

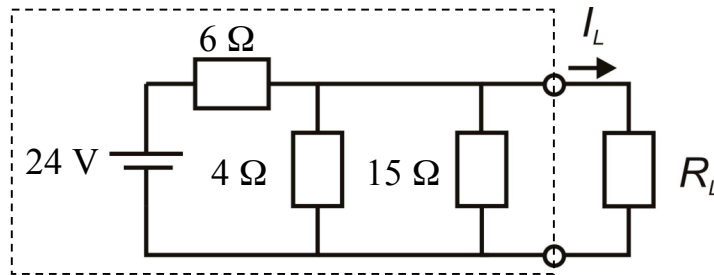
FYSE301 Elektronikka I osa A

Loppukoe 16.3.2012 (Vastaa kaikkiin viiteen tehtävään)

1. Selitä lyhyesti (6 pistettä)

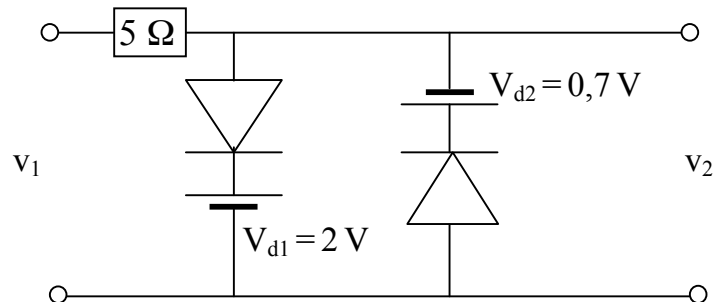
- a) pn-liitoksen virta-jännite-käyttäytyminen
- b) varauksenkuljettajien lukumäärä itseispuolijohteissa ja seostetuissa puolijohteissa
- c) Energia-aukko puolijohteissa ja eristeissä

2. Laske kuormavastuksen R_L (kuva 1) läpi kulkeva virta I_L muuntamalla sitä syöttävä piiri (katkoviivoitettu osa) Thevenin-ekvivalenttikseen ja esitä I_L R_L :n funktiona (älä kiinnitä vielä R_L :n arvoa). Laske virta I_L kun $R_L=20\ \Omega$. (6 pistettä)



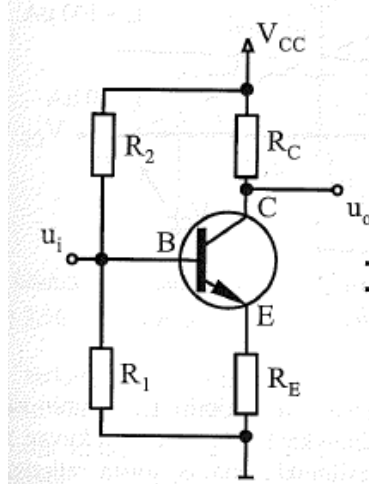
Kuva 1.

3. Piirrä kuvan 2 kytkennän antojännitte v_2 ottojännitteen $v_1 \in [-5V, 5V]$ funktiona (diodit ovat ideaalisia eli diodissa ei ole itsessään kynnyksjännitettä). (6 pistettä)



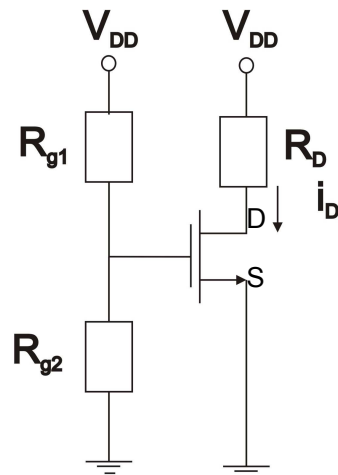
Kuva 2.

4. Kuvan 3 yhteisemitterivahvistinkytkennälle $R_C=500 \Omega$, $R_E=150 \Omega$, $R_1=3,7 \text{ k}\Omega$ ja $R_2=14,8 \text{ k}\Omega$. Käyttöjännite $V_{CC}=20 \text{ V}$, transistorin $\beta=100$ ja $V_{BE}=0,7 \text{ V}$. Oletetaan että $V_{CE(sat)} \approx 0 \text{ V}$.
- a) Tunnista symbolista minkälainen transistori on kyseessä. Transistorin eri alueet on seostettu arseenilla ja boorilla, kummalla saa aikaan p-tyypin seostuksen ja miksi? (2 p)
- b) Määritä transistorin kuormitussuora (2 p)
- c) Hahmottele transistorin ominaiskäyrät (V_{CE} , I_C) V_{CE} :n välille 0-25 V ja I_B :n arvoille 100, 200, 300 ja 400 μA . (2 p)



Kuva 3.

5. Kuva 4 esittää MOSFET-transistorin biasointikytkentää, jolla lepotilan toimintapiste asetetaan halutuksi. Oletetaan että piirissä on BS170 NMOS transistori (liite).
- (a) Piirrä avaustyyppin (enhancement mode) NMOS-transistorin poikkileikkaus, josta selviää transistorin toimintaperiaate. Nimeä transistorin osat. (2 p)
- (b) Määritä liitteen tiedoista mikä on i) hilan (gate) kynnyksjännite, ii) virta I_D kun $V_{GS}=0 \text{ V}$ ja $V_{DS}=25 \text{ V}$ (2 p)
- (c) Olkoon kuvan 4 mukaisessa kytkennässä $V_{DD} = 29 \text{ V}$ ja $R_D = 10 \Omega$. Määritä nieluvirta (I_D) ja nielu-lähdejännite (V_{DS}), kun $V_{GS} = 6 \text{ V}$. Kuinka hilavastukset on valittava jotta saadaan $V_{GS} = 6 \text{ V}$? Käytä apuna liitettä, jos siltä tuntuu. (2 p)



Kuva 4.

Joitain kenties hyödyllisiä yhtälöitä:

$$\sigma = ne\mu; n = p = n_i; n_i = e^{-E_g/2kT}; i = I_s(e^{ev/\eta kT} - 1); i_D = K(V_{GS} - V_T)^2; i_D = I_{DSS}(1 - V_{GS}/V_P)^2;$$

$$\beta = \alpha / (1 - \alpha);$$

BS170 / MMBF170 N-Channel Enhancement Mode Field Effect Transistor

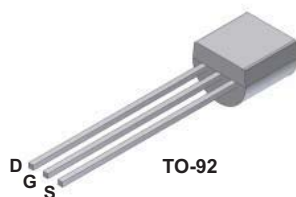
General Description

These N-Channel enhancement mode field effect transistors are produced using Fairchild's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while provide rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 500mA DC. These products are particularly suited for low voltage, low current applications such as small servo motor control, power MOSFET gate drivers, and other switching applications.

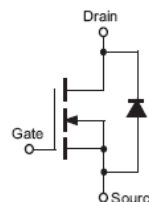
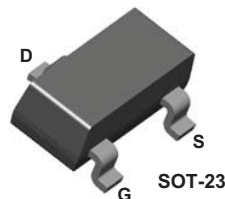
Features

- High density cell design for low $R_{DS(ON)}$.
- Voltage controlled small signal switch.
- Rugged and reliable.
- High saturation current capability.

BS170



MMBF170



Absolute Maximum Ratings $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	BS170	MMBF170	Units
V_{DSS}	Drain-Source Voltage	60		V
V_{DGR}	Drain-Gate Voltage ($R_{GS} \leq 1M\Omega$)	60		V
V_{GSS}	Gate-Source Voltage	± 20		V
I_D	Drain Current - Continuous	500	500	mA
	- Pulsed	1200	800	
T_J, T_{STG}	Operating and Storage Temperature Range	- 55 to 150		$^\circ\text{C}$
T_L	Maximum Lead Temperature for Soldering Purposes, 1/16" from Case for 10 Seconds	300		$^\circ\text{C}$

Thermal Characteristics $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	BS170	MMBF170	Units
P_D	Maximum Power Dissipation	830	300	mW
	Derate above 25°C	6.6	2.4	mW/ $^\circ\text{C}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	150	417	$^\circ\text{C}/\text{W}$

Electrical Characteristics $T_A=25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Units
OFF CHARACTERISTICS							
BV_{DSS}	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 100\mu A$	All	60			V
I_{DSS}	Zero Gate Voltage Drain Current	$V_{DS} = 25V, V_{GS} = 0V$	All			0.5	μA
I_{GSSF}	Gate - Body Leakage, Forward	$V_{GS} = 15V, V_{DS} = 0V$	All			10	nA
ON CHARACTERISTICS (Notes 1)							
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 1mA$	All	0.8	2.1	3	V
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 200mA$	All		1.2	5	Ω
g_{FS}	Forward Transconductance	$V_{DS} = 10V, I_D = 200mA$	BS170		320		mS
		$V_{DS} \geq 2 V_{DS(on)}, I_D = 200mA$	MMBF170		320		
Dynamic Characteristics							
C_{iss}	Input Capacitance	$V_{DS} = 10V, V_{GS} = 0V, f = 1.0MHz$	All		24	40	pF
C_{oss}	Output Capacitance		All		17	30	pF
C_{rSS}	Reverse Transfer Capacitance		All		7	10	pF
Switching Characteristics (Notes 1)							
t_{on}	Turn-On Time	$V_{DD} = 25V, I_D = 200mA, V_{GS} = 10V, R_{GEN} = 25\Omega$	BS170			10	ns
		$V_{DD} = 25V, I_D = 500mA, V_{GS} = 10V, R_{GEN} = 50\Omega$	MMBF170			10	
t_{off}	Turn-Off Time	$V_{DD} = 25V, I_D = 200mA, V_{GS} = 10V, R_{GEN} = 25\Omega$	BS170			10	ns
		$V_{DD} = 25V, I_D = 500mA, V_{GS} = 10V, R_{GEN} = 50\Omega$	MMBF170			10	

Note:

1. Pulse Test: Pulse Width $\leq 300\mu s$, Duty Cycle $\leq 2.0\%$.

Ordering Information

Part Number	Package	Package Type	Lead Frame	Pin array
BS170	TO-92	BULK	STRAIGHT	D G S
BS170_D26Z	TO-92	Tape and Reel	FORMING	D G S
BS170_D27Z	TO-92	Tape and Reel	FORMING	D G S
BS170_D74Z	TO-92	AMMO	FORMING	D G S
BS170_D75Z	TO-92	AMMO	FORMING	D G S
MMBF170	SOT-23	Tape and Reel		

Typical Electrical Characteristics

BS170 / MMBF170

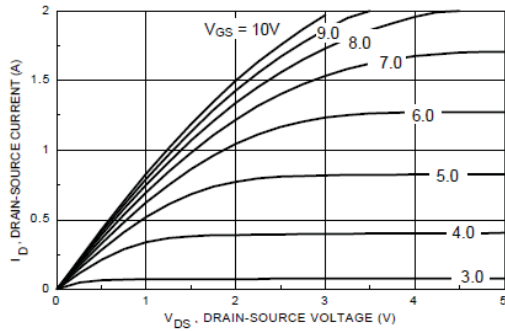


Figure 1. On-Region Characteristics.

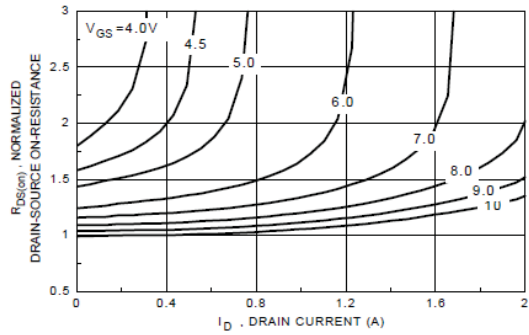


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current.

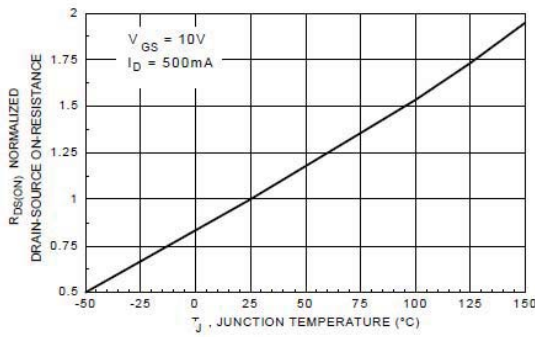


Figure 3. On-Resistance Variation with Temperature.

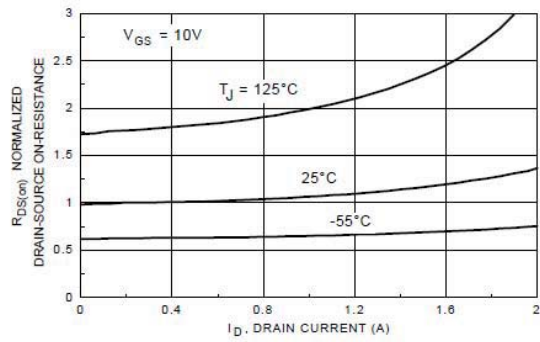


Figure 4. On-Resistance Variation with Drain Current and Temperature.

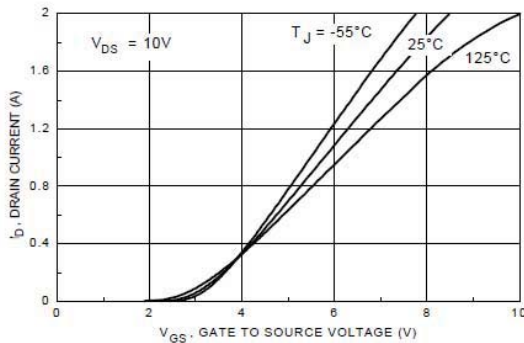


Figure 5. Transfer Characteristics.

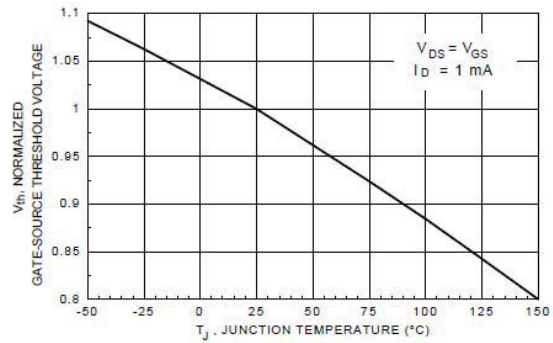


Figure 6. Gate Threshold Variation with Temperature.

Typical Electrical Characteristics (continued)

BS170 / MMBF170

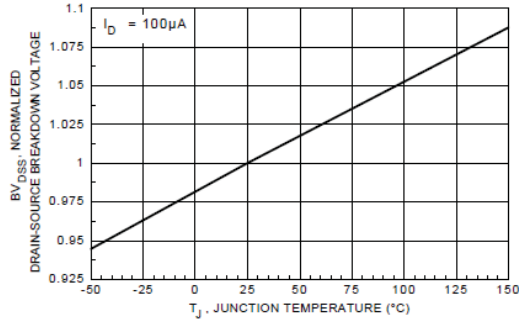


Figure 7. Breakdown Voltage Variation with Temperature.

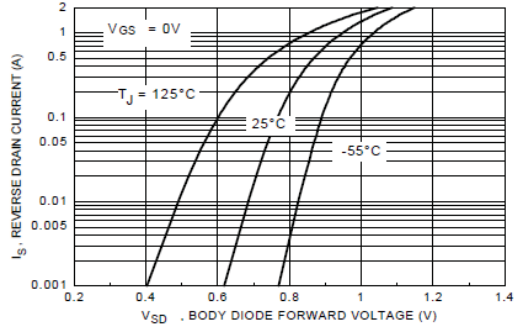


Figure 8. Body Diode Forward Voltage Variation with Current and Temperature.

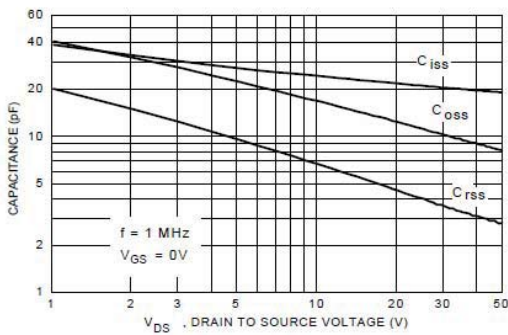


Figure 9. Capacitance Characteristics.

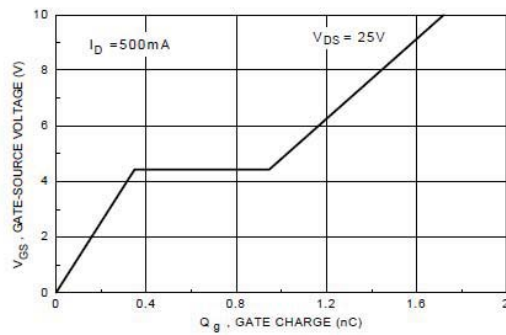


Figure 10. Gate Charge Characteristics.

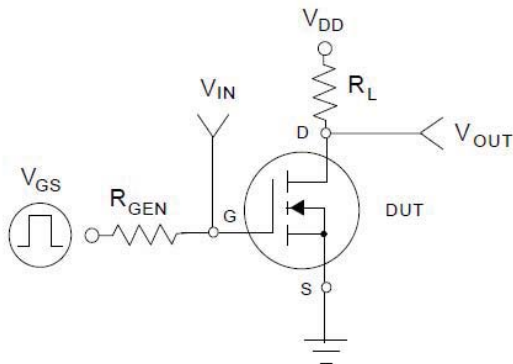


Figure 11. Switching Test Circuit.

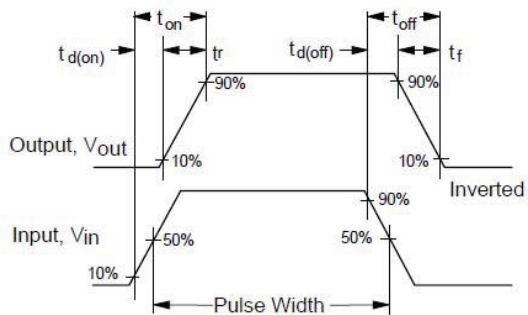


Figure 12. Switching Waveforms.

Periodic Table of the Elements

hydrogen 1 H																				helium 2 He [4.0026]			
lithium 3 Li	beryllium 4 Be																	fluorine 9 F	oxygen 8 O	nitrogen 7 N	carbon 6 C	boron 5 B	
sodium 11 Na	magnesium 12 Mg																	chlorine 17 Cl	sulfur 16 S	phosphorus 15 P	silicon 14 Si	aluminum 13 Al	
potassium 19 K	calcium 20 Ca																	argon 18 Ar	arsenic 33 As	germanium 32 Ge	zinc 30 Zn	gallium 31 Ga	
rubidium 37 Rb	strontium 38 Sr																	potassium 39 K	tin 50 Sn	antimony 51 Sb	cadmium 48 Cd	indium 49 In	
cesium 55 Cs	barium 56 Ba																	mercury 80 Hg	lead 82 Pb	bismuth 83 Bi	thallium 81 Tl	thorium 88 Th	
francium 87 Fr	radium 88 Ra																	polonium 84 Po	astatine 85 At	polonium 84 Po	lead 82 Pb	ununoctium 114 Uuo	

lanthanum 57 La	cerium 58 Ce	praseodymium 59 Pr	neodymium 60 Nd	promethium 61 Pm	samarium 62 Sm	europium 63 Eu	gadolinium 64 Gd	terbium 65 Tb	dysprosium 66 Dy	holmium 67 Ho	erbium 68 Er	thulium 69 Tm	ytterbium 70 Yb
actinium 89 Ac	thorium 90 Th	protactinium 91 Pa	uranium 92 U	neptunium 93 Np	plutonium 94 Pu	americium 95 Am	curium 96 Cm	berkelium 97 Bk	californium 98 Cf	einsteinium 99 Es	fermium 100 Fm	mendelevium 101 Md	nobelium 102 No

* Lanthanide series

** Actinide series