

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 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.

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 be used for power up or power down simulations.

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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.

$R < 2500\Omega$	$CJ0 = 4.72E-16 * R + 58E-16$	
$R > 2500\Omega$	$CJ0 = 0.265E-16 * R + 29E-16$	
$R = 50k\Omega$	$CJ0 = 0.1149pF$	input pulldown resistor

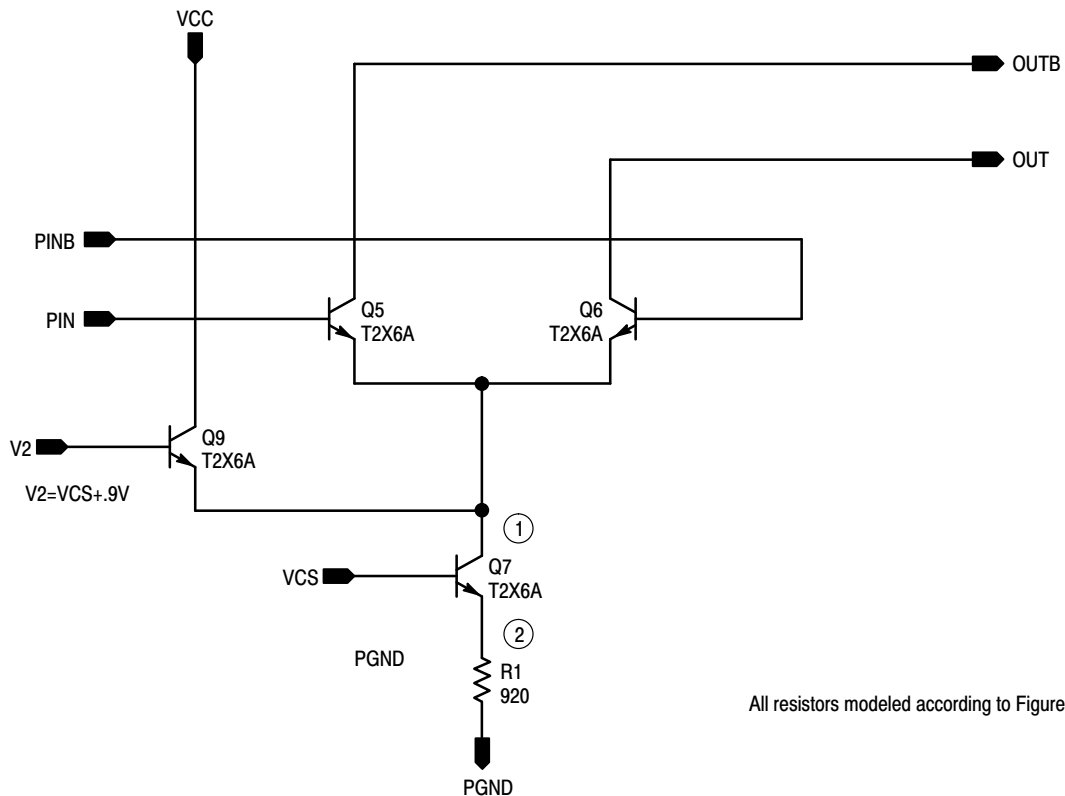
In the model file, 3 subcircuits are used: RES for resistor values $< 2.5k\Omega$, RESK for $R > 2.5k\Omega$ and RPD for the input pulldown resistors. As the parasitic capacitance of the Diode is a function of the resistivity, the capacitance needs to be calculated. As calculations of model parameters 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

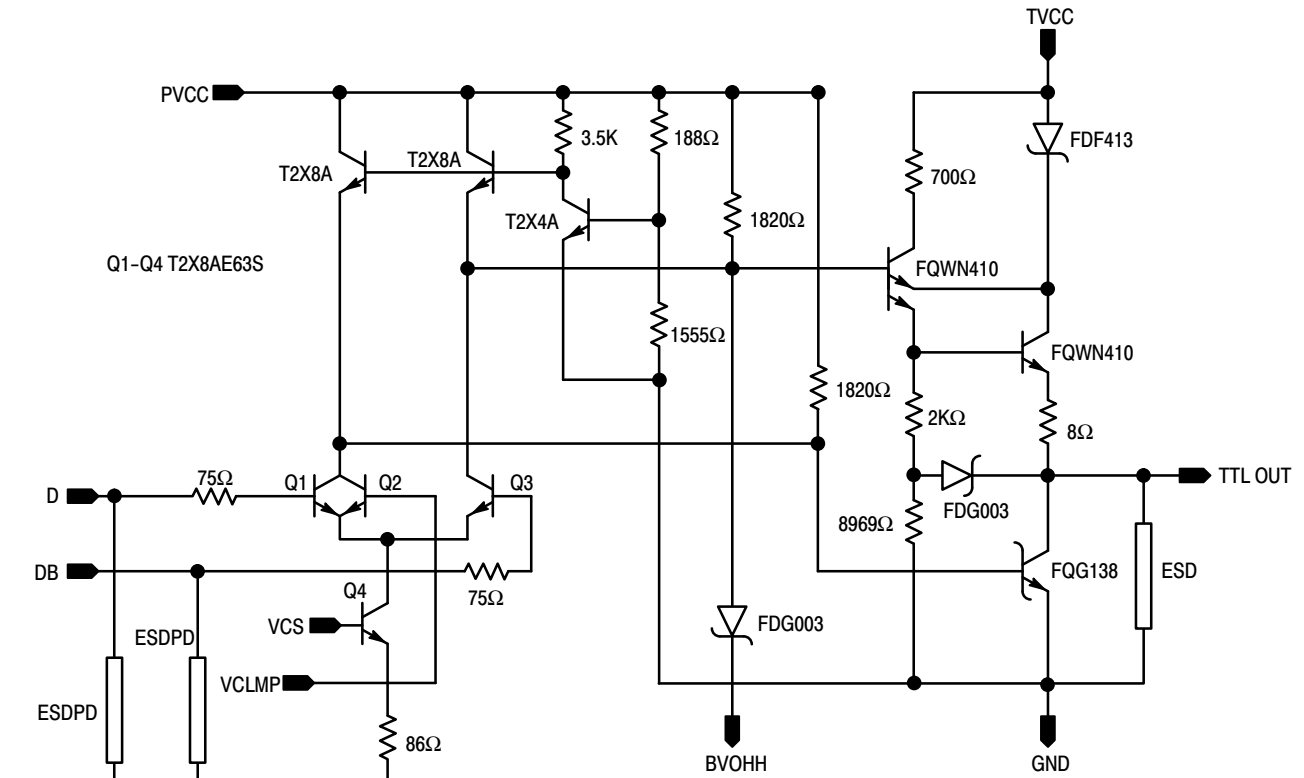
For typical load ECL and PECL outputs should be terminated 50Ω to $VTT = VCC - 2V$. TTL outputs are loaded with $20pF$ to GROUND and 500Ω to GROUND.



All resistors modeled according to Figure 11.

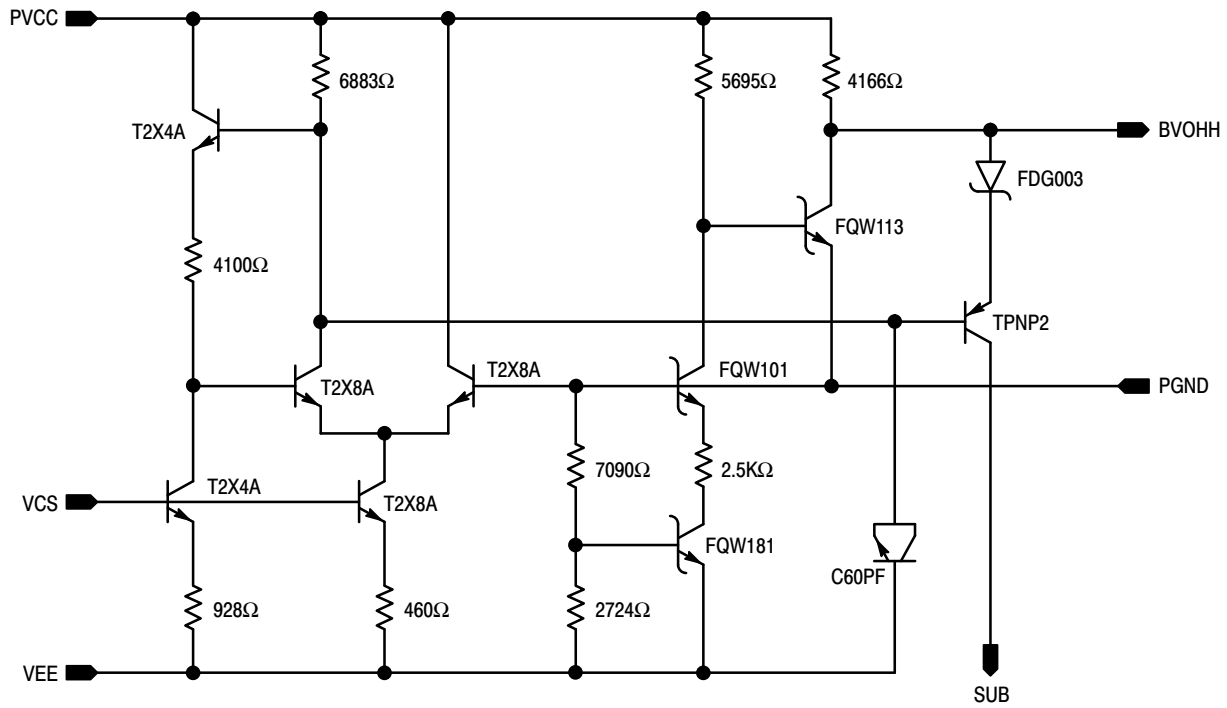
Figure 1. . PECL_IN

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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

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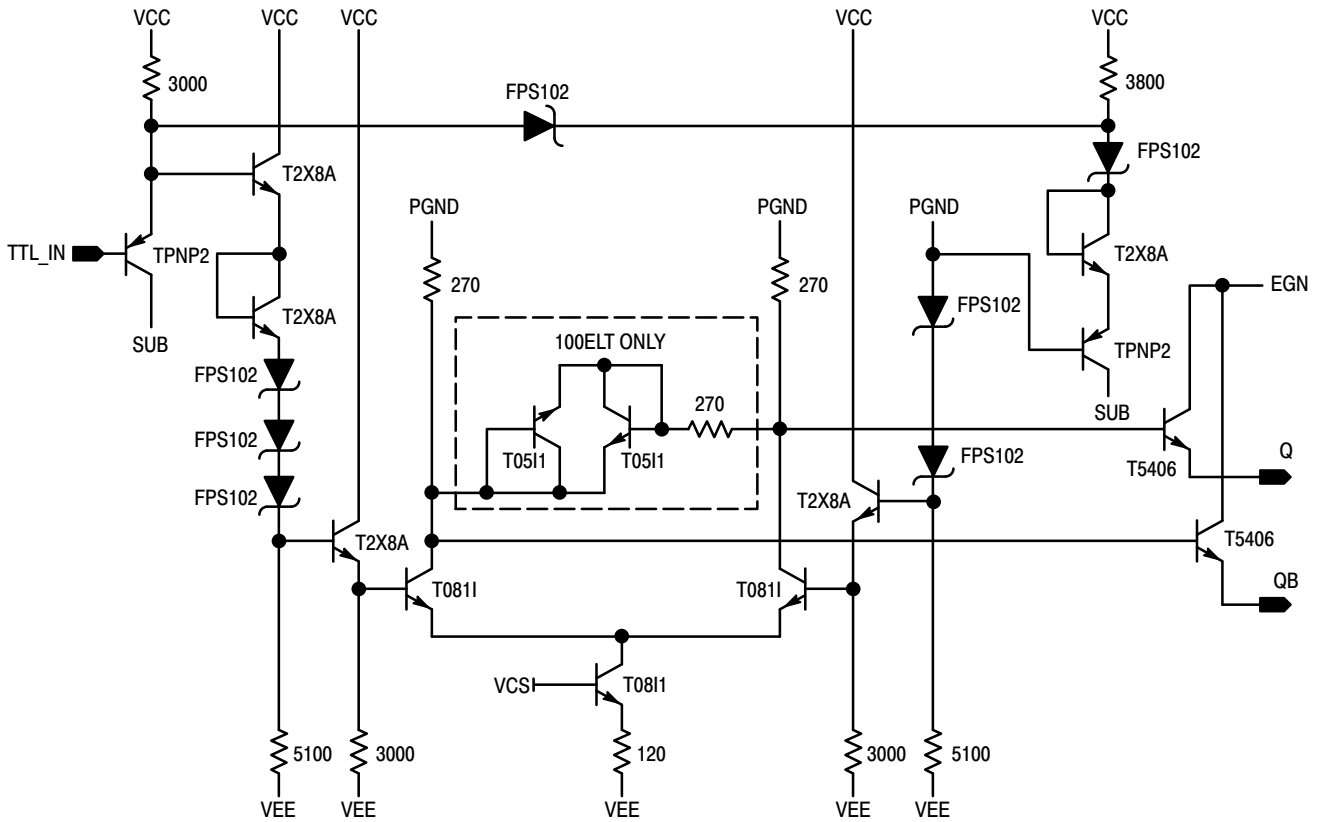


Figure 3 . TTL_ECL

All resistors modeled according to Figure 11.

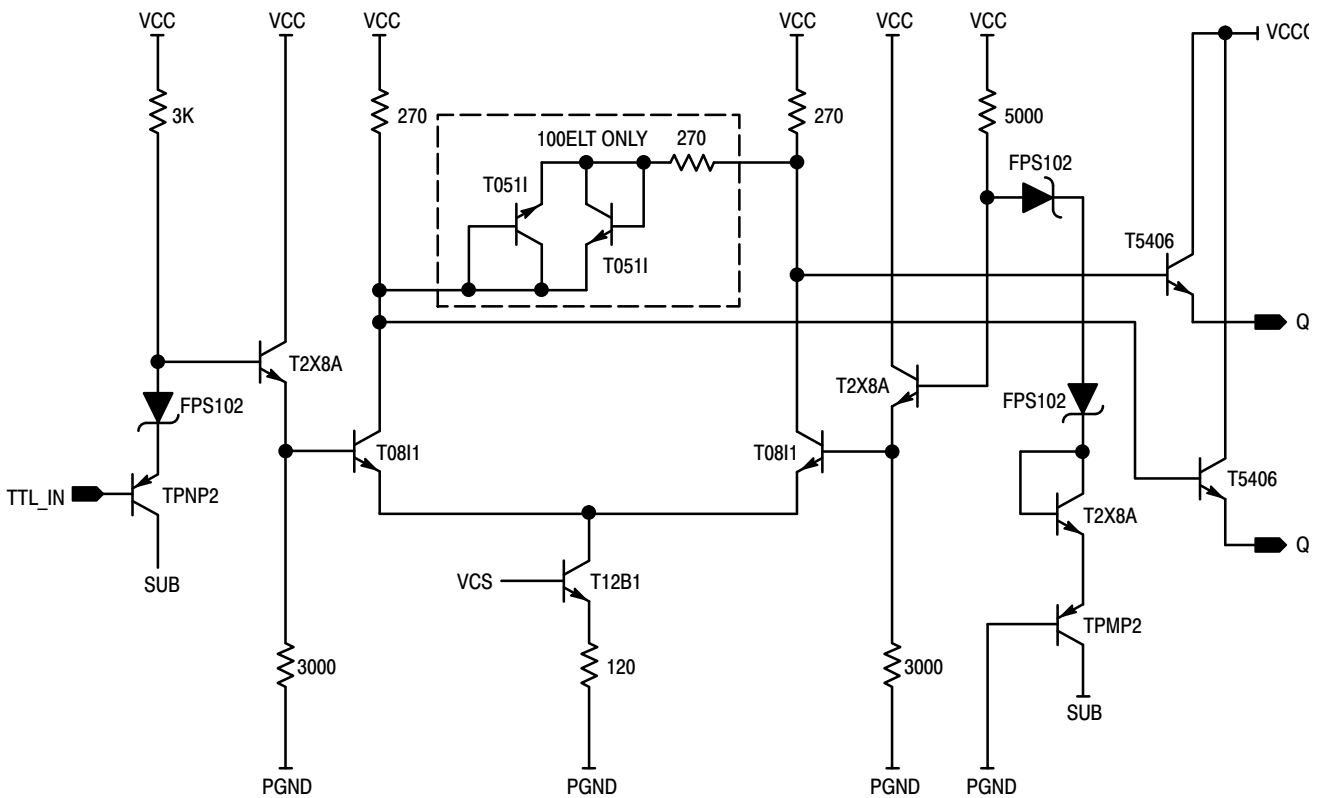


Figure 4 . TTL_PECL

All resistors modeled according to Figure 11.

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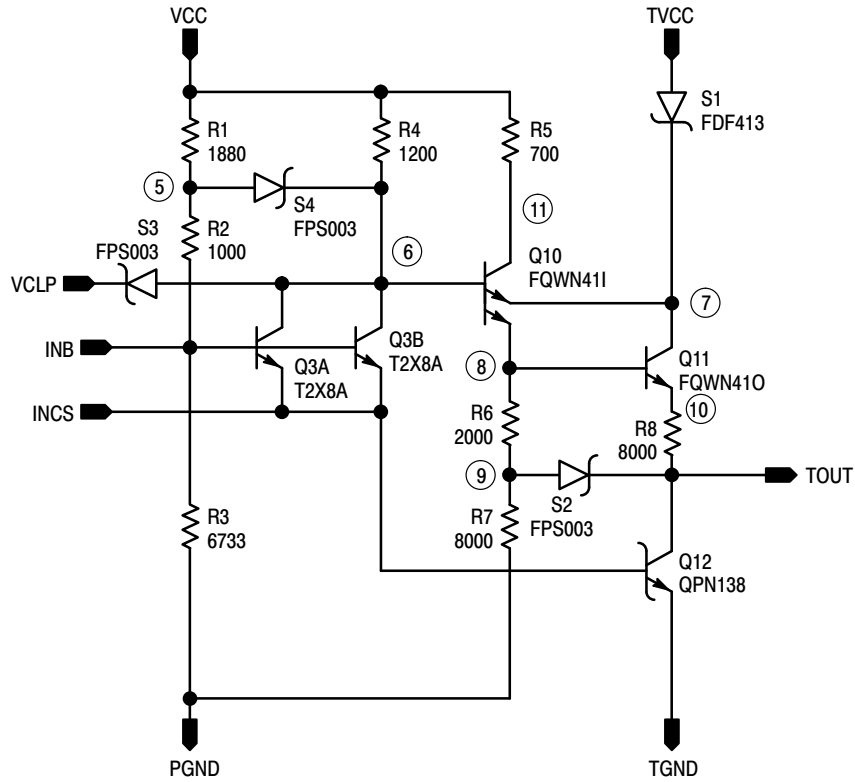


Figure 5. . TTL_OUT

All resistors modeled according to Figure 11.

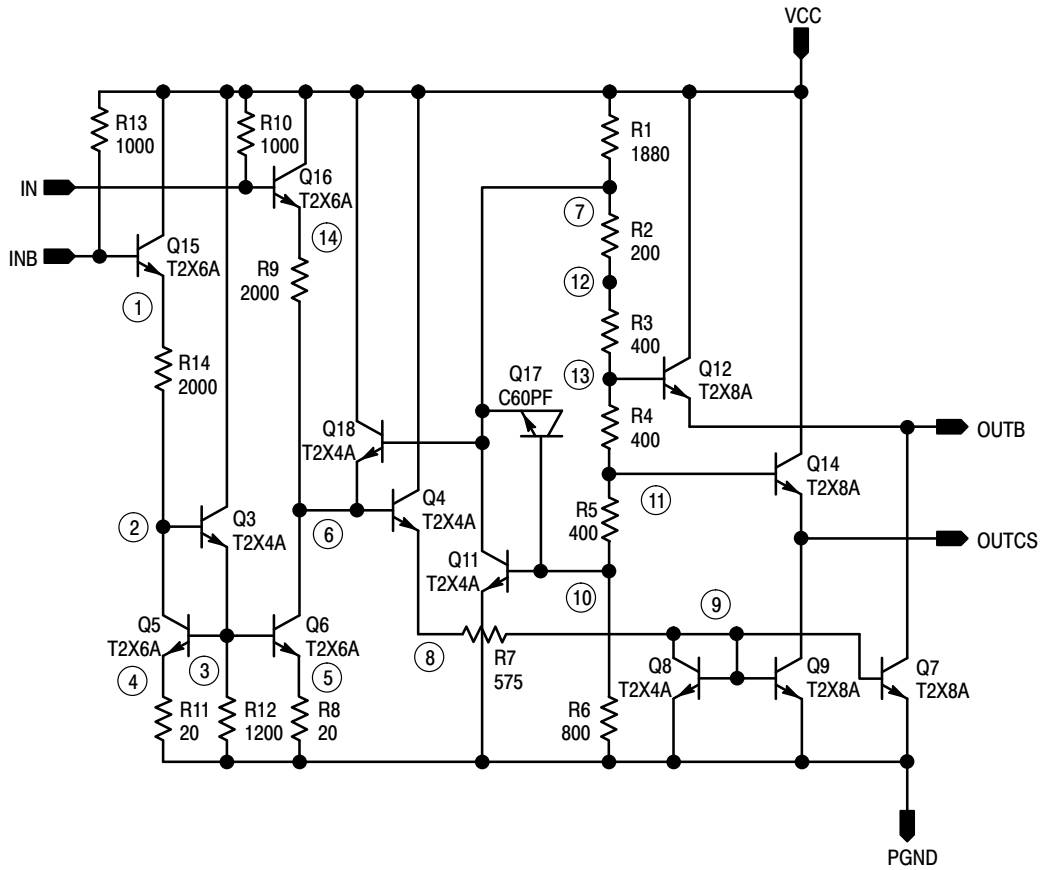
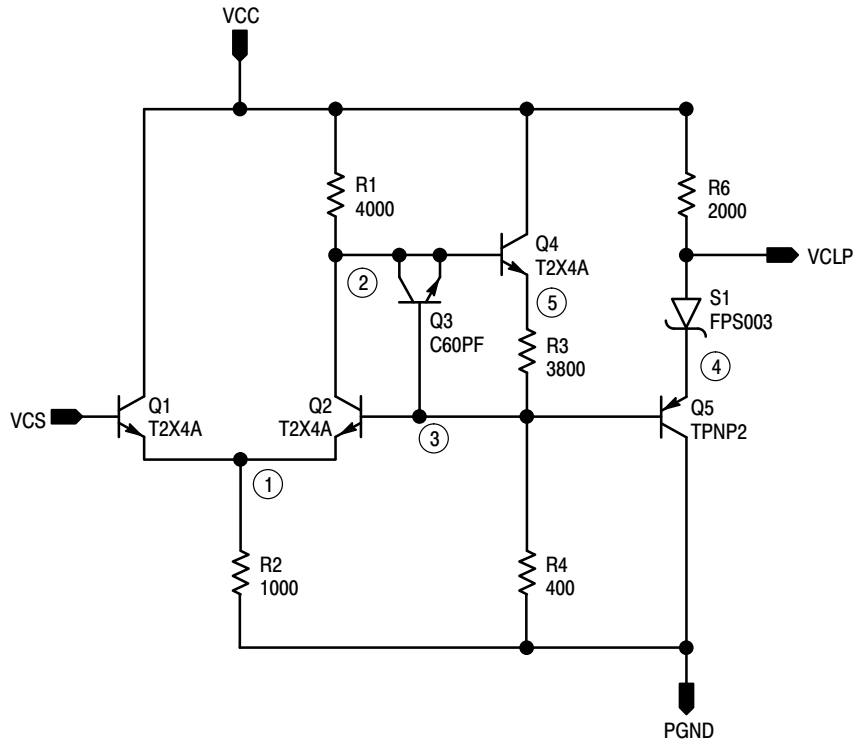


Figure 6. . MACRO ETL ETXR

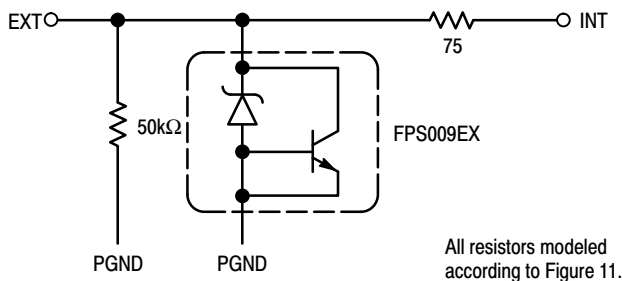
All resistors modeled according to Figure 11.

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All resistors modeled according to Figure 11.

Figure 7. . VCLP



All resistors modeled according to Figure 11.

Figure 8. . ESD Protection ECL/PECL Input

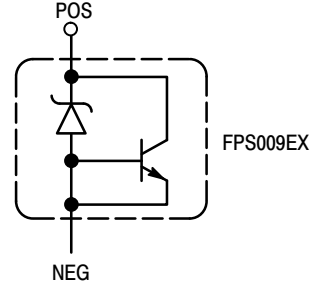


Figure 9. . ESD Protection for all Outputs and TTL Inputs

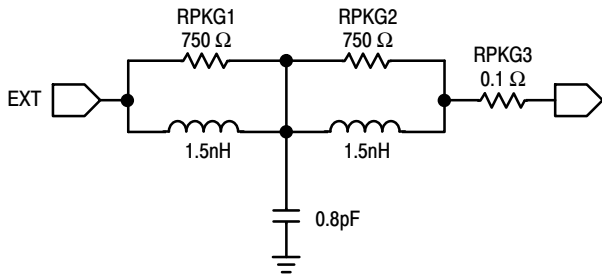


Figure 10. . Package Pin Model

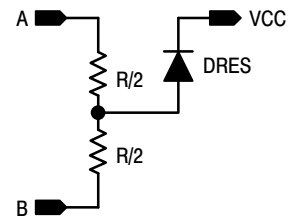


Figure 11. . Resistor Model

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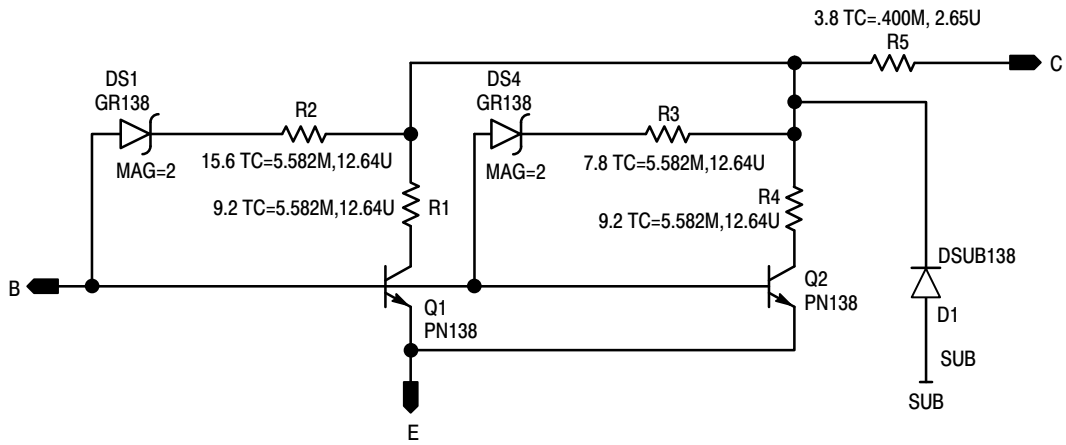


Figure 12. . QPN138

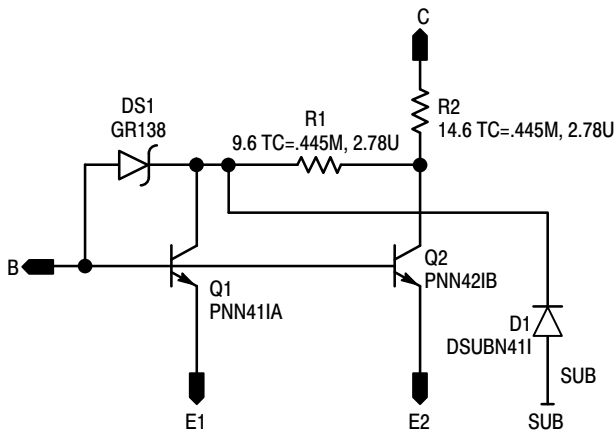


Figure 13. . QWN410

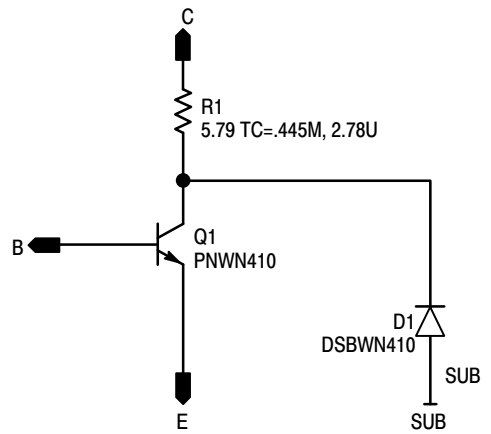


Figure 14. . QPN410

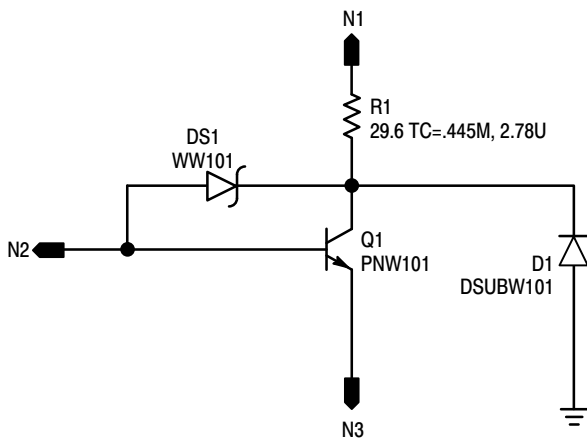


Figure 15. . FDG003

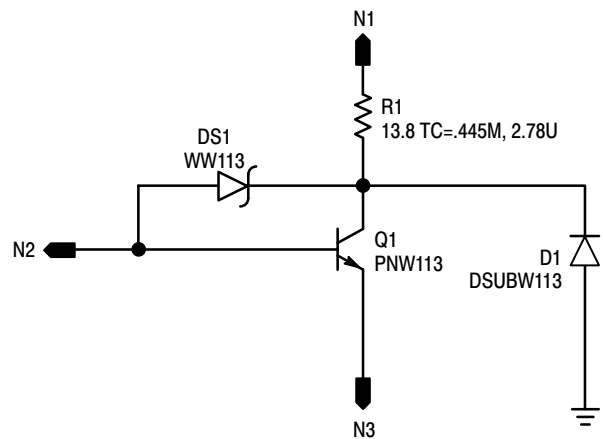


Figure 16. . FQW113

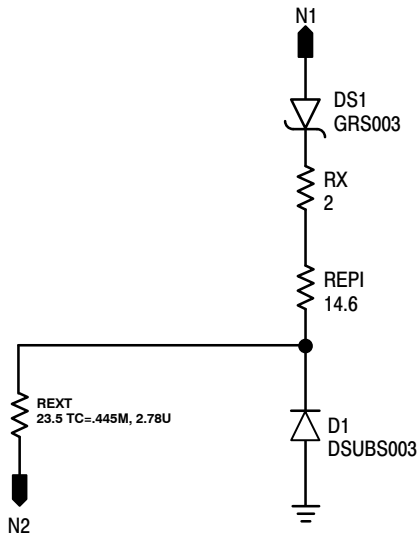


Figure 17. . FDG003

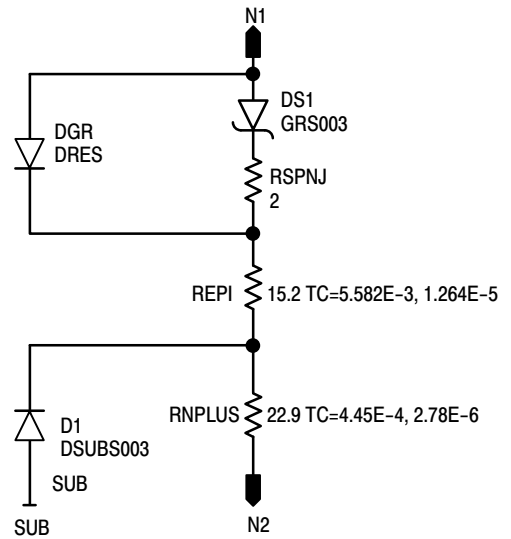


Figure 18. . FPS003

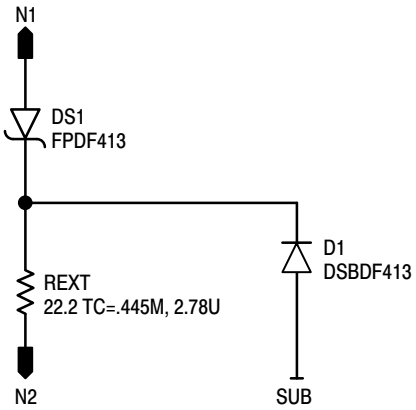


Figure 19. . FDF413

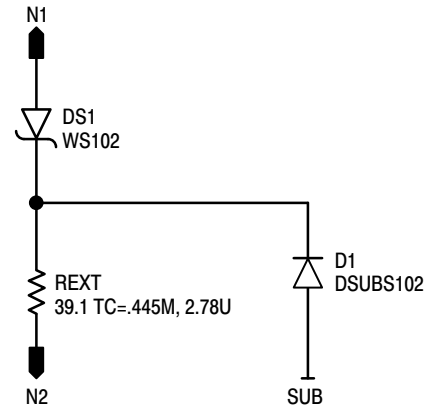


Figure 20. . FPS102

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Models

```
*****
* Spice Model Files for the:  MC10ELT20      MC100ELT20      *
*                               MC10ELT21      MC100ELT21      *
*                               MC10ELT22      MC100ELT22      *
*                               MC10ELT23      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
```

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```
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 QTTL 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 QTTL GN ESD
X8 VCC VC PKG8
X9 GND GN PKG8
X10 DECL DEC PKG8
X11 DECLB DECB PKG8
X12 QTTL QTTL 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 QTTL 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 QTTL GN ESD
X8 VCC VC PKG8
X9 GND GN PKG8
X10 DECL DEC PKG8
X11 DECLB DECB PKG8
X12 QTTL QTTL 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
```

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```

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

```

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.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

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.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 QECLB TTL_PECL_10H
 X6 VC GN DEC PIN ESDPD
 X7 VC GN DECB PINB ESDPD
 X8 QTT GN ESD
 X9 DTTL GN ESD
 X10 QEC GN ESD
 X11 QECLB GN ESD
 X12 VCC VC PKG8
 X13 GND GN PKG8
 X14 DECL DEC PKG8
 X15 DECLB DECB PKG8
 X16 QTTL QTT PKG8
 X17 DTTL DTTL PKG8
 X18 QECL QEC PKG8
 X19 QECLB QECLB 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 QECLB TTL_PECL_100K
 X6 VC GN DEC PIN ESDPD

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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

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

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


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```
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        tnp2
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
```

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

```
.SUBCKT TTL_PECL_100K VCC PGND VCS TIN POUT PBOU
  Q1    PGND TIN 1 PGND      tnp2
  Q2    VCC 2 3 PGND        t2x8a
  Q3    VCC 10 9 PGND       t2x8a
  Q4    12 12 13 PGND      t2x8a
  Q5    PGND PGND 13 PGND   tnp2
  Q6    4 3 5 PGND         t08i1
  Q7    7 9 5 PGND         t08i1
  Q8    5 VCS 6 PGND       t12b1
  Q9    VCC 4 PBOU 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 PBOU
  Q1    PGND TIN 1 PGND      tnp2
  Q2    VCC 2 3 PGND        t2x8a
  Q3    VCC 10 9 PGND       t2x8a
  Q4    12 12 13 PGND      t2x8a
  Q5    PGND PGND 13 PGND   tnp2
  Q6    4 3 5 PGND         t08i1
  Q7    7 9 5 PGND         t08i1
  Q8    5 VCS 6 PGND       t12b1
  Q9    VCC 4 PBOU 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
```

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```
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  tnp2
QTE2    VCC 1 3 VEE     t2x8a
QTE3    3 3 4 VEE      t2x8a
QTE4    9 9 10 VEE     t2x8a
QTE5    VEE PGND 10 VEE  tnp2
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
```

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```
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 tnp2
QTE2    VCC 1 3 VEE     t2x8a
QTE3    3 3 4 VEE      t2x8a
QTE4    9 9 10 VEE     t2x8a
QTE5    VEE PGND 10 VEE tnp2
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 pgn2 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
```

```
*****
```

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*** 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
```

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

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```
.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
```

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```
+ (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)
```


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```

*****
.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        irb=1.7m
+ 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        vtf=100         itf=10
+ 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          irb=1.7m
+ 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        vtf=100         itf=1.64m
+ 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       irb=1.7m
+ 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        vtf=100         itf=10
+ ptf=0            tf=35p          xtf=2.6         vtf=100         itf=10
+ xcjc=0.1         fc=0.5)

```

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```
*****
.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)
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*****
.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 tnp2       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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