AN1596/D

ECLinPS Lite™ Translator ELT Family SPICE I/O Model Kit

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APPLICATION NOTE

Introduction

The objective of this kit is to provide customers with enough schematic and SPICE parameter information to perform system level interconnect modeling with the Motorola ECLinPS Lite Translator ELT family. The ELT devices MC10ELT2xD and MC100ELT2xD are single or dual supply 1 or 2 Bit translators between the TTL and ECL world. Single supply devices translate between TTL and PECL, dual supply devices translate to or from negative supplied ECL. All devices are designed as 100K compatible 100ELT2x or as 10H compatible 10ELT2x.

The family specifications are located in the High Performance ECL Data book DL140/D. Section 3 represents the temperature and power supply variations that can be expected from the family.

The kit contains representative schematics and model files for the I/O circuits used by the ELT devices. In addition a worst case package model schematic is included for more accurate system level modeling. The package model should be placed on all external inputs, outputs and supply pins.

This note includes the schematics necessary to do I/O modeling and the model text–files. To receive electronic model files on disk or per email please contact your Motorola Logic Application Group.

Input and Output Schematics

One schematic represents the PECL inputs of single supply translators Figure 1, subcircuit PECL_IN. The translation function of the dual supply ECL–TTL–Translator MC10/100ELT25 is represented in Figure 2 ECL_TTL_ELT25. This translator requires a BVOHH reference signal. It is generated in the BVOHH–generator (Figure 2a).

The TTL–(P)ECL Translator function uses separate circuits for PECL and ECL outputs in 10ELT– or 100ELT version shown in Figures 3 and 4 and subcircuits TTL_ECL_100K, TTL_ECL_10H, TTL_PECL_100K, TTL_PECL_10H.

The 10ELT and the 100ELT version of the (P)ECL outputs are identical beside the temperature compensation network included in the 100ELT–type output.

To simulate the TTL outputs the schematic Figure 5 TTL_OUT is used. The bias regulators ETXR, Figure 6 and VCLP, Figure 7 are necessary to generate reference signals. Replacing those subcircuits by voltage/current sources would result in incorrect output modeling.

All inputs and outputs of the ELT family are protected by ESD protection circuitry. The ESDPD subcircuit (Figure 8) is used for ECL and PECL inputs. It contains ESD protection and the standard ECL 75kΩ input pulldown resistors. The ESD circuit of Figure 9 is used for TTL I/Os and the ECL/PECL outputs.

If the user would like to just simulate the output behavior of an TTL output the TTL_OUT circuit can be stimulated with internal signals.

To all external pins the package model PKG8 drawn in Figure 10 needs to be added.

If users want to reduce simulation time and just simulate 1 channel or only the output of a circuit, they need to take care of the correct power supply management. The channels share power supply pins. Dynamic ICC current will add up at power pins. When a simulation is performed with only one channel, the package models of the power pins need to be adjusted. The parasitic capacitance should be divided by two and inductance should be doubled.

Modeling

The bias driver schematics for VBB and VCS generation are not included in this kit, as they are unnecessary for interconnection simulation. In addition their use would result in a relatively large increase in simulation time. Alternatively the internal reference voltages should be driven with ideal constant voltage sources.

Parameter	Typical Level	Worst Case
VBB	VCC–1.325	Data Book
VCS	VEE+1.3V	±50mV

This model kit is intended for simulations within the specified power supply range. If supply voltages drop below minimum specification, VBB and VCS can no longer be

assumed to be constant. Thus this model kit can not been used for power up or power down simulations.

For all schematics the resistors should **NOT** be simulated as simple SPICE resistors. Because these resistors are realized by a diffusion step in wafer processing there are parasitic capacitance associated with each like shown in Figure 11. The capacitance is a function of the resistor value.

R<2500Ω	CJ0=4.72E−16*R+58E−16	
R>2500Ω	CJ0=0.265E−16*R+29E−16	
R=50kΩ	CJ0=0.1149pF	input pulldown resistor

In the model file, 3 subcircuits are used: RES for resistor values <2.5kΩ, RESK for R>2.5kΩ and RPD for the input pulldown resistors. As the parasitic capacitance of the Diode is a function of the resistivity, the capacitance needs to be calculated. As calculations of model parameters are not equal for each SPICE simulator, model files are available for H–SPICE and Berkeley SPICE (P–SPICE). If the user's tool is not able to work with one of those files, they need to be adapted.

Beside the resistor models this kit contains all process parameters and all subcircuits (Figure 12 to Figure 20) necessary to simulate the ELT devices.

The Global nodes in the model files and the schematics are:

VCC	Top rail power supply
VCCP	PECL VCC voltage
VCCT, VCC	TTL VCC voltage
VEE	Bottom Rail Power supply
PGND	Ground for PECL signals
VBB	Switching Bias Voltage
VCS	Current Source Base Voltage (VEE+1.3V)
VCLMP	VCS+0.8V
SUB	Substrate contact. Most negative supply voltage
VTT	External termination sink supply (VCC–2V)
In	Input
InB	Inverted Input
Q	Output
QB	Inverted Output

For typical load ECL and PECL outputs should be terminated 50Ω to VTT=VCC–2V. TTL outputs are loaded with 20pF to GROUND and 500Ω to GROUND.
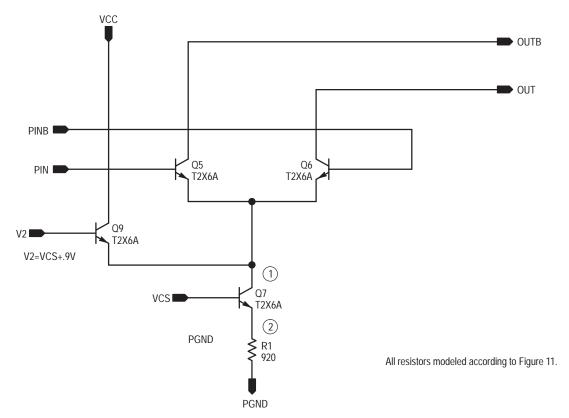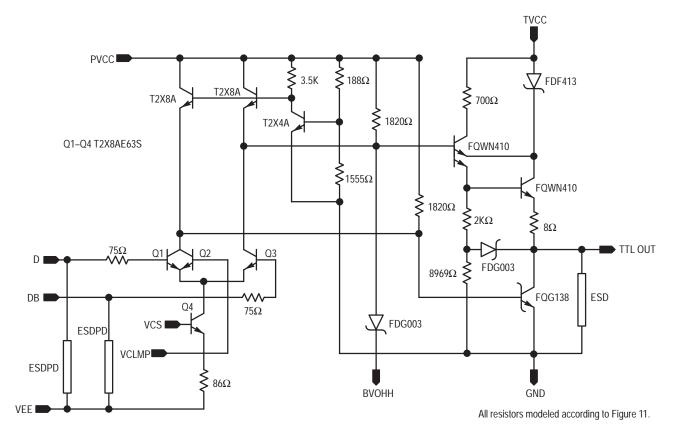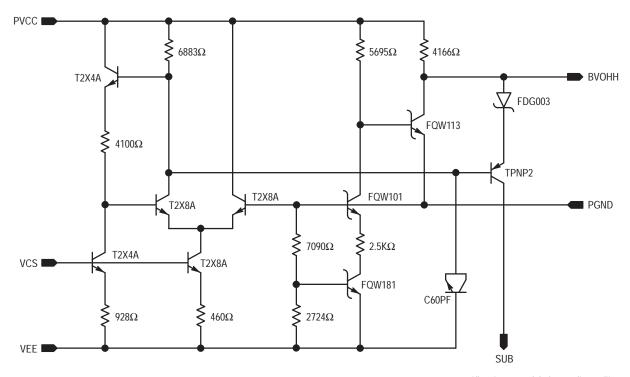

Figure 1. . PECL_IN

All resistors modeled according to Figure 11.

Figure 2. . ECL to TTL MC10/100ELT25

All resistors modeled according to Figure 11.

2a. BVOHH Generator for the MC10/100ELT25

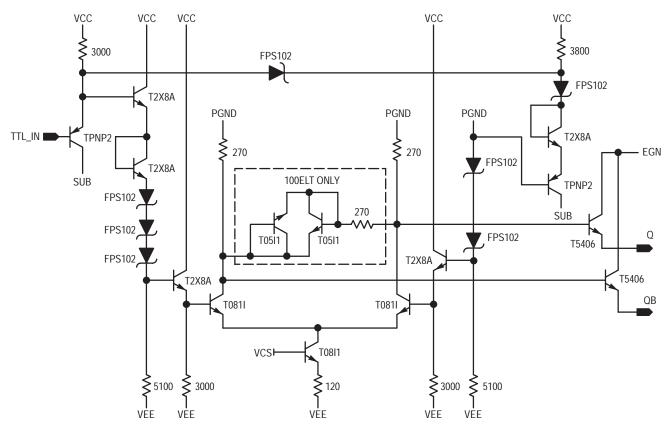All resistors modeled according to Figure 11.

Figure 3. . TTL_ECL
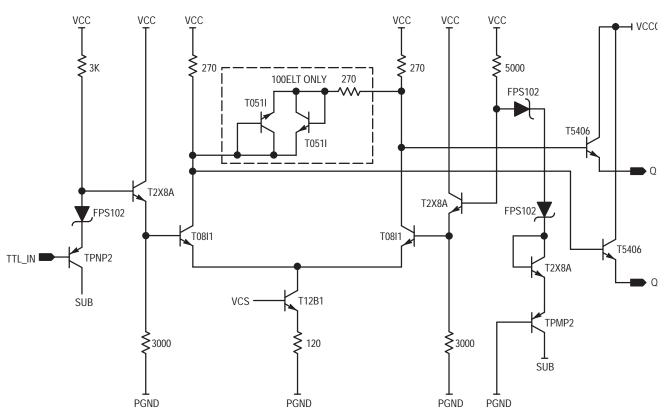
All resistors modeled according to Figure 11.

Figure 4. . TTL_PECL

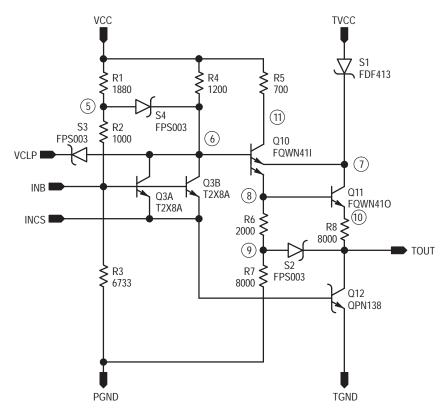All resistors modeled according to Figure 11.

Figure 5. . TTL_OUT
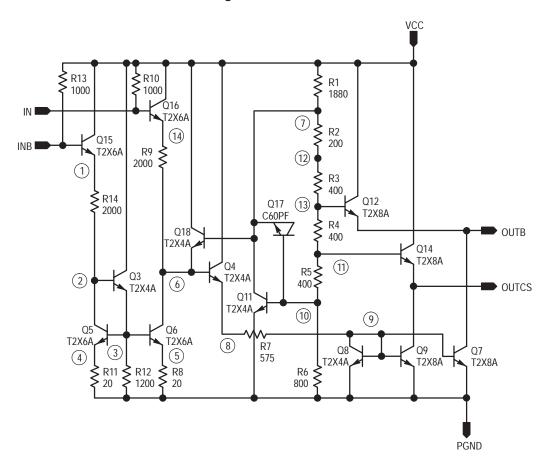
All resistors modeled according to Figure 11.
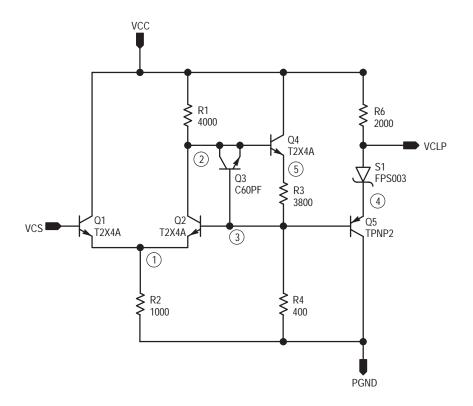
Figure 6. . MACRO ETL ETXR

All resistors modeled according to Figure 11.

All resistors modeled according to Figure 11.

Figure 7. . VCLP

All resistors modeled according to Figure 11.

Figure 8. . ESD Protection ECL/PECL Input

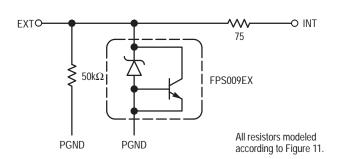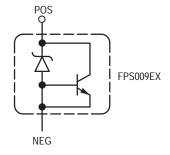**Figure 9. . ESD Protection for all Outputs and TTL Inputs**
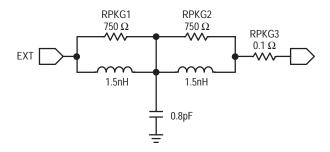
Figure 10. . Package Pin Model
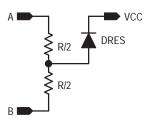
Figure 11. . Resistor Model
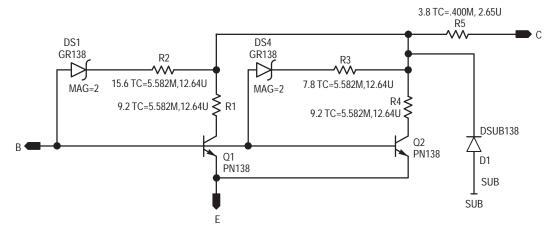
Figure 12. . QPN138
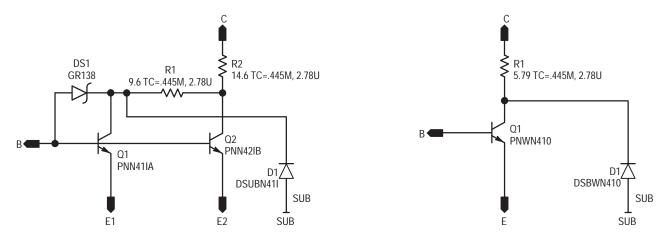
Figure 13. . QWN410

Figure 14. . QPN410
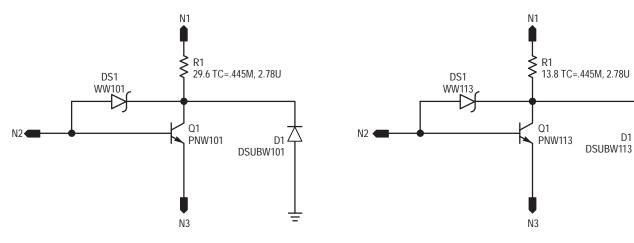
Figure 15. . FDG003

Figure 16. . FQW113

N1

DS1
GRS003

RX
2

REPI
14.6

REXT
23.5 TC=.445M, 2.78U

N2

D1
DSUBS003

Figure 17. . FDG003

N1

DGR
DRES

DS1
GRS003

RSPNJ
2

REPI   15.2 TC=5.582E−3, 1.264E−5

RNPLUS   22.9 TC=4.45E−4, 2.78E−6

D1
DSUBS003

SUB

SUB

N2

Figure 18. . FPS003

N1

DS1
FPDF413

REXT
22.2 TC=.445M, 2.78U

D1
DSBDF413

N2

SUB

Figure 19. . FDF413

N1

DS1
WS102

REXT
39.1 TC=.445M, 2.78U

D1
DSUBS102

N2

SUB
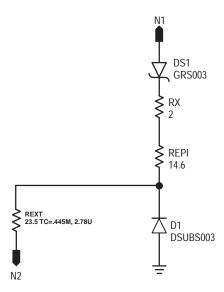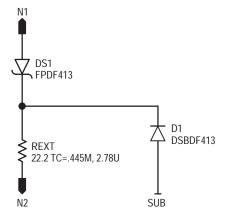
Figure 20. . FPS102

Models

```
***************************************************************************
* Spice Model Files for the:  MC10ELT20    MC100ELT20              *
*                             MC10ELT21    MC100ELT21              *
*                             MC10ELT22    MC100ELT22              *
*                                          MC100ELT23              *
*                             MC10ELT24    MC100ELT24              *
*                             MC10ELT25    MC100ELT25              *
*                             MC10ELT28    MC100ELT28              *
*                                                                 *
***************************************************************************
******              ELT Translator SPICE Model              ******
***************************************************************************
*                                                                 *
* NODES:                                                          *
*                                                                 *
* PGND = (INTERNAL GND)                                           *
* TGND = (OUTPUT GND FOR TTL OUTPUTS)                             *
* TVCC = (VCC FOR THE TTL OUTPUTS)                                *
* VCS  = (CURRENT SOURCE DRIVE FOR THE ECL/PECL GATES=ECL VEE + 1.3V) *
* VBB  = (BIAS FOR SINGLE ENDED ECL/PECL = ECL VCC -1.3V)         *
* SUB  = (SUBSTRATE = MOST NEGATIVE RAIL FOR THE CKT.)            *
* GND  = 0V                                                       *
* VEE  = -5V (databook spec)                                      *
* V2   = VCS + 0.9V                                               *
* D..  = Input (ECL or TTL)                                       *
* Q..  = Output(ECL or TTL)                                       *
*                                                                 *
*  VCS and V2 are internal nodes.                                 *
***************************************************************************


*********************************************************** ELT20 ****


.SUBCKT ELT20_10H  VCC GND D0 Q0 Q0B


VCS      VCS GND   1.3


   X1    VC GN VCS D Q QB                    TTL_PECL_10H
   X2    Q GN                                ESD
   X3    QB GN                               ESD
   X4    D GN                                ESD
   X12   VCC VC                              PKG8
   X13   GND GN                              PKG8
   X15   D0 D                                PKG8
   X16   Q0 Q                                PKG8
   X17   Q0B QB                              PKG8
 .ENDS ELT20_10H


.SUBCKT ELT20_100K  VCC GND D0 Q0 Q0B


VCS      VCS GND   1.3


   X1    VC GN VCS D Q QB                    TTL_PECL_100K
   X2    Q GN                                ESD
   X3    QB GN                               ESD
   X4    D GN                                ESD
```
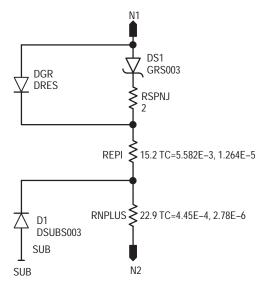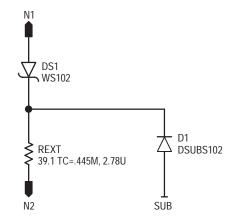
```
    X12  VCC VC                                    PKG8
    X13  GND GN                                    PKG8
    X15  D0 D                                      PKG8
    X16  Q0 Q                                      PKG8
    X17  Q0B QB                                    PKG8
.ENDS ELT20_100k


*********************************************************** ELT21 ****


.SUBCKT ELT21_10H   VCC GND DECL DECLB QTTL


VCS     VCS GND   1.3
V2      V2  GND   2.2


    X1   VC GN VCS VCLP                       VOHCLMP
    X2   VC VC GN GN VCLP INB INCS QTT        TTL_OUT
    X3   VC GN Q QB INB INCS FEED             ETXR
    X4   VC GN VCS PIN PINB V2 Q QB           PECL_IN
    X5   VC GN DEC PIN                        ESDPD
    X6   VC GN DECB PINB                      ESDPD
    X7   QTT GN                               ESD
    X8   VCC VC                               PKG8
    X9   GND GN                               PKG8
    X10  DECL DEC                             PKG8
    X11  DECLB DECB                           PKG8
    X12  QTTL QTT                             PKG8
.ENDS ELT21_10H


.SUBCKT ELT21_100K   VCC GND DECL DECLB QTTL


VCS     VCS GND   1.3
V2      V2  GND   2.2


    X1   VC GN VCS VCLP                       VOHCLMP
    X2   VC VC GN GN VCLP INB INCS QTT        TTL_OUT
    X3   VC GN Q QB INB INCS FEED             ETXR
    X4   VC GN VCS PIN PINB V2 Q QB           PECL_IN
    X5   VC GN DEC PIN                        ESDPD
    X6   VC GN DECB PINB                      ESDPD
    X7   QTT GN                               ESD
    X8   VCC VC                               PKG8
    X9   GND GN                               PKG8
    X10  DECL DEC                             PKG8
    X11  DECLB DECB                           PKG8
    X12  QTTL QTT                             PKG8
.ENDS ELT21_100K


*********************************************************** ELT22 ****


.SUBCKT ELT22_10H   VCC GND D0 D1 Q0 Q0B Q1 Q1B


VCS     VCS GND   1.3


    X1   VC GN VCS D0i Q0i Q0iB                   TTL_PECL_10H
    X2   VC GN VCS D1i Q1i Q1iB                   TTL_PECL_10H
```

```
   XE1   Q0i GN                                            ESD
   XE2   Q0iB GN                                           ESD
   XE3   Q0i GN                                            ESD
   XE4   Q1i GN                                            ESD
   XE5   Q1iB GN                                           ESD
   XE6   D1i GN                                            ESD
   X9    D1 D1i                                            PKG8
   X10   Q1 Q1i                                            PKG8
   X11   Q1B Q1iB                                          PKG8
   X12   VCC VC                                            PKG8
   X13   GND GN                                            PKG8
   X15   D0 D0i                                            PKG8
   X16   Q0 Q0i                                            PKG8
   X17   Q0B Q0iB                                          PKG8
 .ENDS ELT22_10H


.SUBCKT ELT22_100k   VCC GND D0 D1 Q0 Q0B Q1 Q1B


VCS       VCS GND    1.3


   X1    VC GN VCS D0i Q0i Q0iB                  TTL_PECL_10H
   X2    VC GN VCS D1i Q1i Q1iB                  TTL_PECL_10H
   XE1   Q0i GN                                            ESD
   XE2   Q0iB GN                                           ESD
   XE3   D0i GN                                            ESD
   XE4   Q1i GN                                            ESD
   XE5   Q1iB GN                                           ESD
   XE6   D1i GN                                            ESD
   X9    D1 D1i                                            PKG8
   X10   Q1 Q1i                                            PKG8
   X11   Q1B Q1iB                                          PKG8
   X12   VCC VC                                            PKG8
   X13   GND GN                                            PKG8
   X15   D0 D0i                                            PKG8
   X16   Q0 Q0i                                            PKG8
   X17   Q0B Q0iB                                          PKG8
 .ENDS ELT22_100k


*********************************************************** ELT23 ****


.SUBCKT ELT23_100K  VCC GND DECL DECLB QTTL


VCS       VCS GND    1.3
V2        V2  GND    2.2


   X1    VC GN VCS VCLP                          VOHCLMP
   X2    VC VC GN GN VCLP INB INCS QTT           TTL_OUT
   X3    VC GN Q QB INB INCS FEED                ETXR
   X4    VC GN VCS PIN PINB V2 Q QB              PECL_IN
   X5    VC GN DEC PIN                           ESDPD
   X6    VC GN DECB PINB                         ESDPD
   X7    QTT GN                                  ESD
   X8    VCC VC                                  PKG8
   X9    GND GN                                  PKG8
   X10   DECL DEC                                PKG8
   X11   DECLB DECB                              PKG8
   X12   QTTL QTT                                PKG8
```

```
.ENDS ELT23_100K


*********************************************************** ELT24 ****


.SUBCKT ELT24_10H  VCC GND VEE D Q QB


VCS     VCS VEE   1.3


   X1    VC VE GN GN VCS DI QI QBI          TTL_ECL_10H
   X2    QI VE                              ESD
   X3    QBI VE                             ESD
   X4    DI VE                              ESD
   X5    VCC VC                             PKG8
   X6    GND GN                             PKG8
   X7    D DI                               PKG8
   X8    Q QI                               PKG8
   X9    QB QBI                             PKG8
   X10   VEE VE                             PKG8
.ENDS ELT24_10H


.SUBCKT ELT24_100K  VCC GND VEE D Q QB


VCS     VCS VEE   1.3


   X1    VC VE GN GN VCS DI QI QBI          TTL_ECL_100K
   X2    QI VE                              ESD
   X3    QBI VE                             ESD
   X4    DI VE                              ESD
   X5    VCC VC                             PKG8
   X6    GND GN                             PKG8
   X7    D DI                               PKG8
   X8    Q QI                               PKG8
   X9    QB QBI                             PKG8
   X10   VEE VE                             PKG8
.ENDS ELT24_100K


*********************************************************** ELT 25 ****


.SUBCKT ELT25_10H  D DB Q VCC GND VEE


VCLMP   VCLMP VEE   2.1
VCS     VCS   VEE   1.3


   X1    IN INB QT VCCI VCCI VEEI GNDI
+        BVOHH VCLMP VCS                    ECL_TTL_ELT25
   X2    BVOHH VCCI VEEI VCS GNDI VEEI      BVOHH_GEN_ELT25


   XP1   D   IN                             PKG8
   XP2   DB  INB                            PKG8
   XP3   Q   QT                             PKG8
   XP4   VCC VCCI                           PKG8
   XP5   GND GNDI                           PKG8
   XP6   VEE VEEI                           PKG8
.ENDS ELT25_10H
```

```
.SUBCKT ELT25_100K  D DB Q VCC GND VEE


VCLMP     VCLMP VEE    2.1
VCS       VCS   VEE    1.3


   X1   IN INB QT VCCI VCCI VEEI GNDI
+       BVOHH VCLMP VCS                    ECL_TTL_ELT25
   X2   BVOHH VCCI VEEI VCS GNDI VEEI      BVOHH_GEN_ELT25


   XP1  D    IN                           PKG8
   XP2  DB   INB                          PKG8
   XP3  Q    QT                           PKG8
   XP4  VCC VCCI                          PKG8
   XP5  GND GNDI                          PKG8
   XP6  VEE VEEI                          PKG8
.ENDS ELT25_100k


************************************************************ ELT28 ******


.SUBCKT ELT28_10H  VCC GND DECL DECLB QTTL DTTL QECL QECLB


VCS       VCS GND   1.3
V2        V2  GND   2.2


   X1   VC GN VCS VCLP                      VOHCLMP
   X2   VC VC GN GN VCLP INB INCS QTT       TTL_OUT
   X3   VC GN Q QB INB INCS FEED            ETXR
   X4   VC GN VCS PIN PINB V2 Q QB          PECL_IN
   X5   VC GN VCS DTT QEC QECB              TTL_PECL_10H
   X6   VC GN DEC PIN                       ESDPD
   X7   VC GN DECB PINB                     ESDPD
   X8   QTT GN                              ESD
   X9   DTT GN                              ESD
   X10  QEC GN                              ESD
   X11  QECB GN                             ESD
   X12  VCC VC                              PKG8
   X13  GND GN                              PKG8
   X14  DECL DEC                            PKG8
   X15  DECLB DECB                          PKG8
   X16  QTTL QTT                            PKG8
   X17  DTTL DTT                            PKG8
   X18  QECL QEC                            PKG8
   X19  QECLB QECB                          PKG8
.ENDS ELT28_10H


.SUBCKT ELT28_100K  VCC GND DECL DECLB QTTL DTTL QECL QECLB


VCS       VCS GND   1.3
V2        V2  GND   2.2


   X1   VC GN VCS VCLP                      VOHCLMP
   X2   VC VC GN GN VCLP INB INCS QTT       TTL_OUT
   X3   VC GN Q QB INB INCS FEED            ETXR
   X4   VC GN VCS PIN PINB V2 Q QB          PECL_IN
   X5   VC GN VCS DTT QEC QECB              TTL_PECL_100K
   X6   VC GN DEC PIN                       ESDPD
```

```
    X7    VC GN DECB PINB                         ESDPD
    X8    QTT GN                                  ESD
    X9    DTT GN                                  ESD
    X10   QEC GN                                  ESD
    X11   QECB GN                                 ESD
    X12   VCC VC                                  PKG8
    X13   GND GN                                  PKG8
    X14   DECL DEC                                PKG8
    X15   DECLB DECB                              PKG8
    X16   QTTL QTT                                PKG8
    X17   DTTL DTT                                PKG8
    X18   QECL QEC                                PKG8
    X19   QECLB QECB                              PKG8
.ENDS ELT28_100K
```

```
************************************************************************
************************************************************************
****                        I/O Models                            ****
************************************************************************
************************************************************************


************************************************************************
**** The subcircuit ECL_TTL_ELT25 is a netlist of the differential ****
**** MC10/100ELT25 ECL to TTL translator (ECLinPS Lite)            ****
****     VCLMP = VCS+0.8V                                          ****
****     PVCC  = +5V                                               ****
****     TVCC  = +5V                                               ****
****     SUB   = VEE                                               ****
************************************************************************


.SUBCKT  ECL_TTL_ELT25 IN INB TTLOUT PVCC TVCC VEE GND BVOHH VCLMP VCS


   XESDIN   PVCC VEE IN DIN    ESDPD
   XESDINB  PVCC VEE INB DINB  ESDPD
   XESDO    TTLOUT GND         ESD


   Q1       3 1 2 VEE          T2X8A
   Q2       3 VCLMP 2 VEE      T2X8A
   Q3       5 13 2 VEE         T2X8A
   Q4       2 VCS 4 VEE        T2X8A
   Q5       PVCC 6 3 VEE       T2X8A
   Q6       PVCC 6 5 VEE       T2X8A
   Q7       6 7 GND VEE        T2X4A


   XQ1      8 5 9 10 VEE       FQWN41I
   XQ2      9 10 12 VEE        FQWN41O
   XQ3      TTLOUT 3 GND VEE   QPN138


   XR1      PVCC 6 PVCC        RESK params: R=3500
   XR2      PVCC 7 PVCC        RES  params: R=188
   XR3      PVCC 5 PVCC        RES  params: R=1820
   XR4      TVCC 8 TVCC        RES  params: R=700
   XR5      10 11 TVCC         RES  params: R=2000
   XR6      12 TTLOUT TVCC     RES  params: R=8
   XR7      7 GND PVCC         RES  params: R=1555
   XR8      PVCC 3 PVCC        RES  params: R=1820
   XR9      DINB 13 PVCC       RES  params: R=75
   XR10     4 VEE PVCC         RES  params: R=86
   XR11     DIN 1 PVCC         RES  params: R=75
   XR12     11 GND TVCC        RESK params: R=8969


   XD1      5 BVOHH VEE        FDG003
   XD2      11 TTLOUT VEE      FDG003
   XD3      TVCC 9 VEE         FDF413


.ENDS    ECL_TTL_ELT25
```

```
************************************************************************
**** The subcircuit BVOHH_GEN_ELT25 represents the BVOH          ****
**** generator of the MC10/100ELT25 device                      ****
****       PVCC = +5V                                            ****
****       PGND = 0V                                             ****
****       SUB  = VEE                                            ****
************************************************************************


.SUBCKT BVOHH_GEN_ELT25  BVOHH PVCC VEE VCS PGND SUB


    Q1    PVCC 4 3 VEE        T2X4A
    Q2    2 VCS 1 VEE         T2X4A
    Q3    4 2 5 VEE           T2X8A
    Q4    PVCC PGND 5 VEE     T2X8A
    Q5    5 VCS 6 VEE         T2X8A
    Q6    SUB 4 7 VEE         TPNP2
    Q7    4 VEE 4 VEE         C60PF


    XQ1   10 PGND 11 VEE      FQW101
    XQ2   9 8 VEE VEE         FQW101
    XQ3   BVOHH 10 PGND VEE   FQW113


    XD1   BVOHH 7 VEE         FDG003


    XR1   3 2 PVCC            RESK params: R=4100
    XR2   PVCC 4 PVCC         RESK params: R=6883
    XR3   6 VEE PVCC          RES  params: R=460
    XR4   PGND 8 PVCC         RESK params: R=7090
    XR5   8 VEE PVCC          RESK params: R=2724
    XR6   11 9 PVCC           RESK params: R=2500
    XR7   1 VEE PVCC          RES  params: R=928
    XR8   PVCC 10 PVCC        RESK params: R=5695
    XR9   PVCC BVOHH PVCC     RESK params: R=4166


.ENDS    BVOHH_GEN_ELT25


************************************************************************
***** SUBCKT TTL_OUT is the TTL ouput for the             *****
***** MC10/100ELT21, MC100ELT23, MC10/100ELT28.           *****
************************************************************************


.SUBCKT TTL_OUT  TVCC VCC TGND PGND VCLP INB INCS OUT
    Q3a   6 INB INCS PGND     t2x8a
    Q3b   6 INB INCS PGND     t2x8a
    XQ10  11 6 7 8 PGND       FQWN41I
    XQ11  7 8 10 PGND         FQWN41O
    XQ12  OUT INCS TGND PGND  QPN138
    XD1   TVCC 7 PGND         FDF413
    XD2   9 OUT PGND          FPS003
    XD3   6 VCLP PGND         FPS003
    XD4   5 6 PGND            FPS003
    XR1   5 INB VCC           RES  params: R=1000
    XR2   VCC 5 VCC           RES  params: R=1880
    XR3   INB PGND VCC        RESK params: R=6733
    XR5   VCC 6 VCC           RES  params: R=1200
    XR6   TVCC 11 TVCC        RES  params: R=700
    XR7   8 9 VCC             RES  params: R=2000
```

```
   XR8   9 PGND VCC          RESK params: R=8000
   XR9   10 OUT VCC          RES  params: R=8
.ENDS    TTL_OUT


*************************************************************************
***** SUBCKT ETXR is necessary to drive the TTL_OUT SUBCKT     *****
***** used in MC10/100ELT21, MC100ELT23, MC10/100ELT28.        *****
*************************************************************************


.SUBCKT ETXR  VCC PGND IN INB OUTB OUTCS TWO5PHI
   Q3   VCC 2 3 PGND       t2x4a
   Q4   VCC 6 8 PGND       t2x4a
   Q5   2 3 4 PGND         t2x6a
   Q6   6 3 5 PGND         t2x6a
   Q7   OUTB 9 PGND PGND   t2x8a
   Q8   9 9 PGND PGND      t2x4a
   Q9   OUTCS 9 PGND PGND  t2x8a
   Q11  7 10 PGND PGND     t2x4a
   Q12  VCC 13 OUTB PGND   t2x8a
   Q14  VCC 11 OUTCS PGND  t2x8a
   Q15  VCC INB 1 PGND     t2x6a
   Q16  VCC IN 14 PGND     t2x6a
   Q17  7 10 7 PGND        c60pf
   Q18  VCC 7 6 PGND       t2x4a
   XR1  VCC INB VCC        RES params:  R=1000
   XR2  VCC IN VCC         RES params:  R=1000
   XR3  3 PGND VCC         RES params:  R=1200
   XR5  VCC 7 VCC          RES params:  R=1800
   XR6A 7 TWO5PHI VCC      RES params:  R=200
   XR6  TWO5PHI 13 VCC     RES params:  R=400
   XR7  13 11 VCC          RES params:  R=400
   XR8  11 10 VCC          RES params:  R=400
   XR9  10 PGND VCC        RES params:  R=800
   XR11 4 PGND VCC         RES params:  R=20
   XR12 5 PGND VCC         RES params:  R=20
   XR14 8 9 VCC            RES params:  R=575
   XR15 1 2 VCC            RES params:  R=2000
   XR17 14 6 VCC           RES params:  R=2000
.ENDS ETXR


*************************************************************************
**** SUBCKT VOHCLMP IS NECESSARY TO GENERAT A PROPER CLAMP VOLTAGE ****
**** FOR TTL_OUT in MC10/100ELT28, MC100ELT23, MC10/100ELT21.    ****
*************************************************************************


.SUBCKT VOHCLMP  VCC PGND VCS VCLP
   Q1   VCC VCS 1 PGND   t2x4a
   Q2   2 3 1 PGND       t2x4a
   Q3   2 3 2 PGND       c60pf
   Q4   VCC 2 5 PGND     t2x4a
   Q5   PGND 5 4 PGND    tpnp2
   XD1  VCLP 4 PGND      FPS003
   XR1  VCC 2 VCC        RESK params: R=4000
   XR2  1 PGND VCC       RES  params: R=1000
   XR3  5 3 VCC          RESK params: R=3800
   XR4  3 PGND VCC       RES  params: R=2600
   XR6  VCC VCLP VCC     RES  params: R=2000
.ENDS VOHCLMP
```

```
***********************************************************************
*** The SUBCKT TTL_PECL_100K represents 100K TTL to PECL           ***
*** translator used in MC100ELT20, MC100ELT22.                     ***
***********************************************************************


.SUBCKT TTL_PECL_100K  VCC PGND VCS TIN POUT PBOUT
   Q1        PGND TIN 1 PGND      tpnp2
   Q2        VCC 2 3 PGND         t2x8a
   Q3        VCC 10 9 PGND        t2x8a
   Q4        12 12 13 PGND        t2x8a
   Q5        PGND PGND 13 PGND    tpnp2
   Q6        4 3 5 PGND           t08i1
   Q7        7 9 5 PGND           t08i1
   Q8        5 VCS 6 PGND         t12b1
   Q9        VCC 4 PBOUT PGND     t5406
   Q10       VCC 7 POUT PGND      t5406
   Q11       4 4 8 PGND           t05i1
   Q12       8 8 4 PGND           t05i1
   XDSTE5    19 VCC PGND          FPS102
   XDSTE6    VCC 19 PGND          FPS102
   XD1       2 1 PGND             FPS102
   XD2       10 11 PGND           FPS102
   XD3       11 12 PGND           FPS102
   XR1       VCC 2 VCC            RESK params: R=3000
   XR2       3 PGND VCC           RESK params: R=3000
   XR3       9 PGND VCC           RESK params: R=3000
   XR4       VCC 10 VCC           RESK params: R=3000
   XR5       VCC 4 VCC            RES  params: R=270
   XR6       VCC 7 VCC            RES  params: R=270
   XR7       6 PGND VCC           RES  params: R=120
   XR8       7 8 VCC              RES  params: R=270
.ENDS  TTL_PECL_100K


***********************************************************************
*** The SUBCKT TTL_PECL_10H represents 10H TTL to PECL             ***
*** translator used in MC10ELT20,MC10ELT22.                       ***
***********************************************************************


.SUBCKT TTL_PECL_10H  VCC PGND VCS TIN POUT PBOUT
   Q1        PGND TIN 1 PGND      tpnp2
   Q2        VCC 2 3 PGND         t2x8a
   Q3        VCC 10 9 PGND        t2x8a
   Q4        12 12 13 PGND        t2x8a
   Q5        PGND PGND 13 PGND    tpnp2
   Q6        4 3 5 PGND           t08i1
   Q7        7 9 5 PGND           t08i1
   Q8        5 VCS 6 PGND         t12b1
   Q9        VCC 4 PBOUT PGND     t5406
   Q10       VCC 7 POUT PGND      t5406
   XDSTE5    19 VCC PGND          FPS102
   XDSTE6    VCC 19 PGND          FPS102
   XD1       2 1 PGND             FPS102
   XD2       10 11 PGND           FPS102
   XD3       11 12 PGND           FPS102
   XR1       VCC 2 VCC            RESK params: R=3000
   XR2       3 PGND VCC           RESK params: R=3000
   XR3       9 PGND VCC           RESK params: R=3000
   XR4       VCC 10 VCC           RESK params: R=3000
   XR5       VCC 4 VCC            RES  params: R=270
   XR6       VCC 7 VCC            RES  params: R=270
```

```
   XR7      6 PGND VCC           RES  params: R=120
.ENDS  TTL_PECL_10H


*************************************************************************
*** The SUBCKT TTL_ECL_100K is used in the 100K TTL to ECL        ***
*** translator MC100ELT24.                                        ***
*************************************************************************


.SUBCKT TTL_ECL_100K  VCC VEE EGND PGND VCS TTL_IN Q QB
   XRTE1    VCC 1 VCC           RESK params: R=3000
   XRTE2    VCC 2 VCC           RESK params: R=3000
   XRTE3    7 VEE PGND          RESK params: R=5100
   XRTE4    12 VEE PGND         RESK params: R=5100
   XRTE5    8 VEE PGND          RESK params: R=3000
   XRTE6    13 VEE PGND         RESK params: R=3000
   XREO1    PGND 16 PGND        RES  params: R=270
   XREO2    PGND 14 PGND        RES  params: R=270
   XREO3    19 VEE PGND         RES  params: R=120
   XREO4    14 18 PGND          RES  params: R=270
   XDSTE1   4 5 VEE             FPS102
   XDSTE2   5 6 VEE             FPS102
   XDSTE3   1 2 VEE             FPS102
   XDSTE4   2 9 VEE             FPS102
   XDSTE5   11 12 VEE           FPS102
   XDSTE6   PGND 11 VEE         FPS102
   XDSTE7   6 7 VEE             FPS102
   QTE1     VEE TTL_IN 1 VEE    tpnp2
   QTE2     VCC 1 3 VEE         t2x8a
   QTE3     3 3 4 VEE           t2x8a
   QTE4     9 9 10 VEE          t2x8a
   QTE5     VEE PGND 10 VEE     tpnp2
   QTE6     VCC 7 8 VEE         t2x8a
   QTE7     VCC 12 13 VEE       t2x8a
   QEO2     16 8 15 VEE         t08i1
   QEO3     14 13 15 VEE        t08i1
   QEO4     15 VCS 19 VEE       t12b1
   QEO5     EGND 14 Q VEE       t5406
   QEO6     EGND 16 QB VEE      t5406
   QEO7     18 18 16 VEE        t05i1
   QEO8     16 16 18 VEE        t05i1
.ENDS      TTL_ECL_100K


*************************************************************************
*** The SUBCKT TTL_ECL_10H is used in the 10H TTL to ECL          ***
*** translator MC10ELT24.                                         ***
*************************************************************************


.SUBCKT TTL_ECL_10H  VCC VEE EGND PGND VCS TTL_IN Q QB

   XRTE1    VCC 1 VCC           RESK params: R=3000
   XRTE2    VCC 2 VCC           RESK params: R=3000
   XRTE3    7 VEE PGND          RESK params: R=5100
   XRTE4    12 VEE PGND         RESK params: R=5100
   XRTE5    8 VEE PGND          RESK params: R=3000
   XRTE6    13 VEE PGND         RESK params: R=3000
   XREO1    PGND 16 PGND        RES  params: R=270
   XREO2    PGND 14 PGND        RES  params: R=270
   XREO3A   19 VEE PGND         RES  params: R=120
   XDSTE1   4 5 VEE             FPS102
```

```
   XDSTE2  5 6 VEE              FPS102
   XDSTE3  1 2 VEE              FPS102
   XDSTE4  2 9 VEE              FPS102
   XDSTE5  11 12 VEE            FPS102
   XDSTE6  PGND 11 VEE          FPS102
   XDSTE7  6 7 VEE              FPS102
   QTE1    VEE TTL_IN 1 VEE     tpnp2
   QTE2    VCC 1 3 VEE          t2x8a
   QTE3    3 3 4 VEE            t2x8a
   QTE4    9 9 10 VEE           t2x8a
   QTE5    VEE PGND 10 VEE      tpnp2
   QTE6    VCC 7 8 VEE          t2x8a
   QTE7    VCC 12 13 VEE        t2x8a
   QEO2    16 8 15 VEE          t08i1
   QEO3    14 13 15 VEE         t08i1
   QEO4    15 VCS 19 VEE        t12b1
   QEO5    EGND 14 Q VEE        t5406
   QEO6    EGND 16 QB VEE       t5406
.ENDS  TTL_ECL_10H


***************************************************************************
*** The SUBCKT PECL_IN represents the PECL input in PECL-TTL       ***
*** translators in MC10/100ELT21, MC10/100ELT23, MC10/100ELT28.   ***
***************************************************************************


.SUBCKT PECL_IN  VCC PGND VCS PIN PINB V2 OUT OUTB
   Q5   OUTB PIN 1 PGND t2x6a
   Q6   OUT PINB 1 PGND t2x6a
   Q7   1 VCS 2 PGND    t2x6a
   Q9   VCC V2 1 PGND   t2x6a
   XR1  2 pgnd VCC      RES params: R=820
.ENDS PECL_IN


***************************************************************************
*** The SUBCKT PKG8 is the model for the 8-ld SOIC-package. It can  ***
*** be used for all pins.                                           ***
***************************************************************************


.SUBCKT PKG8   EXT INT
   CPKG   82 0    0.8p
   RPKG1  EXT 82  750
   RPKG2  82 83   750
   RPKG3  83 INT  0.1
   LPKG1  EXT 82  1.5n
   LPKG2  82 83   1.5n
.ENDS  PKG8


***************************************************************************
*** The SUBCKT ESD represents the ESD-protection circuitry for the  ***
*** TTL-I/O-Pins and (P)ECL Outputs.                                ***
***************************************************************************


.SUBCKT ESD   POS NEG
   X  POS NEG NEG  FPS009EX
.ENDS ESD


***************************************************************************
```

```
*** The SUBCKT ESDPD represents the ESD-protection circuitry for    ***
*** the (P)ECL-Inputs.                                              ***
*********************************************************************


.SUBCKT ESDPD  VCCE PGND IN OUT
   XFP  IN PGND PGND  FPS009EX
   XRB  IN OUT VCCE    RES params: R=75
   XRP  IN PGND VCCE  RPD params: R=50K
.ENDS   ESDPD
```

```
*************************************************************************
*************************************************************************
****** Most Subcircuits that represents transistor circuitry,    *****
****** built with several primitives                             *****
*************************************************************************
*************************************************************************

.SUBCKT FPS009EX  N1 N2 SUB
   R1   N1 1          4.97 TC=0.445m,2.78u
   Q1   1 N2 N2 SUB  pn009e
   D1   SUB 1         dsub009e
   DS1  N2 1          gr009e
.ENDS   FPS009EX


*************************************************************************


.SUBCKT QPN138  C B E SUB
   Q1   3 B E SUB  pn138
   Q2   5 B E SUB  pn138
   DS1  B 1     gr138
   DS4  B 4     gr138
   D1   SUB 2   dsub138
   R1   2 3     9.2  TC=5.582m,12.64u
   R2   1 2     15.6 TC=5.582m,12.64u
   R3   4 2     7.8  TC=5.582m,12.64u
   R4   2 5     9.2  TC=5.582m,12.64u
   R5   2 C     3.8  TC=5.582m,12.64u
.ENDS   QPN138


*************************************************************************


.SUBCKT FQWN41I  C B E1 E2 SUB
   Q1   1 B E1 SUB  pnn41ia
   Q2   2 B E2 SUB  pnn42ib
   DS1  b 1         gr138
   D1   SUB 1       dsubn41i
   R1   1 2         9.6  TC=0.445m,2.78u
   R2   C 2         14.6 TC=0.445m,2.78u
.ENDS   FQWN41I


*************************************************************************


.SUBCKT FQWN41O  C B E SUB
   Q1   1 B E SUB  pnwn41o
   D1   SUB 1       dsbwn41o
   R1   C 1         5.79 TC=0.445m,2.78u
.ENDS   FQWN41O


*************************************************************************


.SUBCKT FQW101  C B E SUB
   QPNW101 1 B E   PNW101
   DS1     B 1     WW101
   D1      SUB 1   DSUBW101
   R1      C 1     29.6    TC=0.445M,2.78U
.ENDS   FQW101
```

```
*************************************************************************


.SUBCKT FQW113  C B E SUB
   Q1   1 B E    PNW113
   DS1  B 1      WW113
   D1   SUB 1    DSUBW113
   R1   C 1      13.8        TC=0.445M,2.78U
.ENDS   FQW113


*************************************************************************


.SUBCKT FDG003  N1 N2 SUB
   D1   SUB 3    DSUBS003
   DS1  N1  1    GRS003
   REXT N2  3    23.5        TC=0.445M,2.78U
   RX   1   2    2.0
   REPI 2   3    14.6
.ENDS   FDG003


*************************************************************************


.SUBCKT FPS003  N1 N2 SUB
   DS1  N1 1    grs003
   DGR  N1 2    dres
   D1   SUB 3   dsubs003
   R1   1 2     2
   R2   2 3     15.2 TC=5.582m,12.64u
   R3   3 N2    22.9 TC=0.445m, 2.78u
.ENDS   FPS003


*************************************************************************


.SUBCKT FDF413  N1 N2 SUB
   DS1  N1 1    fpdf413
   D1   SUB 1   dsbdf413
   R1   1 N2    22.2 TC=0.445m,2.78u
.ENDS   FDF413


*************************************************************************


.SUBCKT FPS102  N1 N2 SUB
   DS1  N1 1    ws102
   D1   SUB 1   dsubs102
   R1   1 N2    39.1 TC=0.455m,2.78u
.ENDS   FPS102


*************************************************************************


.SUBCKT RES  A B VCC   params: R=50
    *   Assumes Sheet Rho=100OHM, Resistor Width=10U, and Cap in Farads.
    *   Use for Resistors up to 2500OHM
   Ra  A 1   {R/2} TC=900U
   Rb  1 B   {R/2} TC=900U
   D1  1 VCC DRES
    .MODEL DRES D
```

```
    + (IS=3.7E-16
    +  CJO=4.72E-16*R+58E-16)
.ENDS RES


************************************************************************


.SUBCKT RESK  A B VCC  params: R=3000
    *   Assumes Sheet Rho=500OHM, Resistor Width=10U, and Cap in Farads.
    *   Use for Resistors > 2500OHM
    Ra  A 1    {R/2} TC=900U
    Rb  1 B    {R/2} TC=900U
    D1  1 VCC  DRES
     .MODEL DRES D
      + (IS=3.7E-16
      +  CJO=0.265E-16*R+29E-16)
.ENDS RESK


************************************************************************


.SUBCKT RPD  A B VCC   params: R=50K
    Ra  A 1   {R/2} TC=900U
    Rb  1 B   {R/2} TC=900U
    D1  1 VCC  DRPD
     .MODEL DRPD D
      + (IS=3.7E-16
      +  CJO=0.1149P)
.ENDS RPD


************************************************************************
***********************   MODEL-PARAMETER   ***********************
************************************************************************


************************************************************************
.MODEL t2x4a          NPN
    + (is=0.01288f  bf=100       br=1.5        re=2         ikf=14.3m
    +  vaf=46       ise=0.2394f  rb=400        rbm=200      irb=850u
    +  ikr=0.364    var=3.58     isc=0.06404f  rc=35.4      nc=1.045
    +  nr=0.9972    cje=44.5f    vje=1.037     mje=0.572    nf=1.000
    +  xti=4.7      cjc=61f      vjc=0.75      mjc=0.266    ne=2.000
    +  xtb=1.15     cjs=109.4f   vjs=0.5815    mjs=0.5273   tr=9.92n
    +  ptf=30       tf=35p       xtf=2.6       vtf=1.67     itf=8.08m
    +  xcjc=59m     fc=0.8       eg=1.11)
************************************************************************
.MODEL t2x6a          NPN
    + (is=0.01973f  bf=100       br=1.5        re=1.66      ikf=0.0195
    +  vaf=46       ise=0.358f   rb=678        rbm=50       irb=12u
    +  ikr=0.3655   var=3.58     isc=0.04519f  rc=27.24     nc=1.045
    +  nr=1.027     cje=60.17f   vje=0.92      mje=0.413    nf=1.000
    +  xti=4.7      cjc=70.8f    vjc=0.75      mjc=0.2665   ne=2.000
    +  xtb=1.15     cjs=120.2f   vjs=581.5m    mjs=0.5273   tr=9.92n
    +  ptf=50       tf=35p       xtf=2.6       vtf=1.578    itf=11.66m
    +  xcjc=74.1m   fc=0.8       eg=1.11)
```

```
***********************************************************************
.MODEL t2x8a          NPN
     + (is=0.02532f  bf=100       br=1.5       re=1.50      ikf=27.3m
     + vaf=46         ise=0.478f   rb=222       rbm=111      irb=1.7m
     + ikr=365.5m     var=3.58     isc=0.080f   rc=22.67     nc=1.045
     + nr=0.9972      cje=79.6f    vje=1.037    mje=0.572    nf=1
     + xti=4.7        cjc=88.7f    vjc=0.75     mjc=0.266    ne=2
     + xtb=1.15       cjs=130.9f   vjs=581.5m   mjs=527.3m   tr=9.92n
     + ptf=50         tf=35E-12    xtf=2.6      vtf=1.578    itf=16m
     + xcjc=0.085     fc=0.8       eg=1.11)
***********************************************************************
.MODEL pn138          NPN
     + (is=0.163f     bf=100       br=1.5       re=0         ikf=0.179
     + vaf=46         ise=0        rb=75.9      rbm=31.1
     + ikr=6.975m     var=3.58     isc=0.193f   rc=5.29      nc=1.045
     + nr=1           cje=773f     vje=0.9      mje=0.4      nf=1.008
     + xti=5          cjc=378f     vjc=0.53     mjc=0.37     ne=1
     + xtb=1.15       eg=1.11      tr=9.92n
     + ptf=0          tf=35p       xtf=2.6      vtf=100      itf=10
     + xcjc=0.1       fc=0.5)
***********************************************************************
.MODEL gr138          D
     + (is=0.138p     rs=5.6       n=1.044      tt=10p       cjo=174.2f
     + vj=0.4         m=0.33       eg=0.69      xti=2        bv=30)
***********************************************************************
.MODEL dsub138        D
     + (cjo=1.87P     eg=1.15      vj=0.51      m=0.24)
***********************************************************************
.MODEL dsub009e       D
     + (cjo=106f      eg=1.15      vj=0.51      m=0.24)
***********************************************************************
.MODEL pn009e         NPN
     + (is=0.392f     bf=100       br=1.5       re=0         ikf=431m
     + vaf=46         ise=0        rb=185       rbm=39
     + ikr=0.3m       var=3.58     isc=4.25f    rc=3.9       nc=1.045
     + nr=1           cje=1.37p    vje=0.9      mje=0.4      nf=1.008
     + xti=5          cjc=609f     vjc=0.53     mjc=0.37     ne=1
     + xtb=1.15       eg=1.11      tr=9.92n
     + ptf=0          tf=35p       xtf=2.6      vtf=100      itf=1.64m
     + xcjc=0.1       fc=0.5)
***********************************************************************
.MODEL gr009e         D
     + (is=0.54p      rs=9.57      n=1.044      tt=10p       cjo=683f
     + vj=0.4         m=0.33       eg=0.69      xti=2        bv=30)
***********************************************************************
.MODEL dsubn41i       D
     + (cjo=303.3f    eg=1.15      vj=0.51      m=0.24)
***********************************************************************
.MODEL pnn41ia        NPN
     + (is=0.02625f   bf=100       br=1.5       re=0         ikf=0.029
     + vaf=46         ise=0        rb=467       rbm=189.2
     + ikr=1.125m     var=3.58     isc=0.0311f  rc=58        nc=1.045
     + nr=1           cje=131.6f   vje=0.9      mje=0.4      nf=1.008
     + xti=5          cjc=60.4f    vjc=0.53     mjc=0.37     ne=1
     + xtb=1.15       eg=1.11      tr=9.92n
     + ptf=0          tf=35p       xtf=2.6      vtf=100      itf=10
     + xcjc=0.1       fc=0.5)
```

```
******************************************************************
.MODEL pnn42ib        NPN
     + (is=0.02625f  bf=100        br=1.5        re=0          ikf=0.029
     + vaf=46         ise=0         rb=744.7      rbm=189.2
     + ikr=1.125m     var=3.58      isc=0.0311f   rc=58         nc=1.045
     + nr=1           cje=131.6f    vje=0.9       mje=0.4       nf=1.008
     + xti=5          cjc=60.4f     vjc=0.53      mjc=0.37      ne=1
     + xtb=1.15       eg=1.11       tr=9.92n
     + ptf=0          tf=35p        xtf=2.6       vtf=100       itf=10
     + xcjc=0.1       fc=0.5)
******************************************************************
.MODEL dsbwn41o       D
     + (cjo=789.8f    eg=1.15       vj=0.51       m=0.24)
******************************************************************
.MODEL pnwn41o        NPN
     + (is=0.164f     bf=100        br=1.5        re=0          ikf=0.180
     + vaf=46         ise=0         rb=83.2       rbm=38.7
     + ikr=7.01m      var=3.58      isc=0.194f    rc=9.31       nc=1.045
     + nr=1           cje=776.3f    vje=0.9       mje=0.4       nf=1.008
     + xti=5          cjc=417.9f    vjc=0.53      mjc=0.37      ne=1
     + xtb=1.15       eg=1.11       tr=9.92n
     + ptf=0          tf=35p        xtf=2.6       vtf=100       itf=10
     + xcjc=0.1       fc=0.5)
******************************************************************
.MODEL grs003         D
     + (is=0.0427p    rs=53         n=1.044       tt=10p        cjo=54f
     + vj=0.4         m=0.33        eg=0.69       xti=2         bv=30)
******************************************************************
.MODEL dsubs003       D
     + (is=0.1f       rs=0          n=1           tt=500p       cjo=127f
     + eg=1.15        vj=0.51       m=0.24        xti=3
     + bv=35)
******************************************************************
.MODEL ws102          D
     + (is=0.1p       rs=77         n=1.044       tt=10p        cjo=62.2f
     + vj=0.4         m=0.33        eg=0.69       xti=2         bv=30)
******************************************************************
.MODEL dsubs102       D
     + (is=0.1f       rs=0          n=1           tt=500p       cjo=85f
     + eg=1.15        vj=0.51       m=0.24        xti=3
     + bv=35)
******************************************************************
.MODEL fpdf413        D
     + (is=0.902p     rs=3.78       n=1.044       tt=10p        cjo=755.1f
     + vj=0.4         m=0.33        eg=0.69       xti=2         bv=30)
******************************************************************
.MODEL dsbdf413       D
     + (is=0.1f       rs=0          n=1           tt=500p       cjo=780f
     + eg=1.15        vj=0.51       m=0.24        xti=3
     + bv=35)
******************************************************************
.MODEL t05i1          NPN
     + (is=0.02118f   bf=100        br=1.5        re=1.533      ikf=21.3m
     + vaf=46         ise=0.250f    rb=52.7       rbm=0         irb=0
     + ikr=530u       var=3.58      isc=0.09562f  rc=26.33      nc=1.045
     + nr=0.997       cje=67.7f     vje=1.037     mje=571.8m    nf=1
     + xti=4.7        cjc=99.5f     vjc=0.603     mjc=0.266     ne=2
     + xtb=1.15       cjs=152f      vjs=0.5052    mjs=0.3465    tr=9.92n
     + ptf=20         tf=35p        xtf=2.6       vtf=1.67      itf=8.08m
     + xcjc=69m       fc=0.8        eg=1.11)
```

```
*******************************************************************
.MODEL t08i1          NPN
      + (is=0.03333f  bf=100       br=1.5        re=1.333      ikf=33.6m
      + vaf=46        ise=1.0f     rb=56.6       rbm=0         irb=0
      + ikr=115m      var=3.58     isc=0.1847f   rc=22.86      nc=1.045
      + nr=995m       cje=99.3f    vje=1.037     mje=571.8m    nf=1
      + xti=4.7       cjc=124.4f   vjc=603m      mjc=266m      ne=2
      + xtb=1.15      cjs=170.4f   vjs=505.2m    mjs=346.5m    tr=9.92n
      + ptf=40        tf=35p       xtf=2.6       vtf=1.67      itf=8.08m
      + xcjc=89m      fc=0.8       eg=1.11)
*******************************************************************
.MODEL t12b1          NPN
      + (is=0.057f    bf=100       br=1.5        re=1.25       ikf=82.8m
      + vaf=46        ise=2.4f     rb=170        rbm=170       irb=1.7m
      + ikr=0.27      var=3.58     isc=0.101f    rc=13.3       nc=1.045
      + nr=1.019      cje=15f      vje=658m      mje=273m      nf=1
      + xti=3         cjc=27f      vjc=603m      mjc=369m      ne=2
      + xtb=1.15      cjs=101f     vjs=429m      mjs=259m      tr=9.92n
      + tf=35p        xtf=2.6      vtf=1.4       itf=8m
      + xcjc=620m     fc=5m        eg=1.11)
*******************************************************************
.MODEL t5406          NPN
      + (is=0.33f     bf=100       br=1.5        re=833m       ikf=0.48
      + vaf=46        rb=86.6      var=3.58      rc=23.6       nc=1.045
      + cje=.495p     cjc=722f     xtb=1.15      cjs=576f      tr=9.92n
      + tf=35p        xtf=2.6      eg=1.11)
*******************************************************************
.MODEL tpnp2          PNP
      + (is=0.0769f   bf=70        br=1          rb=164        rc=56
      + cje=86f       cjc=1.4p     tf=1n)
*******************************************************************
.MODEL c60pf          NPN
      + (is=0.88224f  bf=100       br=1.5        rb=141        rc=16
      + re=0.3        cje=3.657p   cjc=2.927p    cjs=1.029p    nc=1.045
      + eg=1.11)
*******************************************************************
.MODEL dres           D
      + (is=0.37f     cjo=414f)
*******************************************************************
.MODEL DSUBW113 D   (CJO=179.8FF eg=1.15    vj=.51 m=.24)
*******************************************************************
.MODEL PNW113 npn   (IS=2.45E-17 bf=100 NF=1.008 vaf=30.0 IKF=.0270
+  ISE=0 NE=1 br=1.5 NR=1 XCJC=.1 var=8.4
+  IKR=1.05MA ISC=2.9E-17 nc=1.045 RB=497.6 RBM=200
+  RE=0 RC=62.2
+  CJE=123.4FF vje=0.92 mje=0.413
+  CJC=68.3FF vjc=0.75 mjc=0.266
+  tf=35E-12 xtf=2.6 VTF=100 ITF=10A PTF=0
+  tr=9.92E-9 xtb=1.15 XTI=5 FC=.5
+  eg=1.11)
*******************************************************************
.MODEL WW113 D      (IS=4.6E-13 RS=60.1 N=1.044 TT=10PS
+  CJO=61.6FF VJ=.4 M=.33
+  EG=.69 XTI=2 FC=.5 BV=30)
```

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* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
.MODEL DSUBW101 D   (CJO=109.4FF eg=1.15   vj=.51 m=.24)
.MODEL PNW101 npn   (IS=7E-18 bf=100 NF=1.008 vaf=30.0 IKF=.0077
+   ISE=0 NE=1 br=1.5 NR=1 XCJC=.1 var=8.4
+   IKR=.3MA ISC=8.28E-18 nc=1.045 RB=1508.3 RBM=466.7
+   RE=0 RC=217.6
+   CJE=41.3FF vje=0.92 mje=0.413
+   CJC=32FF vjc=0.75 mjc=0.266
+   tf=35E-12 xtf=2.6 VTF=100 ITF=10A PTF=0
+   tr=9.92E-9 xtb=1.15 XTI=5 FC=.5
+   eg=1.11)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
.MODEL WW101 D      (IS=2.15E-13 RS=125.3 N=1.044 TT=10PS
+   CJO=28.8FF VJ=.4 M=.33
+   EG=.69 XTI=2 FC=.5 BV=30)
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *


.END
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