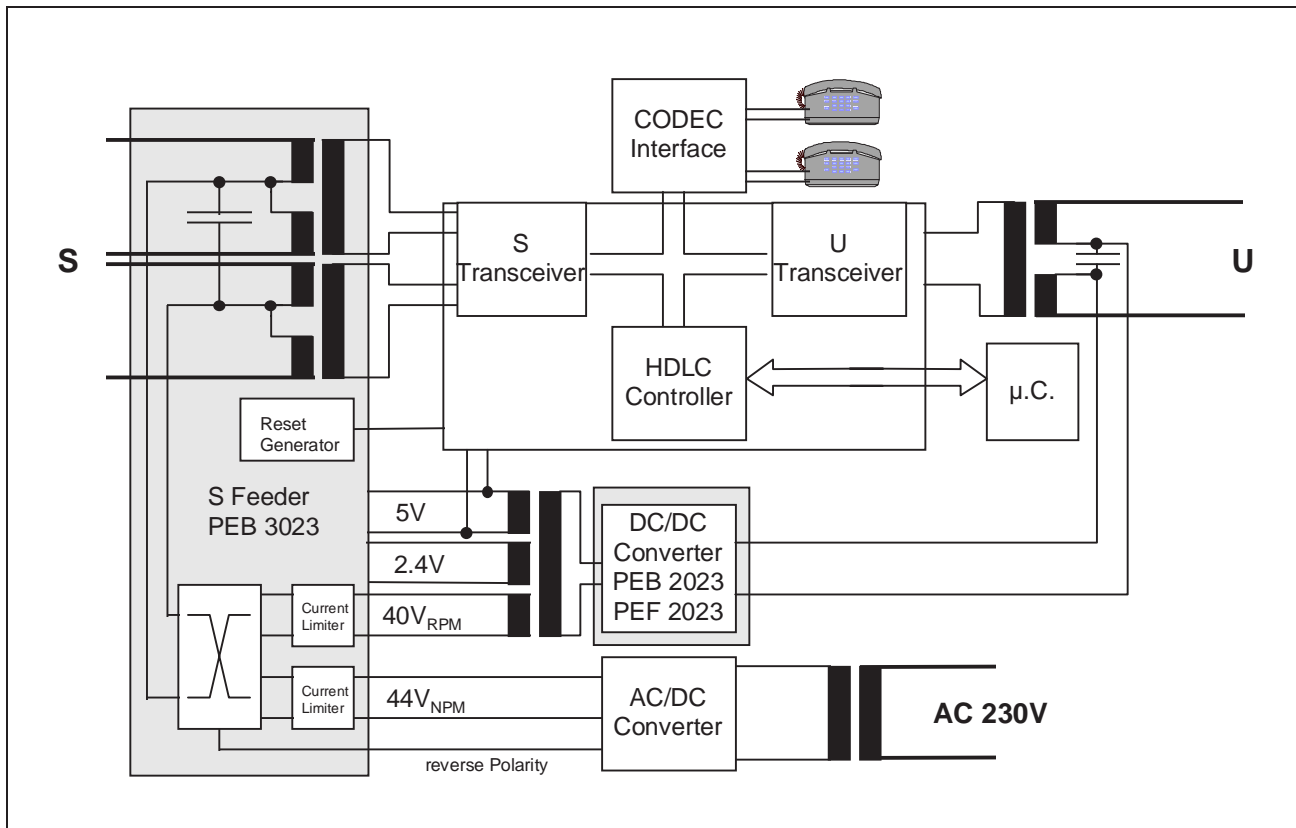
In the subscriber terminal the PEB/F 2023 is used for feeding the internal circuits.

The PEB/F 2023 accommodates both galvanically isolated and non-isolated configurations. Considering the diversity of DC/DC-converter applications, this part of the specification only shows how to use the special ISDN-features of the PEB/F 2023.



**Figure 2**  
**PEB/F 2023 in ISDN-Concept**

In **figure 3** the S-transformers are replaced by the PEB/F 3023 which is called S-Feeder. When using the S-Feeder a capacitive coupling between S-receive-path and the S-Transceiver is necessary. For the S-transmit-path the S-Feeder need an extra 2.4V transmitter supply voltage. Because of the DC-voltage-drop on the S-Feeder (about 2V and 4V) the input voltages  $V_{RPM}$  and  $V_{NPM}$  must be increased (to about 42V and 44V).



**Figure 3**  
**PEB/F 2023 in ISDN-Concept**

Figure 4 shows the PEB/F 2023 in flyback configuration with transformer isolation using supply voltage range 3. This application circuit is used to supply the internal IC's of the NT from the U-interface and also to supply the S-interface in case of restricted power mode. The DC/DC-converter begins operating when the input voltage exceeds 38V ( $U_{ZD}+8V$ , see supply voltage range 3). In the start-up phase the PEB/F 2023 is supplied through  $V_S$ . After this start-up phase, the PEB/F 2023 is supplied via  $V_{EXT}$  (power housekeeping input) and the DC/DC-converter will operate until the input voltage falls below 20V (input undervoltage detection). For power saving reasons the value of resistor  $R_6$  is as high as possible.

The maximum static  $V_S$  supply voltage in this example is 120V. How to get a higher maximum dynamic  $V_S$  supply voltage see chapter „1.6 Surge Protection“ on pages 14 and 15.

To get a very fast input undervoltage detection see chapter „1.7 Fast Input Undervoltage Detection“ on page 15.

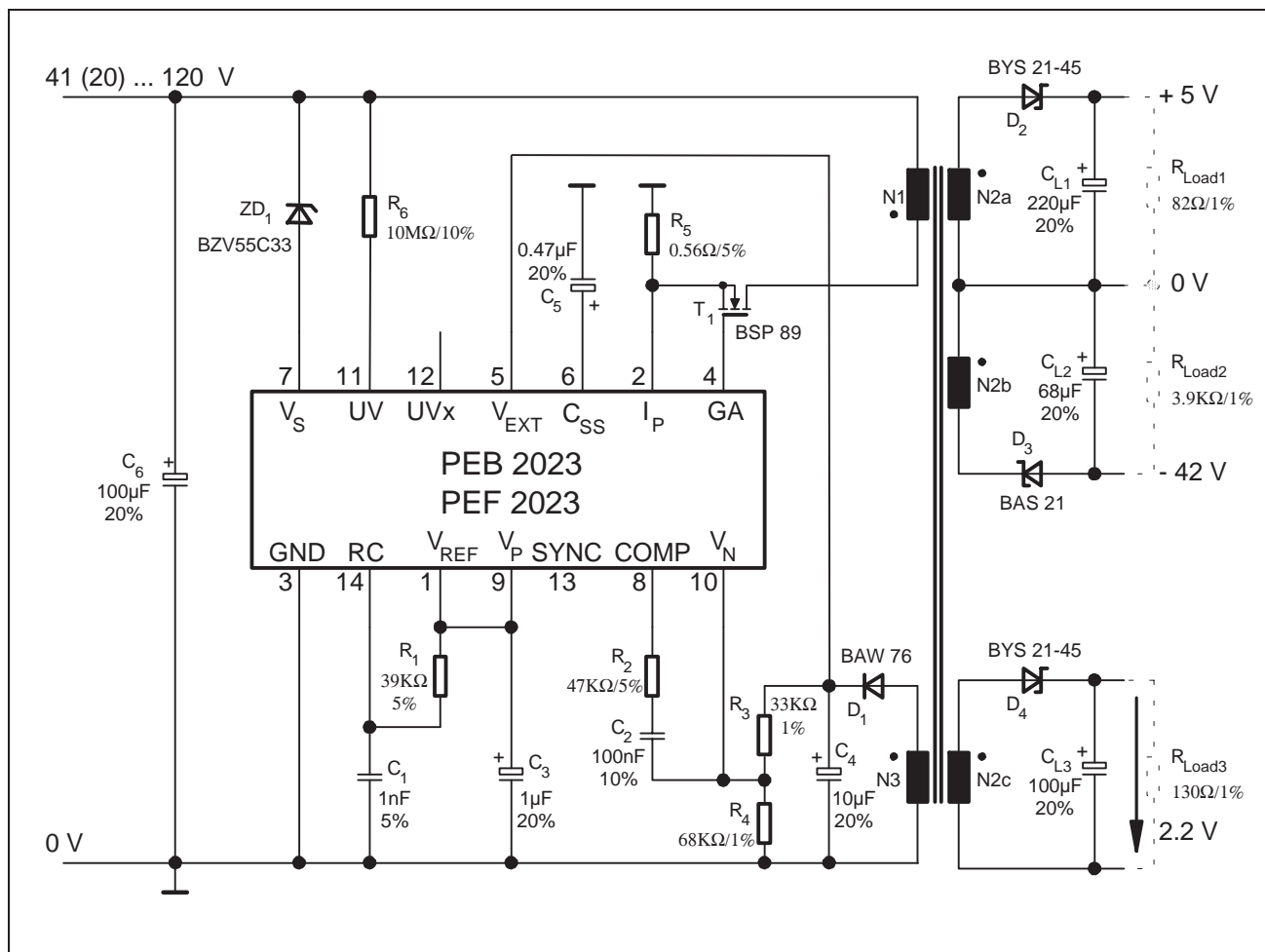


Figure 4  
PEB/F 2023 in Flyback Configuration with Transformer Isolation

Figure 5 shows the PEB/F 2023 in a non-isolated minimum configuration by using supply voltage range 1 (for this input voltages also supply voltage range 2 is possible). The voltage drop over  $R_6$  is the difference between input voltage and undervoltage detection level. To get low power dissipation the value of resistor  $R_6$  should be as high as possible. The minimum current through  $R_6$  is about 100nA, the maximum current is 1mA (see absolute maximum ratings).

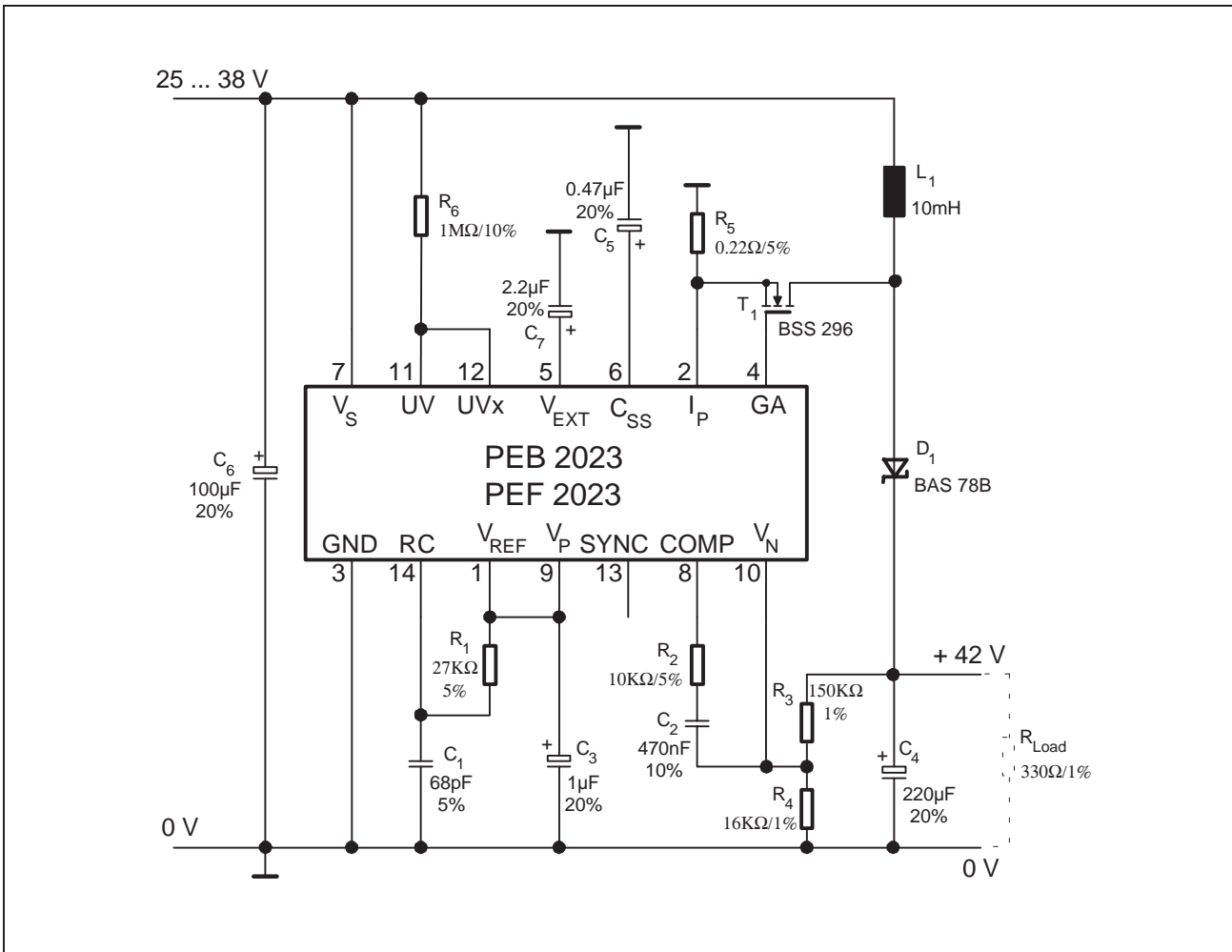


Figure 5  
PEB/F 2023 in a non-isolated Minimum Configuration

Figure 6 shows the PEB/F 2023 in a non-isolated flyback configuration with transformer using supply voltage range 0. The voltage drop over  $R_6$  is  $V_{EXT}-1V$ . To get low power dissipation the value of resistor  $R_6$ , should be as high as possible. For calculating the value of resistor  $R_6$  the minimum current through  $R_6$  is about 100nA and the maximum current is about 100μA.

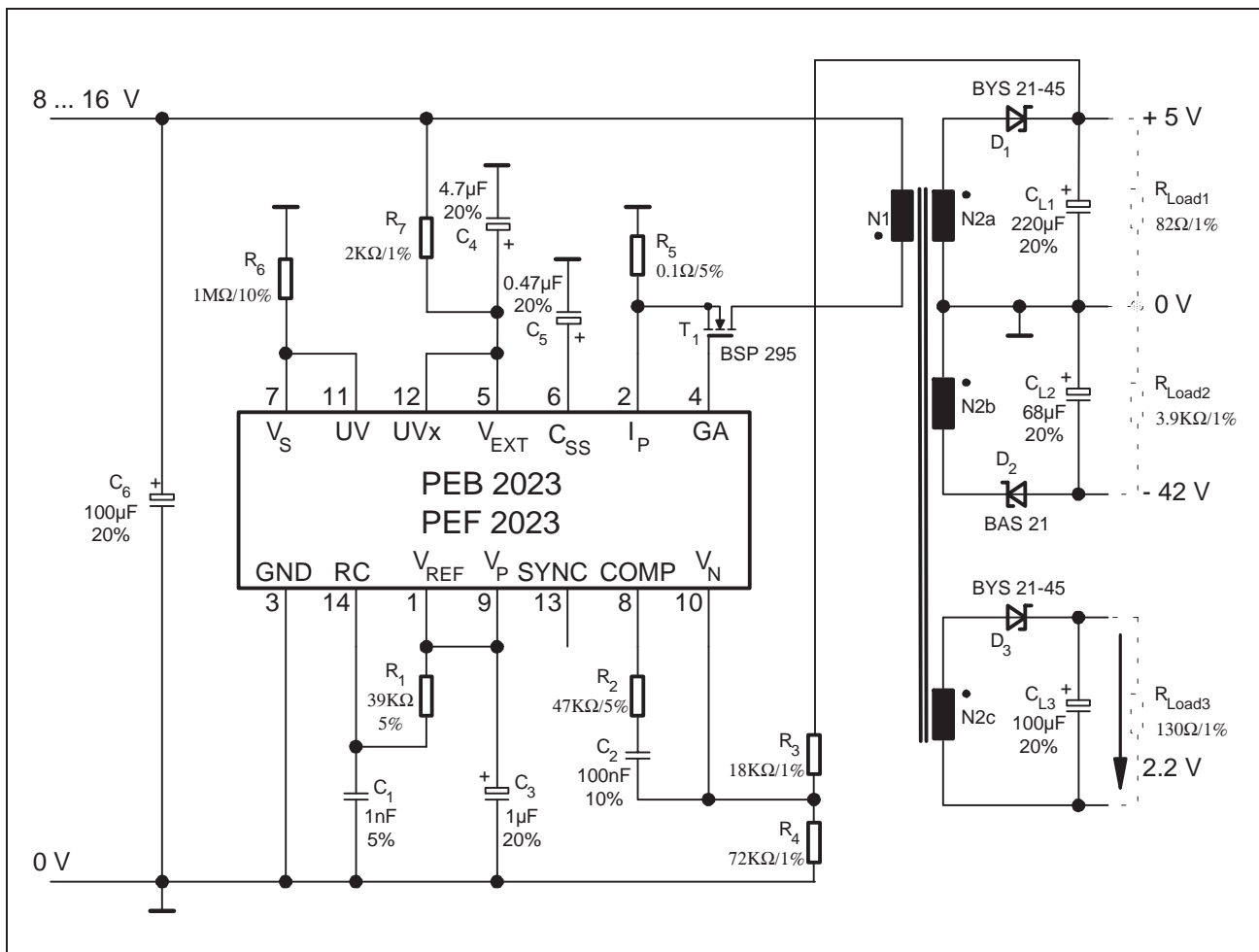
For calculation of resistor  $R_7$ :

$$\begin{aligned}
 V_{IN}, \text{ input voltage : } & V_{INmin} = 8V, & V_{INmax} &= 16V \\
 & V_{EXT} : & V_{EXTmin} &= 6V, & V_{EXTmax} &= 9V \\
 I_{R7}, \text{ input current : } & I_{R7min} = 1mA, & I_{R7max} &= 6mA
 \end{aligned}$$

$$R_{7min} = \frac{V_{INmax} - V_{EXTmax}}{I_{R7max}} = 1,667k\Omega \qquad R_{7max} = \frac{V_{INmin} - V_{EXTmin}}{I_{R7min}} = 2k\Omega$$

To get lower power dissipation the value of resistor  $R_7$  should also be as high as possible. For this reason we use  $R_{7max}$ . If in the calculation above  $R_{7min}$  is higher than  $R_{7max}$ , then the input voltage range is not correct;  $V_{INmax}-V_{INmin}$  is too large.

*Note: If  $V_{INmin} = 6V$  and  $V_{INmax} = 9V$  then the resistor  $R_7$  is not necessary. The input voltage  $V_{IN}$  can directly be connected to  $V_{EXT}$ .*



**Figure 6**  
**PEB/F 2023 in a non-isolated Flyback Configuration**

1.6 Surge Protection

In telephone and ISDN-systems the topic “surge protection” or “lightning overvoltage protection” is very important. For the PEB/F 2023 overvoltage protection is necessary when the DC/DC converter input supply voltage  $V_{IN}$  is connected to the U- or S-interface-lines.

Figure 7 shows how to protect the PEB/F 2023 when using supply voltage range 3 (see also figure 4). For supply voltage ranges 1 and 2 the principle is the same.

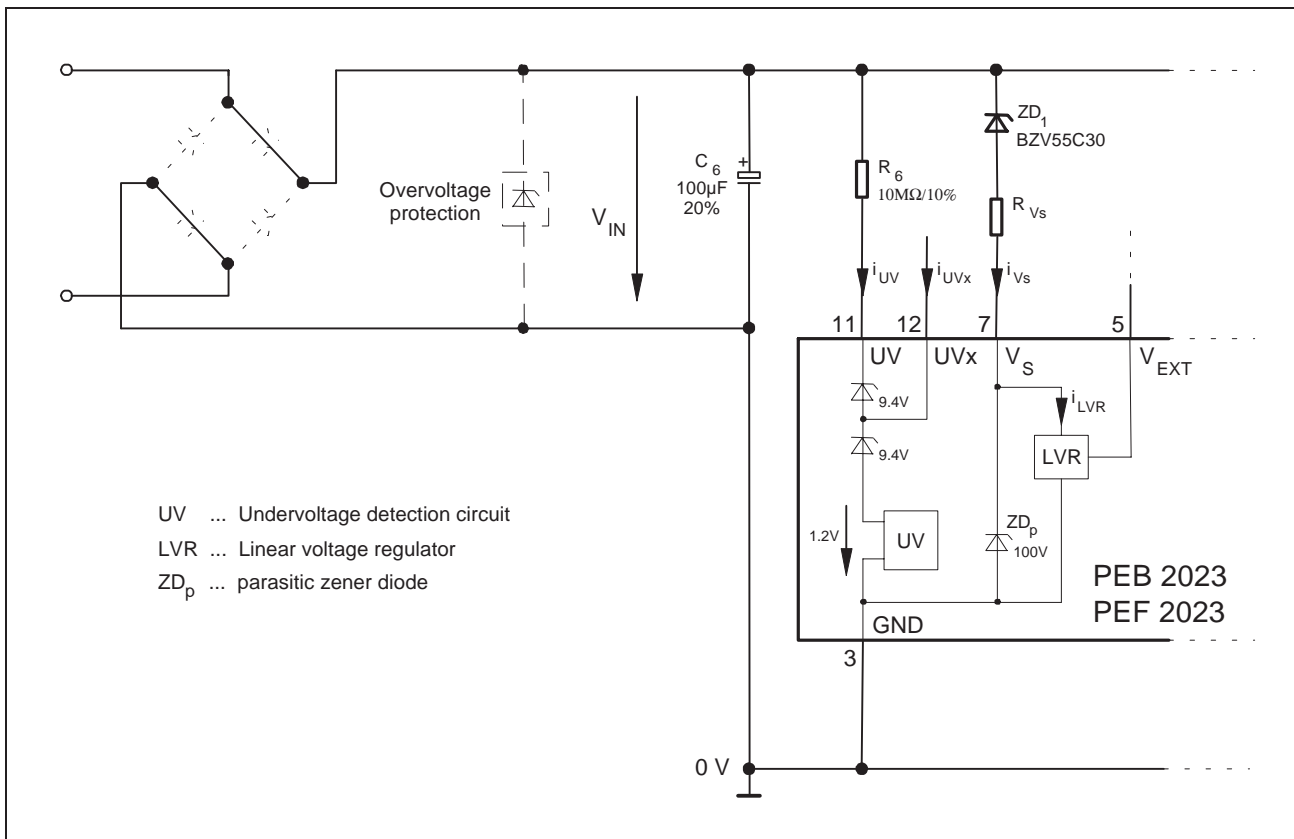


Figure 7  
PEB/F 2023 Surge Protection

The DC/DC converter begins operating when the input voltage exceeds  $V_{ZD1}+8V+V_{RVs}$ . In the start-up phase the PEB/F 2023 is supplied through  $V_S$ . After this start-up phase, the PEB/F 2023 is supplied via  $V_{EXT}$  (power housekeeping input, see figure 4) and the DC/DC-converter will operate until the input voltage falls below 20V (input undervoltage detection).

The current  $i_{LVR}$  needed in the start-up phase is less than 500µA. With this current and the value of resistor  $R_{Vs}$  the voltage  $V_{RVs}$  can be calculated.

For static and transient currents  $i_{UV}$  and  $i_{UVx}$ , respectively, absolute maximum ratings are valid. Because of the high value of  $R_6$  (for power saving reasons),  $i_{UV}$  and  $i_{UVx}$  normally are sufficiently low.

Limits for voltage and current on pin  $V_S$  are also defined in the maximum ratings.

Calculation example: figure 7 with  $R_{Vs} = 4,7k\Omega$

$$V_{INstart} = V_{ZD1} + 8 + (R_{Vs} \cdot i_{LVR}) = 30V + 8V + (4,7k\Omega \cdot 500\mu A) = 40,35V$$

for  $t \leq 100msec$ :

$$V_{INmax} = V_{ZD1} + 100 + (R_{Vs} \cdot i_{Vsmax}) = 30V + 100V + (4,7k\Omega \cdot 10mA) = 177V$$

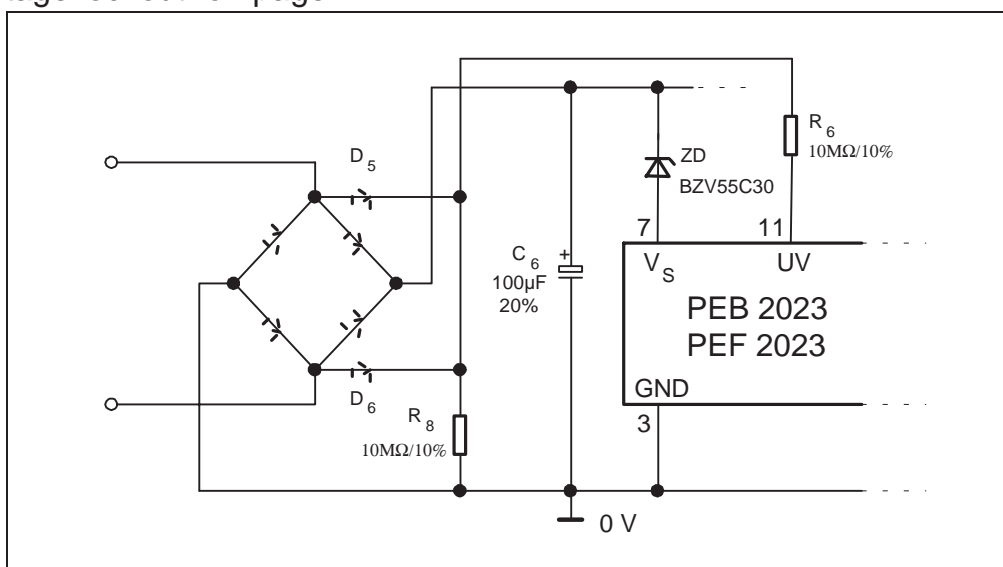
for  $t \leq 10msec$ :

$$V_{INmax} = V_{ZD1} + 100 + (R_{Vs} \cdot i_{Vsmax}) = 30V + 100V + (4,7k\Omega \cdot 30mA) = 271V$$

In this example the DC/DC converter begins operating when the input voltage exceeds 40,35V. The maximum transient input voltage is 177V / 271V for a duration of 100msec / 10msec. The maximum static input voltage is given by  $V_{ZD1} + 90V = 120V$ , see absolute maximum ratings.

## 1.7 Fast Input Undervoltage Detection

With three extra devices ( $D_5$ ,  $D_6$  and  $R_8$ , see **figure 8**) an undervoltage state on the input can be detected faster than the voltage on capacitor  $C_6$  decreases. See also chapter „undervoltage lockout“ on page 17.



**Figure 8**  
**PEB/F 2023, Fast Input Undervoltage Detection**

## 2 Functional Description

The PEB/F 2023 contains the following functional blocks:

- Supply and Biasing
- Undervoltage Detection
- Temperature Compensated Voltage Reference
- Sawtooth Oscillator
- Error Amplifier
- Pulse Width Modulator
- Digital Current Limiting
- Soft Start
- Control Logic (double pulse inhibit)
- Output Driver

The reference voltage provides 4V for the regulation loop. A high gain error amplifier compares the reference voltage to the output voltage. The output of the error amplifier is then compared to a periodic ramp, which is generated by the sawtooth-oscillator circuit. The comparator output is a fixed-frequency, variable pulse width logic signal, which passes through logic circuits and the output driver and out to the external high voltage power-switching-FET.

A digital current limiting device suppresses the PWM logic signal when the voltage difference between current limit sense input  $I_P$  and GND reaches 100 mV to protect the external power-switching-FET.

Non-isolated and isolated SMPS-configurations are possible. Logic and analog circuits are implemented in BICMOS in order to achieve low power dissipation.

### Start-Up Procedure

Before the switched-mode DC/DC converter starts, a sequence of several conditions has to be passed in order to avoid any system malfunction.

An integrated 6V linear voltage regulator supplies the internal low-voltage BICMOS-circuits from the input voltage  $V_S$ . The generated supply voltage is connected to pin  $V_{EXT}$  and has to be buffered by an external capacitor ( $C_{min} = 1\mu F$ ). Power dissipation of the linear voltage regulator can be reduced, if an external supply is used for that purpose by connecting it to pin  $V_{EXT}$ . If the input voltage at  $V_{EXT}$  is greater than 6.2V, the internal linear voltage regulator turns off and the internal BICMOS-circuits are then fed from the external voltage source (power housekeeping input  $V_{EXT}$ ). In this case, the input current at  $V_{EXT}$  is approximately 0.6mA.



---

**Functional Description**

**Note:** *An internal 9.4V zener diode protects the  $V_{EXT}$  input against overvoltages. The maximum zener current is 6mA! If the external supply isn't stabilized, the input current must be limited (e.g. by a resistor, see also supply voltage range 0)!*

**Supply Voltage Ranges**

Supply Voltage Range 0: 8V to 16V

In this supply voltage range the PEB/F 2023 can be supplied from a 12V battery. Connect the positive supply voltage via a resistor ( $R_7$  in figure 6) to pin  $V_{EXT}$  and pin  $V_S$  via a resistor ( $R_6$  in figure 6) to GND. Pin UV must be connected to pin  $V_S$ . Pin UVx must be connected to pin  $V_{EXT}$ . For calculating the values of the two resistors  $R_6$  and  $R_7$ , see the description of figure 6.

Supply Voltage Range 1: 12V to 80V

Connect the input voltage to pin  $V_S$  and via a resistor ( $R_6$  in figure 5) to pins UV and UVx. For calculating the value of this resistor see the description of figure 5.

Supply Voltage Range 2: 22V to 90V

Connect the input voltage to pin  $V_S$  and via a resistor to pin UV. Pin UVx is not connected (floating).

Supply Voltage Range 3:  $U_{ZD}+8V$  to  $U_{ZD}+90V$

Connect the input voltage via a zener diode (minimum zener voltage  $U_{ZD} = 14V$ ) to pin  $V_S$  and via a resistor ( $R_6$  in figure 4) to pin UV. Pin UVx is not connected (floating).

**Undervoltage Lockout**

At the undervoltage detection pin UV, a resistor with a value of about 100k $\Omega$ ..10M $\Omega$  is required to protect this pin against high currents (see absolute maximum ratings). The level of undervoltage detection when using supply voltage range 1 is 8V..12V, using supply voltage range 2 or 3, it is 18V..22V. To get a higher undervoltage detection level a zener diode in series with the resistor is required.

When the PEB/F 2023 detects an undervoltage condition, the gate output driver will be turned off. The DC/DC conversion is disabled and the PEB/F 2023 shows a high input impedance seen from the undervoltage detection pins (UV, UVx) and from pin  $V_S$  to GND. Also the voltage on  $V_{EXT}$  will decrease. When the undervoltage condition is removed, the DC/DC converter will be enabled once again with a soft start.

**Note:** *When using supply voltage range 0 the undervoltage detection circuit is not working. The resistor connected between  $V_S$  and GND bypasses this undervoltage detection circuit ( $R_6$  in figure 6).*

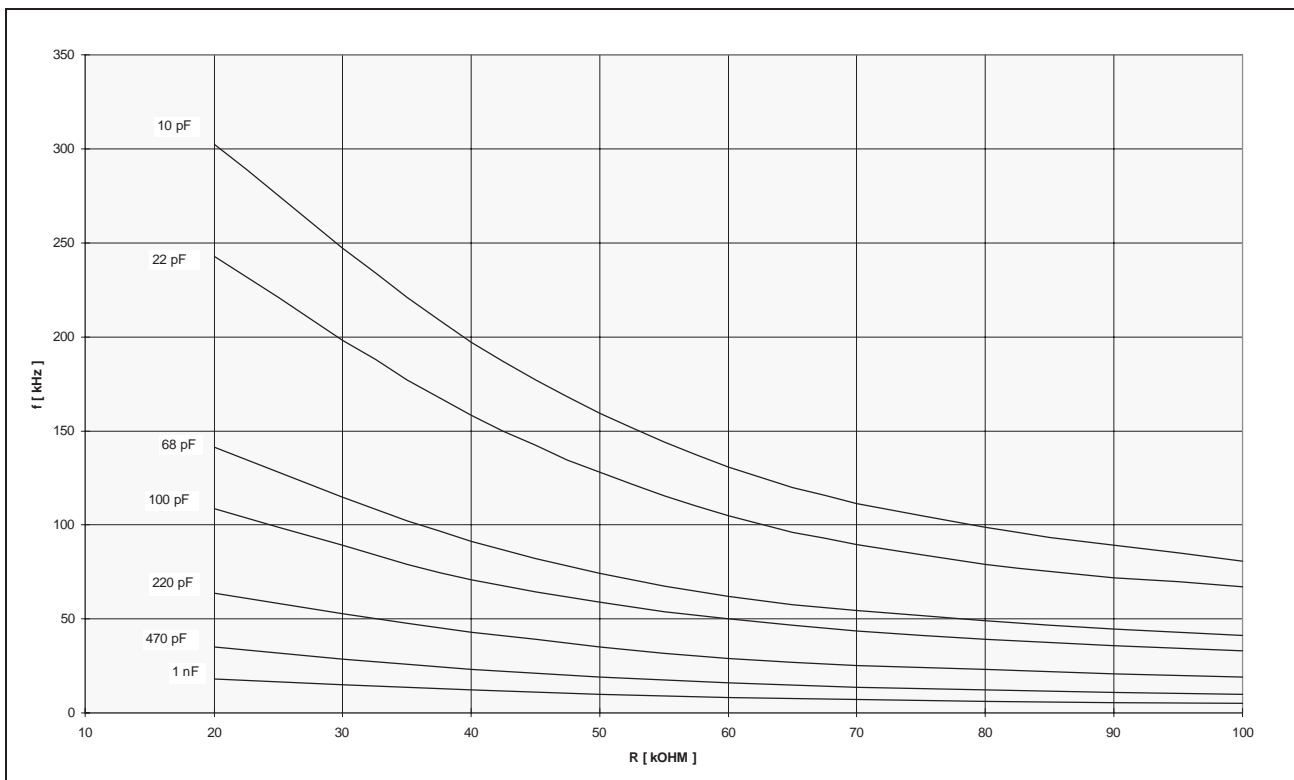
### Voltage Reference

The reference regulator of the PEB/F 2023 is based on a temperature compensated bandgap. This circuitry is fully active at supply voltages (pin  $V_{EXT}$ ) above 6 volts and provides up to 0.5mA of load current to external circuitry at 4 volts. This reference has to be buffered by an external capacitor ( $C_{min} = 1\mu F$ ).

### Sawtooth Oscillator

The oscillator frequency is programmed by the two components  $R_1$  and  $C_1$  (see figure 4, 5 or 6). The oscillator timing capacitor  $C_1$  is charged by  $V_{REF}$  through  $R_1$  and discharged by an internal 10kΩ discharge-resistor. The rise-time of the sawtooth oscillator can be programmed with  $R_1$  and  $C_1$ . The internal discharge-resistor and  $C_1$  define the fall-time. At the beginning of the discharge period a positive synchronization pulse is generated at pin SYNC. Otherwise the PEB/F 2023 can be synchronized via pin SYNC to an external logic clock by programming the oscillator to free run at a frequency 10% lower than the synchronization frequency. The PEB/F 2023 is synchronized by the rising edge of the sync. signal. So multiple devices can be synchronized together by programming one master unit for the desired frequency (only one possible interfering frequency).

Note that the frequency of the output driver is half the oscillator frequency. The switching frequency as a function of  $R_1$  and  $C_1$  is shown in **figure 9**.



**Figure 9**  
**Switching Frequency**

### Error Amplifier

Conventional operational amplifier for closed-loop gain and phase compensation.  
Low output impedance: unity-gain stable.

### Pulse Width Modulator

The pulse width modulator compares the sawtooth-voltage of the oscillator output with the output of the error amplifier and with the voltage of the external soft start capacitor at pin  $C_{SS}$ .

### Current Limiting

When the sense voltage reaches a threshold voltage of 100mV a shutdown signal is sent to the control logic. Sense voltage is the voltage between pin  $I_P$  and pin GND. Because of the small value of the current-sensing-resistor ( $R_5$  in figure 4, 5 or 6) the board layout has to be done carefully.

### Soft Start

The soft start circuit protects the power transistors and rectifier diodes from high current surges during power supply turn-on. When the supply voltage is connected to the PEB/F 2023 the undervoltage lockout circuit holds the soft start capacitor voltage at zero. When the supply voltage reaches the normal operating range, an internal 1.5 $\mu$ A current source will charge the external soft start capacitor. As the soft start voltage ramps up to +5 volts, the duty cycle of the PWM linearly increases to whatever value the regulation loop requires.

### Control Logic

The control logic inhibits double pulses during one duty cycle and limits the maximum duty cycle to 50%.

### Disable Input Realization

One way to disable the function of the PEB/F 2023 is to connect an external n-channel MOS-transistor between the pins UV(drain) and GND(source). By switching on this external transistor the PEB/F 2023 detects an 'undervoltage' and turns off. After switching off this external transistor the PEB/F 2023 turns on and starts the DC/DC conversion with a soft start.

A second possibility is to connect an external n-channel MOS-transistor between the pins  $C_{SS}$ (drain) and GND(source). By switching on this external transistor the PEB/F 2023 disables the gate output driver because of the soft start circuitry. After switching off this external transistor the PEB/F 2023 turns on and starts the DC/DC conversion with a soft start.

Electrical Characteristics

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

| Parameter   | Symbol                                 | Limit Values |                 | Unit     | Test Condition                        |
|---|--|--------------|-----------------|----------|---------------------------------------|
|   |  | min.         | max.            |          |                                       |
| Supply voltage (pin $V_S$ ) for sup. voltage range 1                | $V_{S1}$                               | -0.3         | 80              | V        | Referred to GND                       |
| Supply voltage (pin $V_S$ ) for sup. voltage range 2 or 3           | $V_{S2,3}$                             | -0.3         | 90              | V        | Referred to GND                       |
| Transient input current on pin $V_S$ (sup. voltage range 1, 2 or 3) | $i_{V_S}$                              | -10<br>-30   | 10<br>30        | mA<br>mA | $t \leq 100$ msec<br>$t \leq 10$ msec |
| Analog input voltage (pins $I_P$ , COMP, $V_P$ , $V_N$ , SYNC, RC)  | $V_{IA}$                               | -0.3         | $V_{EXT} + 0.3$ | V        | Referred to GND                       |
| Reference output current (pin $V_{REF}$ )                           | $I_{O REF}$                            |              | 5               | mA       |                                       |
| SYNC-output current (pin SYNC)                                      | $I_{O SYNC}$                           |              | 5               | mA       |                                       |
| Error amplifier output current (pin COMP)                           | $I_{O COMP}$                           |              | 5               | mA       |                                       |
| Z-current (pin $V_{EXT}$ )  | $I_{Z EXT}$                            |              | 6               | mA       |                                       |
| Output current (pin $V_{EXT}$ )                                     | $I_{O EXT}$                            |              | 6               | mA       |                                       |
| Driver output current (pin GA)                                      | $I_{O DR}$                             |              | 25              | mA       |                                       |
| Undervoltage detection input currents (pins UV, UVx)                | $I_{UV}, I_{UVx}$<br>$i_{UV}, i_{UVx}$ | -10          | 1<br>10         | mA<br>mA | $t \leq 10$ msec                      |
| Junction temperature  | $T_j$                                  | 0            | 150             | °C       |                                       |
| Storage temperature   | $T_{stg}$                              | -40          | 150             | °C       |                                       |
| ESD-voltage, all pins   |  |              | 1               | kV       | Human body model                      |

Note: Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the integrated circuit.

Note: If not otherwise stated than this absolute maximum values are static values. For overvoltage protection (pin  $V_S$  respectively UV and UVx) see chapter 1.6 Surge Protection.

## Electrical Characteristics

### 3.2 Operating Range

| Parameter   | Symbol     | Limit Values |      | Unit | Test Condition  |
|---|------------|--------------|------|------|-----------------|
|   |            | min.         | max. |      |                 |
| Ambient temperature under bias                            |            |              |      |      |                 |
| PEB 2023  | $T_A$      | 0            | 70   | °C   |                 |
| PEF 2023  | $T_A$      | -40          | 85   | °C   |                 |
| Supply voltage (pin $V_S$ ) for sup. voltage range 1      | $V_{S1}$   | 12           | 80   | V    | Referred to GND |
| Supply voltage (pin $V_S$ ) for sup. voltage range 2 or 3 | $V_{S2,3}$ | 8            | 90   | V    | Referred to GND |

*Note:* In the operating range the functions given in the circuit description are fulfilled.

### 3.3 Static Thermal Resistance

| Parameter           | Symbol      | Limit Values |      | Unit | Test Condition |
|---------------------|-------------|--------------|------|------|----------------|
|                     |             | min.         | max. |      |                |
| Junction to ambient | $R_{th,jA}$ |              | 112  | K/W  | P-DSO-14       |

**Electrical Characteristics**

**3.4 DC Characteristics**

| Parameter                         | Symbol | Limit Values |      |      | Unit          | Test Condition   |
|-----------------------------------|--------|--------------|------|------|---------------|--|
|                                   |        | min.         | typ. | max. |               |  |
| Supply current (pin $V_S$ to GND) | $I_S$  |              | 6    | 12   | $\mu\text{A}$ | $V_{\text{EXT}} = 6.2\text{V}$ ,<br>$V_S = 40\text{V}$ |

**Reference  $V_{\text{REF}}$**

|                       |                       |      |     |      |    |   |
|-----------------------|-----------------------|------|-----|------|----|---|
| Output voltage        | $V_{\text{REF O}}$    | 3.96 | 4.0 | 4.04 | V  | $T_A = 25^\circ\text{C}$ ,<br>$I_L = 0\text{mA}$ , $V_S = 40\text{V}$               |
| Line regulation       | $V_{\text{REF Line}}$ |      | 0.1 | 5    | mV | $T_A = 25^\circ\text{C}$ ,<br>$V_S = 25$ to $65\text{V}$ ,<br>$I_L = 0\text{mA}$ ,  |
| Load regulation       | $V_{\text{REF Load}}$ |      | 2   | 5    | mV | $T_A = 25^\circ\text{C}$ ,<br>$I_L = 0.1$ to $0.3\text{mA}$ ,<br>$V_S = 40\text{V}$ |
| Temperature stability | $V_{\text{REF TS}}$   |      | 10  | 20   | mV | $T_A = -40$ to $85^\circ\text{C}$ ,<br>$I_L = 0\text{mA}$ , $V_S = 40\text{V}$      |

**Oscillator SYNC, RC**

$f_{\text{OSC}} = 20\text{kHz}$ ,  $R_T = 39\text{k}\Omega \pm 1\%$ ,  $C_T = 1\text{nF} \pm 1\%$

|   |                            |     |           |          |     |   |
|---|----------------------------|-----|-----------|----------|-----|---|
| Initial accuracy                          | $\Delta f_O$               |     | $\pm 5$   | $\pm 10$ | %   | $T_A = 25^\circ\text{C}$ ,<br>$V_S = 40\text{V}$          |
| Voltage stability of $f_{\text{OSC}}$     | $\Delta f_{\text{O Line}}$ |     | $\pm 0.1$ | $\pm 1$  | %   | $T_A = 25^\circ\text{C}$ ,<br>$V_S = 25$ to $65\text{V}$  |
| Temperature stability of $f_{\text{OSC}}$ | $\Delta f_{\text{O TS}}$   |     |           | $\pm 5$  | %   | $T_A = -40$ to $85^\circ\text{C}$ ,<br>$V_S = 40\text{V}$ |
| Max. frequency                            | $f_{\text{max}}$           | 550 |           |          | kHz | $R_T = 20\text{k}\Omega$ , $C_T = 10\text{pF}$            |
| H-sawtooth voltage                        | $V_H$                      | 3.0 | 3.2       | 3.4      | V   |   |
| L-sawtooth voltage                        | $V_L$                      | 1.6 | 1.8       | 2.0      | V   |   |
| H-sync output level                       | $V_{\text{SYNCH}}$         | 2.4 | 3.5       | 5.25     | V   | $I_L = 0.5\text{mA}$ ,<br>$V_{\text{EXT}} = 6.2\text{V}$  |
| L-sync output level                       | $V_{\text{SYNCL}}$         |     | 0.2       | 0.8      | V   | $I_L = 20\mu\text{A}$                                     |

**Pulse Width Modulator**

|            |       |   |  |    |   |  |
|------------|-------|---|--|----|---|--|
| Duty cycle | $t_d$ | 0 |  | 50 | % |  |
|------------|-------|---|--|----|---|--|

**Soft Start  $C_{\text{SS}}$**

|                  |       |   |     |   |               |                              |
|------------------|-------|---|-----|---|---------------|------------------------------|
| Charging current | $I_C$ | 1 | 1.5 | 2 | $\mu\text{A}$ | $V_{\text{CSS}} = 0\text{V}$ |
|------------------|-------|---|-----|---|---------------|------------------------------|

Electrical Characteristics

DC Characteristics (cont'd)

| Parameter | Symbol | Limit Values |      |      | Unit | Test Condition |
|-----------|--------|--------------|------|------|------|----------------|
|           |        | min.         | typ. | max. |      |                |

**Error Amplifier**

**COMP,  $V_P$ ,  $V_N$**

|  |           |     |      |     |     |                    |
|--|-----------|-----|------|-----|-----|--------------------|
| Input offset voltage                             | $V_{IO}$  | -10 |      | 10  | mV  | $V_{CM} = 3.0V$    |
| Input current                                    | $I_I$     |     | 25   | 50  | nA  |                    |
| Common mode range                                | $V_{CMR}$ | 1.8 |      | 4.5 | V   |                    |
| DC open loop gain                                | $G_{VO}$  | 60  | 70   |     | dB  |                    |
| Common mode rejection                            | $k_{CMR}$ | 60  | 70   |     | dB  | $f \leq 10kHz$     |
| Unity gain bandwidth                             | $f$       | 0.5 | 1    |     | MHz | $C_L$ (pin) = 10pF |
| Supply voltage rejection<br>$V_{EXT} / V_{COMP}$ | $k_{SVR}$ | 60  | 70   |     | dB  | $f \leq 10kHz$     |
| H-output voltage                                 | $V_{OH}$  | 4.5 |      |     | V   | $I_L = 100\mu A$   |
| L-output voltage                                 | $V_{OL}$  |     | 0.02 | 0.1 | V   | $I_L = 10\mu A$    |

**Current Limit Comparator  $I_P$**

$T_A = 25^\circ C$

|                              |             |    |     |     |         |                             |
|------------------------------|-------------|----|-----|-----|---------|-----------------------------|
| Sense voltage                | $V_{Sense}$ | 90 | 100 | 110 | mV      | $V_S = 40V$                 |
| PEB 2023                     | $V_{Sense}$ | 85 | 100 | 115 | mV      | $V_S = 40V$                 |
| PEF 2323                     | $V_{Sense}$ |    |     |     |         |                             |
| Input bias current           | $I_I$       |    | -25 | -40 | $\mu A$ | $V_{IP} = 0V$               |
| Input voltage range          | $V_I$       | 0  |     | 1   | V       |                             |
| Response time (signal at GA) | $t_{Res}$   |    | 250 | 500 | ns      | $I_P = 0 \rightarrow 200mV$ |

**Output Driver GA**

$T_A = 25^\circ C$ ,

|                        |          |     |     |           |    |   |
|------------------------|----------|-----|-----|-----------|----|---|
| H-output voltage       | $V_{OH}$ | 4.5 |     | $V_{EXT}$ | V  | $I_{Source} = 20mA$ ,<br>$V_{EXT} = 6.2V$ |
| L-output voltage       | $V_{OL}$ |     | 0.3 | 0.4       | V  | $I_{Sink} = 20mA$                         |
| Rise time (10% to 90%) | $t_r$    |     | 50  | 200       | ns | $C_L = 800pF$ ,<br>$V_{EXT} = 6.2V$       |
| Fall time (90% to 10%) | $t_f$    |     | 50  | 200       | ns | $C_L = 800pF$ ,<br>$V_{EXT} = 6.2V$       |

## Electrical Characteristics

### DC Characteristics (cont'd)

| Parameter | Symbol | Limit Values |      |      | Unit | Test Condition |
|-----------|--------|--------------|------|------|------|----------------|
|           |        | min.         | typ. | max. |      |                |

### Undervoltage Detection UV, UVx

|                        |                 |    |    |    |   |                             |
|------------------------|-----------------|----|----|----|---|-----------------------------|
| Start-up threshold 1   | $V_{UV\ St1}$   | 8  | 10 | 12 | V | supply voltage range 1      |
| Start-up threshold 2,3 | $V_{UV\ St2,3}$ | 18 | 20 | 22 | V | supply voltage range 2 or 3 |

### External Supply $V_{EXT}$

|                |       |     |     |     |    |  |
|----------------|-------|-----|-----|-----|----|--|
| Output voltage | $V_O$ | 5.8 | 6.0 | 6.2 | V  |  |
| Output current | $I_O$ |     |     | 2   | mA |  |
| Input voltage  | $V_I$ | 6.2 |     | 9   | V  |  |
| Z-current      | $I_Z$ |     |     | 6   | mA |  |

### General Parameters, $T_A = 25^\circ\text{C}$

|                              |           |  |   |    |               |   |
|------------------------------|-----------|--|---|----|---------------|---|
| Power consumption            | $P_{tot}$ |  | 5 | 6  | mW            | $V_S = 40\text{V}$ ,<br>$f_{OSC} = 20\text{kHz}$ ,<br>$C_{L\ GATE} = 470\text{pF}$ ,<br>$V_{EXT} = 6.2\text{ to }6.7\text{V}$ |
| High impedance input current | $I_{HI}$  |  |   | 10 | $\mu\text{A}$ | „undervoltage“  |

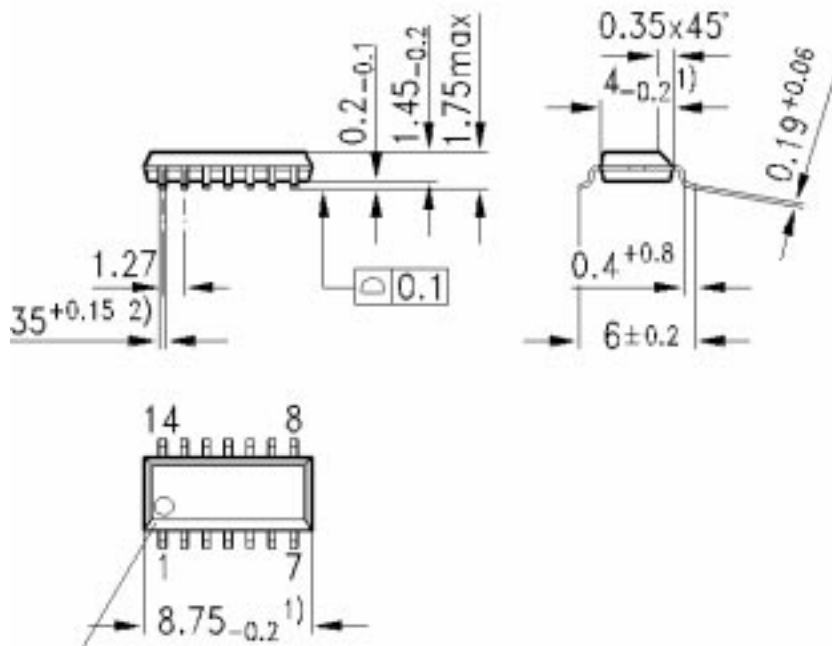
*Note: The listed characteristics are ensured over the operating range of the integrated circuit. Typical characteristics specify mean values expected over the production spread. If not otherwise specified, typical characteristics apply at  $T_A = 25^\circ\text{C}$  and the given supply voltage.*



4 Package Outlines

Plastic Package, P-DSO-14

(Plastic Dual Small Outline)



Index Marking

- 1) Does not include plastic or metal protrusions of 0.15 max per side
- 2) Does not include dambar protrusion of 0.05 max per side