AN10405

Increased circuit efficiency, less required board space and saved money by replacing power transistors by low VCEsat (BISS) transistors

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Document information

Info	Content
Keywords	Bipolar transistors, BISS, low V_{CEsat}, PBSS, power transistors
Abstract	This application note provides information on how to make use of a cost saving opportunity by replacing older medium power and power transistors by Philips' low V_{CEsat} (BISS) transistors. A cross reference table provides a cross reference for leaded and SMD types. Further spreadsheets show a comparison of the most common parameters (V_{CEO}, I_C, V_{CEsat} and h_{FE}).

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1. Introduction

This application note provides information on how to make use of a cost saving opportunity by replacing older medium power and power transistors by Philips' low V_{CEsat} (BISS) transistors[1]. A cross reference table provides a cross reference for leaded and SMD types. Further spreadsheets show a comparison of the most common parameters (V_{CEO}, I_C, V_{CEsat} and h_{FE}).

2. Reduced power dissipation due to low saturation voltage

The low saturation voltage V_{CEsat}, high collector current capability $I_{C(max)}$ and high current gain h_{FE} make BISS transistors an excellent alternative to older medium power transistors in SOT54 (TO-92), SOT223 (SC-73) and SOT89 (SC-62) and power transistors in DPAK, TO-220 and TO-126. Particularly, for switching applications the transistors' power dissipation is significantly lower due to a low collector-emitter saturation voltage as the following example shows:

Table 1: BISS transistors dissipate less power enabling to select smaller and cheaper packages

Example	Power transistor	BISS transistor
Type	BD132	PBSS5350S
Package	SOT32 (TO-126)	SOT54 (TO-92)
I_C	2 A	2 A
V_{CEsat}	700 mV	300 mV
$P_C = V_{CEsat} \times I_C$	1400 mW	600 mW
$h_{FE(min)}$	20	100

Due to the lower power dissipation transistors with a smaller package can be selected. The PBSS5350S in SOT54 (TO-92) for example replaces a BD132 in TO-126. Keeping in mind that for discrete semiconductors package costs are higher than the cost for the silicon savings can be realized by using small SOT54 BISS transistors. Additionally, the circuit efficiency increases and less board space is necessary.

Further, BISS transistors present a higher current gain h_{FE}. As a result, less base current is required to control the transistor which takes load from the driving circuit.

While for switching applications V_{CEsat} is very low, the higher V_{CE} for linear applications leads to a higher power dissipation. A replacement with BISS transistors is limited to 830 mW for leaded BISS transistors and to 1350 mW for surface mount applications (2 W for SOT223 transistors on 6 cm^2 collector mounting pad).

[1] More information on low V_{CEsat} (BISS) transistors is given in the following application notes:
AN10116: Breakthrough In Small Signal - Low V_{CEsat} (BISS) Transistors and their Applications
AN10393: BISS transistors and MEGA Schottky rectifiers – improved technologies for discrete semiconductors

Only a few BISS transistor types are necessary to replace numerous power transistors:

- PBSS8110_ / PBSS9110_ 1 A / 100 V and
- PBSS4350_ / PBSS5350_ 3 A / 50 V replace

- power transistors with 1 – 3 A rated collector current.

- PBSS4540Z / PBSS5540Z 5 A / 40 V and
- PBSS302ND / PBSS302PD 4 A / 40 V replace

- power transistors with 4 – 5 A rated collector current.

Table 19: - Table 24: show the most common parameters of these types for reference.

3. Common replacements

Many popular transistors are included in the cross reference table (Table 2:). Main cross reference data given in Table 3: – Table 18: are provided to confirm the selection. For SMD replacements these tables provide up to three alternatives with the same electrical but different thermal specifications. This enables to use the smallest package possible depending on the actual power dissipation.

The BISS transistors in Table 2: are selected with focus on reducing the number of types. This implies that the provided replacement must not necessarily be the optimum solution with regard to the achievable power dissipation.

4. General selection process

For transistors not included in the cross reference table the following steps need to be done by comparing the data sheets:

1. Limiting values, V_{CEO}: BISS transistors must have equal or higher value.
2. Limiting values, I_C: BISS transistors must have equal or higher value.
3. Characteristics, $V_{CEsat(max)}$: BISS transistors must have equal or lower value, pay attention to comparable operating conditions I_C and I_B. Notes to V_{CEsat}:
   - This parameter is mostly important for switching applications (i.e. not relevant for linear applications).
   - The lower the ratio I_C/I_B the lower the saturation voltage but the higher the required base current.
   - V_{CEsat} values of BISS transistors are far below the values of power transistors.
4. Characteristics, $h_{FE(min)}$: BISS transistors must have equal or higher value, pay attention to comparable operating conditions I_C and V_{CE}. Notes to h_{FE}:
   - This parameter is important for linear and switching applications.
   - The higher V_{CE} the higher the current gain at a specified current.
   - h_{FE} values of BISS transistors are far above the values of power transistors.
5. Calculate resulting power dissipation P_{tot} to select the most appropriate package.
   - Switching applications: $P_{tot} = V_{CEsat} \times I_C + V_{BEsat} \times I_B$
   - Linear applications: $P_{tot} = V_{CE} \times I_C + V_{BE} \times I_B$

   Notes to P_{tot}:
   - For a rough estimation the input power dissipation ($V_{BE(sat)} \times I_B$) can be neglected.
   - For linear applications power dissipation may become an issue since V_{CE} is significantly higher than V_{CEsat} in switching applications.
   - For the package selection the mounting conditions must be considered:

SOT54	0.83 W
SOT223*)	1 – 1.35 W
SOT89*)	1 W
SOT457*)	0.6 W
SOT23*)	0.48 W

*) Mounted on 1 cm² collector mounting pad

   - For switching applications a high power dissipation capability of the package is often not necessary anymore since the heat generation is much lower using BISS transistors due to the very low V_{CEsat} values.
   - An even lower power dissipation due to lower V_{CEsat} values can be achieved by selecting BISS transistors with a lower V_{CEO} value. For example if the application requires only 20 V breakdown voltage, a 20 V transistor should be used instead of a 40 V transistor.

For most of the medium power and power transistors the types given in Table 19:– Table 24: should be sufficient. If not please look for data sheets of transistors starting with “PBSS” on the Internet or contact your nearest Philips sales office.

5. Cross reference table for common replacements

Table 2: Cross reference table for replacing (medium) power by BISS transistors

original type	replacement				
	SOT54	SOT223	SOT457	SOT23	cross ref. data
BC635	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BC636	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BC637	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BC638	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BC639	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BC640	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCP51	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCP52	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCP53	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCP54	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BCP55	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BCP56	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BCX51	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCX52	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCX53	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 11
BCX54	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BCX55	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BCX56	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 3
BD131	PBSS4350S	PBSS4350Z	PBSS4350D		Table 7
BD132	PBSS5350S	PBSS5350Z	PBSS5350D		Table 15
BD135	PBSS4350S	PBSS4350Z	PBSS4350D		Table 5
BD136	PBSS5350S	PBSS5350Z	PBSS5350D		Table 13
BD137	PBSS4350S	PBSS4350Z	PBSS4350D		Table 5
BD138	PBSS5350S	PBSS5350Z	PBSS5350D		Table 13
BD139	PBSS4350S	PBSS4350Z	PBSS4350D		Table 5
BD140	PBSS5350S	PBSS5350Z	PBSS5350D		Table 13
BD329	PBSS4350S	PBSS4350Z	PBSS4350D		Table 8
BD330	PBSS5350S	PBSS5350Z	PBSS5350D		Table 16
BD433		PBSS4540Z	PBSS302ND		Table 10
BD434		PBSS5540Z	PBSS302PD		Table 18
BD435		PBSS4540Z	PBSS302ND		Table 10
BD436		PBSS5540Z	PBSS302PD		Table 18
KSH200		PBSS4540Z			Table 9
KSH210		PBSS5540Z			Table 17
KSH31	PBSS4350S	PBSS4350Z	PBSS4350D		Table 6
KSH32	PBSS5350S	PBSS5350Z	PBSS5350D		Table 14
MJD148		PBSS4540Z	PBSS302ND		Table 10

original type	replacement				
	SOT54	SOT223	SOT457	SOT23	cross ref. data
MJD200		PBSS4540Z			Table 9
MJD210		PBSS5540Z			Table 17
MJD31	PBSS4350S	PBSS4350Z	PBSS4350D		Table 6
MJD32	PBSS5350S	PBSS5350Z	PBSS5350D		Table 14
TIP29	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 4
TIP29A	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 4
TIP29B	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 4
TIP29C	PBSS8110S	PBSS8110Z	PBSS8110D	PBSS8110T	Table 4
TIP30	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 12
TIP30A	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 12
TIP30B	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 12
TIP30C	PBSS9110S	PBSS9110Z	PBSS9110D	PBSS9110T	Table 12
TIP31	PBSS4350S	PBSS4350Z	PBSS4350D		Table 6
TIP32	PBSS5350S	PBSS5350Z	PBSS5350D		Table 14

6. Basic cross reference data, NPN transistors

Table 3:

	original type leaded	SMD		replacement leaded	SMD	
type	**BC635 BC637 BC639**	**BCP54 BCP55 BCP56**	**BCX54 BCX55 BCX56**	**PBSS8110S**	**PBSS8110D**	**PBSS8110T**
package	SOT54	SOT223	SOT89	SOT54	SOT457	SOT23
P_{tot}	830 mW	1000 mW*)	850 mW*)	830 mW	600 mW*)	480 mW*)
V_{CEO}	45 / 60 / 80 V			100 V		
I_C	1 A			1 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 0,5 A, I_B = 50 mA		120 mV	@ I_C = 0,5 A, I_B = 50 mA	
$h_{FE(min)}$	63	@ I_C = 0,15 A, V_{CE} = 2 V		150	@ I_C = 0,25 A, V_{CE} = 10 V	
	40	@ I_C = 0,5 A, V_{CE} = 2 V		100	@ I_C = 0,5 A, V_{CE} = 10 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 4:

	original type leaded			replacement leaded	SMD	
type	**TIP29 TIP29A TIP29B TIP29C**			**PBSS8110S**	**PBSS8110Z**	**PBSS8110T**
package	TO-220AB			SOT54	SOT223	SOT23
P_{tot}	2000 mW			830 mW	1000 mW*)	480 mW*)
V_{CEO}	40 / 60 / 80 / 100 V			100 V		
I_C	1 A			1 A		
$V_{CEsat(max)}$	700 mV	@ I_C = 1 A, I_B = 125 mA		200 mV	@ I_C = 1 A, I_B = 100 mA	
$h_{FE(min)}$	40	@ I_C = 0,2 A, V_{CE} = 4 V		150	@ I_C = 0,25 A, V_{CE} = 10 V	
	15	@ I_C = 1 A, V_{CE} = 4 V		80	@ I_C = 1 A, V_{CE} = 10 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 5:

	original type leaded		replacement leaded	SMD	
type	**BD135 BD137 BD139**		**PBSS4350S**	**PBSS4350Z**	**PBSS4350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}	1250 mW		830 mW	1350 mW*)	600 mW*)
V_{CEO}	45 / 60 / 80 V		50 V		
I_C	1,5 A		3 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 0,5 A, I_B = 50 mA	90 mV	@ I_C = 0,5 A, I_B = 50 mA	
$h_{FE(min)}$	25	@ I_C = 0,5 A, V_{CE} = 2 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 6:

	original type leaded	SMD	replacement leaded	SMD	
type	**TIP31**	**MJD31 KSH31**	**PBSS4350S**	**PBSS4350Z**	**PBSS4350D**
package	TO-220	TO-252 DPAK	SOT54	SOT223	SOT457
P_{tot}	2000 mW	1560 mW	830 mW	1350 mW*)	600 mW*)
V_{CEO}	40 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	1200 mV	@ I_C = 3 A, I_B = 375 mA	290 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	25	@ I_C = 1 A, V_{CE} = 4 V	200	@ I_C = 1 A, V_{CE} = 2 V	
	10	@ I_C = 3 A, V_{CE} = 4 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 7:

	original type leaded		replacement leaded	SMD	
type	**BD131**		**PBSS4350S**	**PBSS4350Z**	**PBSS4350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}			830 mW	1350 mW*)	600 mW*)
V_{CEO}	45 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	300 mV	@ I_C = 0,5 A, I_B = 50 mA	90 mV	@ I_C = 0,5 A, I_B = 50 mA	
	700 mV	@ I_C = 2 A, I_B = 200 mA	290 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	40	@ I_C = 0,5 A, V_{CE} = 12 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	20	@ I_C = 2 A, V_{CE} = 1 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 8:

	original type leaded		replacement leaded	SMD	
type	**BD329**		**PBSS4350S**	**PBSS4350Z**	**PBSS4350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}			830 mW	1350 mW*)	600 mW*)
V_{CEO}	20 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 2 A, I_B = 200 mA	290 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	85	@ I_C = 0,5 A, V_{CE} = 1 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	40	@ I_C = 2 A, V_{CE} = 1 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 9:

	original type SMD		replacement SMD	
type	**MJD200 KSH200**		**PBSS4540Z**	
package	TO-252 DPAK		SOT223	
P_{tot}	1400 mW		1350 mW*)	
V_{CEO}	25 V		40 V	
I_C	5 A		5 A	
$V_{CEsat(max)}$	300 mV	@ I_C = 0,5 A, I_B = 50 mA	90 mV	@ I_C = 0,5 A, I_B = 50 mA
	750 mV	@ I_C = 2 A, I_B = 200 mA	150 mV	@ I_C = 2 A, I_B = 200 mA
	1800 mV	@ I_C = 5 A, I_B = 1000 mA	355 mV	@ I_C = 5 A, I_B = 500 mA
$h_{FE(min)}$	70	@ I_C = 0,5 A, V_{CE} = 1 V	300	@ I_C = 0,5 A, V_{CE} = 2 V
	45	@ I_C = 2 A, V_{CE} = 1 V	250	@ I_C = 2 A, V_{CE} = 2 V
	10	@ I_C = 5 A, V_{CE} = 2 V	100	@ I_C = 5 A, V_{CE} = 2 V

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 10:

	original type leaded	SMD	replacement SMD		
type	**BD433 BD435**	**MJD148**	**PBSS4540Z**	**PBSS302ND**	
package	TO-126	TO-252 DPAK	SOT223	SOT457	
P_{tot}		1750 mW	1350 mW*)	600 mW*)	
V_{CEO}	22 / 32 V	45 V	40 V	40 V	
I_C	4 A	4 A	5 A	4 A	
$V_{CEsat(max)}$	500 mV	@ I_C = 2 A, I_B = 200 mA	150 mV	180 mV	@ I_C = 2 A, I_B = 200 mA
$h_{FE(min)}$	85	@ I_C = 0,5 A, V_{CE} = 1 V	300	300	@ I_C = 0,5 A, V_{CE} = 2 V
	50	@ I_C = 2 A, V_{CE} = 1 V	250	250	@ I_C = 2 A, V_{CE} = 2 V

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

7. Basic cross reference data, PNP transistors

Table 11:

	original type leaded	SMD		replacement leaded	SMD	
type	**BC636 BC638 BC640**	**BCP51 BCP52 BCP53**	**BCX51 BCX52 BCX53**	**PBSS9110S**	**PBSS9110D**	**PBSS9110T**
package	SOT54	SOT223	SOT89	SOT54	SOT457	SOT23
P_{tot}	830 mW	1000 mW*)	850 mW*)	830 mW	550 mW*)	480 mW*)
V_{CEO}	45 / 60 / 80 V			100 V		
I_C	1 A			1 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 0,5 A, I_B = 50 mA		120 mV	@ I_C = 0,5 A, I_B = 50 mA	
$h_{FE(min)}$	63	@ I_C = 0,15 A, V_{CE} = 2 V		150	@ I_C = 0,25 A, V_{CE} = 5 V	
	40	@ I_C = 0,5 A, V_{CE} = 2 V		100	@ I_C = 0,5 A, V_{CE} = 5 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 12:

	original type leaded			replacement leaded	SMD	
type	**TIP30 TIP30A TIP30B TIP30C**			**PBSS9110S**	**PBSS9110Z**	**PBSS9110T**
package	TO-220AB			SOT54	SOT223	SOT23
P_{tot}	2000 mW			830 mW	1000 mW*)	480 mW*)
V_{CEO}	40 / 60 / 80 / 100 V			100 V		
I_C	1 A			1 A		
$V_{CEsat(max)}$	700 mV	@ I_C = 1 A, I_B = 125 mA		320 mV	@ I_C = 1 A, I_B = 100 mA	
$h_{FE(min)}$	40	@ I_C = 0,2 A, V_{CE} = 4 V		150	@ I_C = 0,25 A, V_{CE} = 5 V	
	15	@ I_C = 1 A, V_{CE} = 4 V		125	@ I_C = 1 A, V_{CE} = 5 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 13:

	original type		replacement		
	leaded		leaded	SMD	
type	**BD136** **BD138** **BD140**		**PBSS5350S**	**PBSS5350Z**	**PBSS5350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}	1250 mW		830 mW	1350 mW*)	600 mW*)
V_{CEO}	45 / 60 / 80 V		50 V		
I_C	1,5 A		3 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 0,5 A, I_B = 50 mA	100 mV	@ I_C = 0,5 A, I_B = 50 mA	
$h_{FE(min)}$	25	@ I_C = 0,5 A, V_{CE} = 2 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 14:

	original type		replacement		
	leaded	SMD	leaded	SMD	
type	**TIP32**	**MJD32** **KSH32**	**PBSS5350S**	**PBSS5350Z**	**PBSS5350D**
package	TO-220	TO-252 DPAK	SOT54	SOT223	SOT457
P_{tot}	2000 mW	1560 mW	830 mW	1350 mW*)	600 mW*)
V_{CEO}	40 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	1200 mV	@ I_C = 3 A, I_B = 375 mA	300 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	25	@ I_C = 1 A, V_{CE} = 4 V	200	@ I_C = 1 A, V_{CE} = 2 V	
	10	@ I_C = 3 A, V_{CE} = 4 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 15:

	original type leaded		replacement leaded	SMD	
type	**BD132**		**PBSS5350S**	**PBSS5350Z**	**PBSS5350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}			830 mW	1350 mW*)	600 mW*)
V_{CEO}	45 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	300 mV	@ I_C = 0,5 A, I_B = 50 mA	100 mV	@ I_C = 0,5 A, I_B = 50 mA	
	700 mV	@ I_C = 2 A, I_B = 200 mA	300 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	40	@ I_C = 0,5 A, V_{CE} = 12 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	20	@ I_C = 2 A, V_{CE} = 1 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 16:

	original type leaded		replacement leaded	SMD	
type	**BD330**		**PBSS5350S**	**PBSS5350Z**	**PBSS5350D**
package	SOT32 (TO-126)		SOT54	SOT223	SOT457
P_{tot}			830 mW	1350 mW*)	600 mW*)
V_{CEO}	20 V		50 V		
I_C	3 A		3 A		
$V_{CEsat(max)}$	500 mV	@ I_C = 2 A, I_B = 200 mA	300 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	85	@ I_C = 0,5 A, V_{CE} = 1 V	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	40	@ I_C = 2 A, V_{CE} = 1 V	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 17:

	original type SMD		replacement SMD	
type	**MJD210** **KSH210**		**PBSS5540Z**	
package	TO-252 DPAK		SOT223	
P_{tot}	1400 mW		1350 mW*)	
V_{CEO}	25 V		40 V	
I_C	5 A		5 A	
$V_{CEsat(max)}$	300 mV	@ I_C = 0,5 A, I_B = 50 mA	120 mV	@ I_C = 0,5 A, I_B = 50 mA
	750 mV	@ I_C = 2 A, I_B = 200 mA	160 mV	@ I_C = 2 A, I_B = 200 mA
	1800 mV	@ I_C = 5 A, I_B = 1000 mA	375 mV	@ I_C = 5 A, I_B = 500 mA
$h_{FE(min)}$	70	@ I_C = 0,5 A, V_{CE} = 1 V	250	@ I_C = 0,5 A, V_{CE} = 2 V
	45	@ I_C = 2 A, V_{CE} = 1 V	150	@ I_C = 2 A, V_{CE} = 2 V
	10	@ I_C = 5 A, V_{CE} = 2 V	50	@ I_C = 5 A, V_{CE} = 2 V

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 18:

	original type SMD		replacement SMD		
type	**BD434** **BD436**		**PBSS5540Z**	**PBSS302PD**	
package	TO-126		SOT223	SOT457	
P_{tot}			1350 mW*)	600 mW*)	
V_{CEO}	22 / 32 V		40 V	40 V	
I_C	4 A		5 A	4 A	
$V_{CEsat(max)}$	500 mV	@ I_C = 2 A, I_B = 200 mA	160 mV	180 mV	@ I_C = 2 A, I_B = 200 mA
$h_{FE(min)}$	85	@ I_C = 0,5 A, V_{CE} = 1 V	250	200	@ I_C = 0,5 A, V_{CE} = 2 V
	50	@ I_C = 2 A, V_{CE} = 1 V	150	175	@ I_C = 2 A, V_{CE} = 2 V

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

8. Basic data on the BISS transistors

Table 19: 1 A / 100 V NPN BISS transistors

	leaded	SMD	
type	**PBSS8110S**	**PBSS8110D**	**PBSS8110T**
package	SOT54	SOT457	SOT23
P_{tot}	830 mW	600 mW*)	480 mW*)
V_{CEO}	100 V		
I_C	1 A		
$V_{CEsat(max)}$	120 mV	@ I_C = 0,5 A, I_B = 50 mA	
	200 mV	@ I_C = 1 A, I_B = 100 mA	
$h_{FE(min)}$	150	@ I_C = 0,25 A, V_{CE} = 10 V	
	100	@ I_C = 0,5 A, V_{CE} = 10 V	
	80	@ I_C = 1 A, V_{CE} = 10 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 20: 3 A / 50 V NPN BISS transistors

	leaded	SMD	
type	**PBSS4350S**	**PBSS4350Z**	**PBSS4350D**
package	SOT54	SOT223	SOT457
P_{tot}	830 mW	1350 mW*)	
V_{CEO}	50 V		
I_C	3 A		
$V_{CEsat(max)}$	90 mV	@ I_C = 0,5 A, I_B = 50 mA	
	290 mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	200	@ I_C = 1 A, V_{CE} = 2 V	
	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 21: 4 – 5 A / 40 V NPN BISS transistors

	SMD		
type	**PBSS4540Z**	**PBSS302ND**	
package	SOT223	SOT457	
P_{tot}	1350 mW*)	600 mW*)	
V_{CEO}	40 V	40 V	
I_C	5 A	4 A	
$V_{CEsat(max)}$	90 mV		I_C = 0,5 A, I_B = 50 mA
	150 mV	180 mV	I_C = 2 A, I_B = 200 mA
	355 mV	-	I_C = 5 A, I_B = 500 mA
$h_{FE(min)}$	300	300	I_C = 0,5 A, V_{CE} = 2 V
	250	250	I_C = 2 A, V_{CE} = 2 V
	100	-	I_C = 5 A, V_{CE} = 2 V

Table 22: 1 A / 100 V PNP BISS transistors

	leaded	SMD	
type	**PBSS9110S**	**PBSS9110D**	**PBSS9110T**
package	SOT54	SOT457	SOT23
P_{tot}	830 mW	550 mW*)	480 mW*)
V_{CEO}	100 V		
I_C	1 A		
$V_{CEsat(max)}$	120 mV	@ I_C = 0,5 A, I_B = 50 mA	
	320 mV	@ I_C = 1 A, I_B = 100 mA	
$h_{FE(min)}$	150	@ I_C = 0,25 A, V_{CE} = 5 V	
	150	@ I_C = 0,5 A, V_{CE} = 5 V	
	125	@ I_C = 1 A, V_{CE} = 5 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 23: 3 A / 50 V PNP BISS transistors

	leaded	SMD	
type	**PBSS5350S**	**PBSS5350Z**	**PBSS5350D**
package	SOT54	SOT223	SOT457
P_{tot}	830 mW	1350 mW*)	
V_{CEO}	50 V		
I_C	3 A		
$V_{CEsat(max)}$	100 mV	@ I_C = 0,5 A, I_B = 50 mA	
	mV	@ I_C = 2 A, I_B = 200 mA	
$h_{FE(min)}$	200	@ I_C = 0,5 A, V_{CE} = 2 V	
	200	@ I_C = 1 A, V_{CE} = 2 V	
	100	@ I_C = 2 A, V_{CE} = 2 V	

*) Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for collector 1 cm^2

Table 24: 4 – 5 A / 40 V PNP BISS transistors

	SMD		
type	**PBSS5540Z**	**PBSS302PD**	
package	SOT223	SOT457	
P_{tot}	1350 mW*)	600 mW*)	
V_{CEO}	40 V	40 V	
I_C	5 A	4 A	
$V_{CEsat(max)}$	120 mV	60 mV	@ I_C = 0,5 A, I_B = 50 mA
	160 mV	180 mV	@ I_C = 2 A, I_B = 200 mA
	375 mV	-	@ I_C = 5 A, I_B = 500 mA
$h_{FE(min)}$	250	200	@ I_C = 0,5 A, V_{CE} = 2 V
	150	175	@ I_C = 2 A, V_{CE} = 2 V
	50	-	@ I_C = 5 A, V_{CE} = 2 V

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11. Contents

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