Application Note No. 025

1400 - 1600 MHz PIN-Diode Transmit-Receive Switch

RF & Protection Devices

Never stop thinking

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1400 - 1600 MHz PIN-Diode Transmit-Receive Switch
Revision History: 2006-10-20, Rev. 2.0

Previous Version: 2000-07-28

Page	Subjects (major changes since last revision)
All	Layout changes

1 1400 - 1600 MHz PIN-Diode Transmit-Receive Switch

This application note describes a non-mechanical transmit-receive switch for the PDC 1500 mobile telephone system.

1.1 Advantages

- No power consumption in receive state
- Low component count
- Low cost
- µP-compatible control input
- Diode current independent of operating voltage
- No negative supply voltage necessary

1.2 Small Signal Performance Data at 1400... 1600 MHz

Table 1 Small Signal Performance (R = 120 Ω; I = 5.8 mA)

Transmit-state (ON = GND)		**Receive-State (ON = V+)**	
TX-Antenna Loss: (dB)	0.33... 0.4[1)]	RX-Antenna Loss: (dB)	0.56... 0.75[1)]
Antenna-RX Isolation: (dB)	25.9... 24.7	TX-RX Isolation: (dB)	16.5... 15.6
TX-RX Isolation: (dB)	27.1... 25.1	TX-Antenna Isolation: (dB)	17.6... 16.1

1) These values are the overall losses. Evaluation of a dummy-circuit with diodes replaced by open/short shows 0.15 dB loss in TX-Antenna path and 0.2 dB from Antenna to RX.

1.3 Large Signal Performance Data

Measurement Setup:

- TX-Port: f = 1500 MHz, 30 dB power, harmonic suppression > 100 dBc
- RX-Port: DC-blocked 50 Ω termination
- Antenna Port: DC-blocked spectrum analyzer
- V+ = 5 V

Values referred to input power level at TX-Port:

Table 2 Large Signal Performance

R / Ω	I / mA	Attenuation	1. Harmonic @ 3 GHz	2. Harmonic @ 4.5 GHZ
56	10	0.33 dB	94.5 dBc	> 100 dBc
120	5.8	0.33 dB	89.5 dBc	> 100 dBc
270	2.8	0.33 dB	86.5 dBc	89.5 dBc
680	1.2	0.33 dB	72.5 dBc	76.0 dBc

Please note that there is no compression until damage level of diode power dissipation (250 mW) is reached.

1.4 Schematic

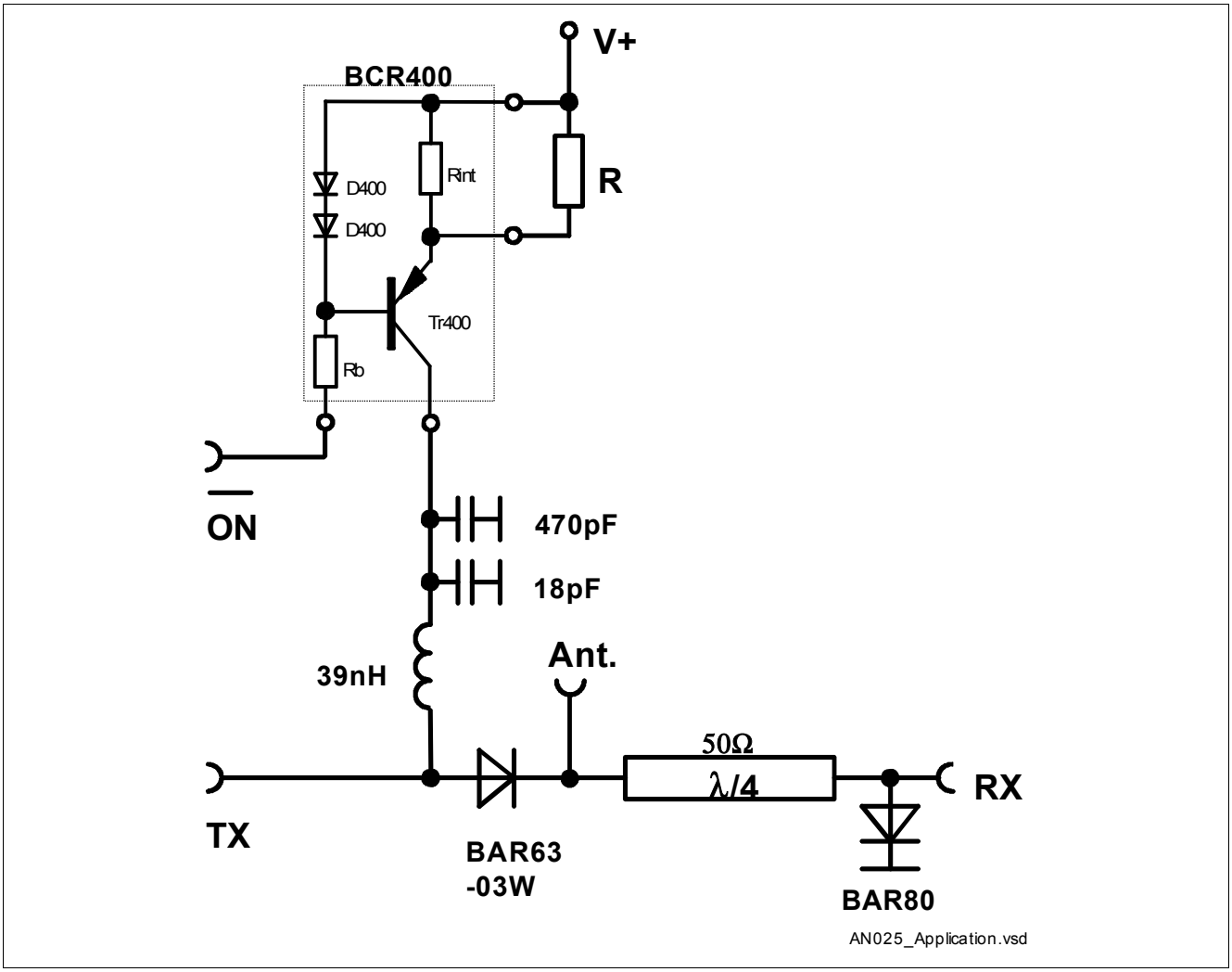

Figure 1 Application

1.5 Functional Description

- In transmit mode both diodes are forward biased into conduction by current provided by the BCR400. The short-circuit created by the BAR80 at the RX-port is transformed into an open-circuit at the Antenna-port by the λ/4 microstrip line.
- In receive mode both diodes have zero bias current and therefore do not conduct. The RF passes from Antenna- to RX -port.
- The BCR400 current source is controlled by the logic signal ON. This is a logic low for transmit mode, and a logic high for receive mode. The bias current in transmit state can be adjusted by changing the value of R.

The performance of the switch can be further improvemened by compensation of the remaining diode-capacitance in the off-state.

A shunt-inductor to BAR63-03W can be added that creates a parallel resonance with the diode establishing an open-circuit at the resonance frequency. An additional capacitor in series with this inductor is also necessary to block the DC path across the diode.

1.6 Layout

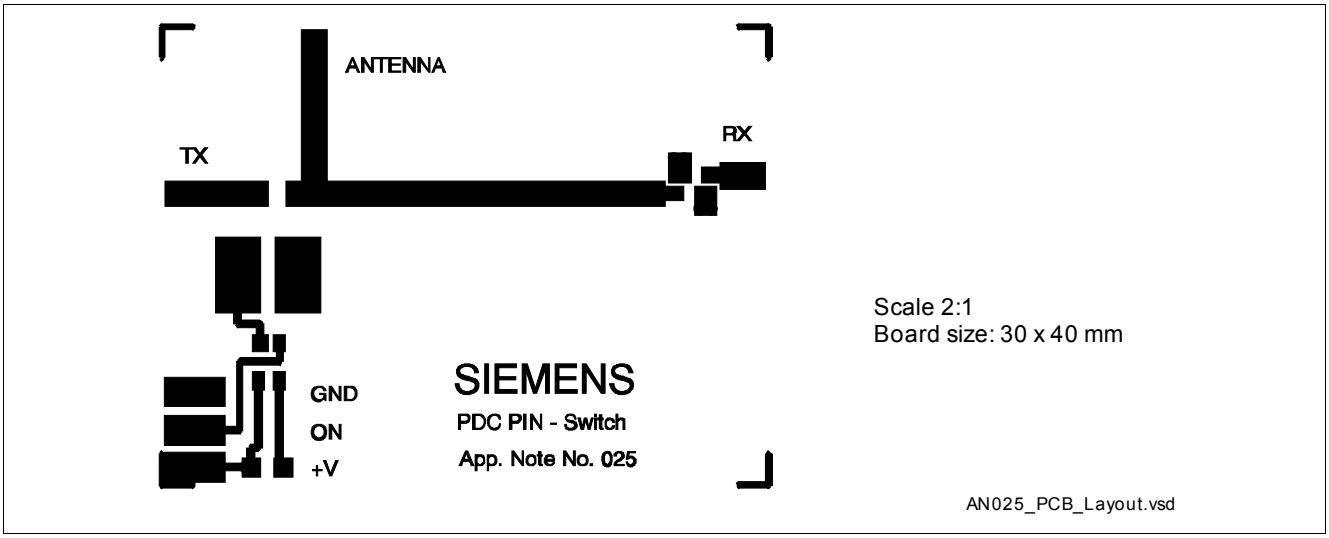

Figure 2 PCB Layout

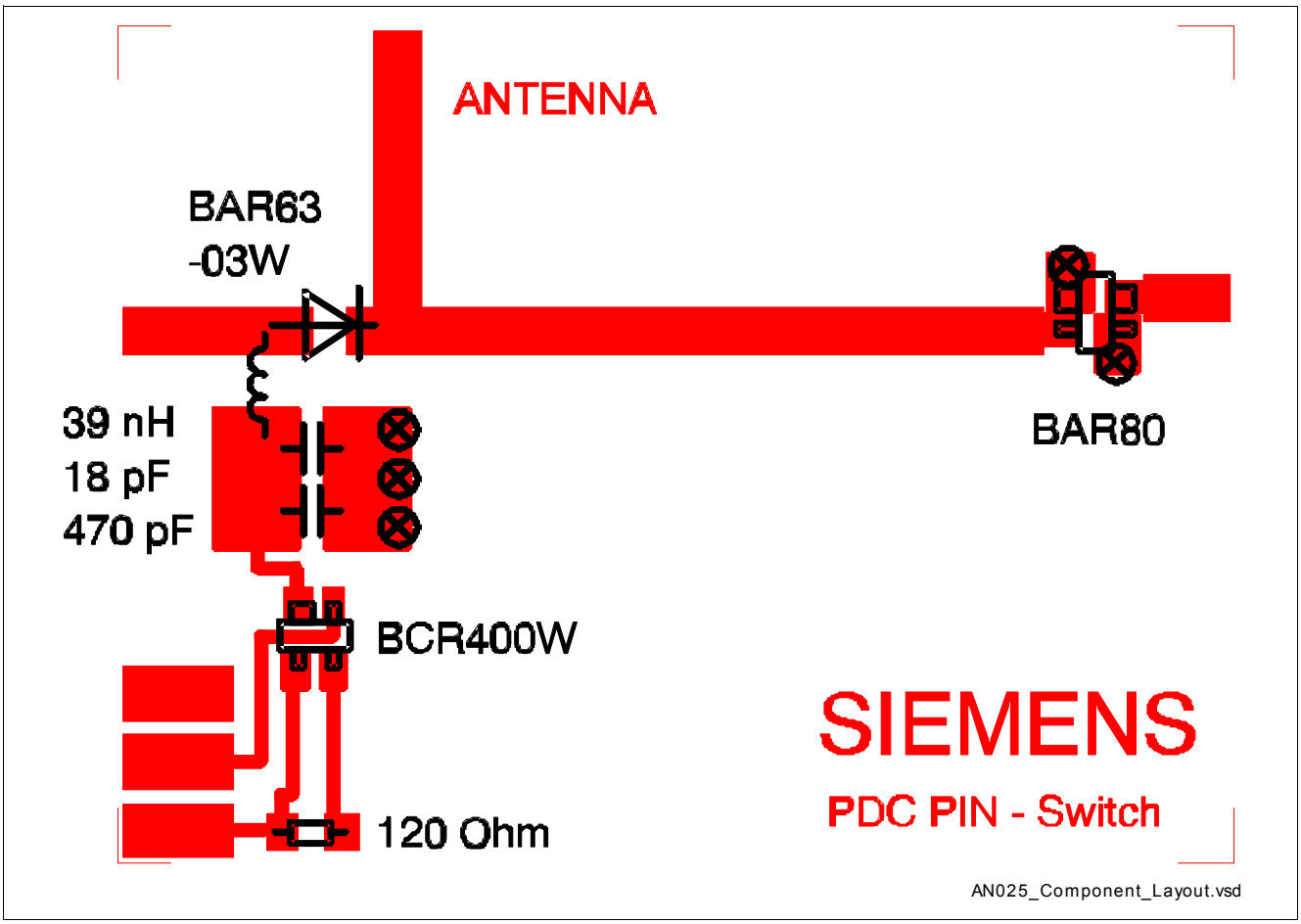

Figure 3 Component Layout

Table 3 Part List

BAR80	PIN diode	MW4	Infineon
BAR63-03W	PIN diode	SOD323	Infineon
BCR400W	Bias controller	SOT343	Infineon
18 pF	Capacitor	0805	S+M
470 pF	Capacitor	0805	S+M
120 Ω	Resistor	0805	S+M
39 nH	Inductor	SIMID 02	S+M
Board	1 mm Epoxy FR4, 30 x 40 mm		

1.7 Simulation Results - Microwave Harmonica V 6.0

1.7.1 Simulated circuit model

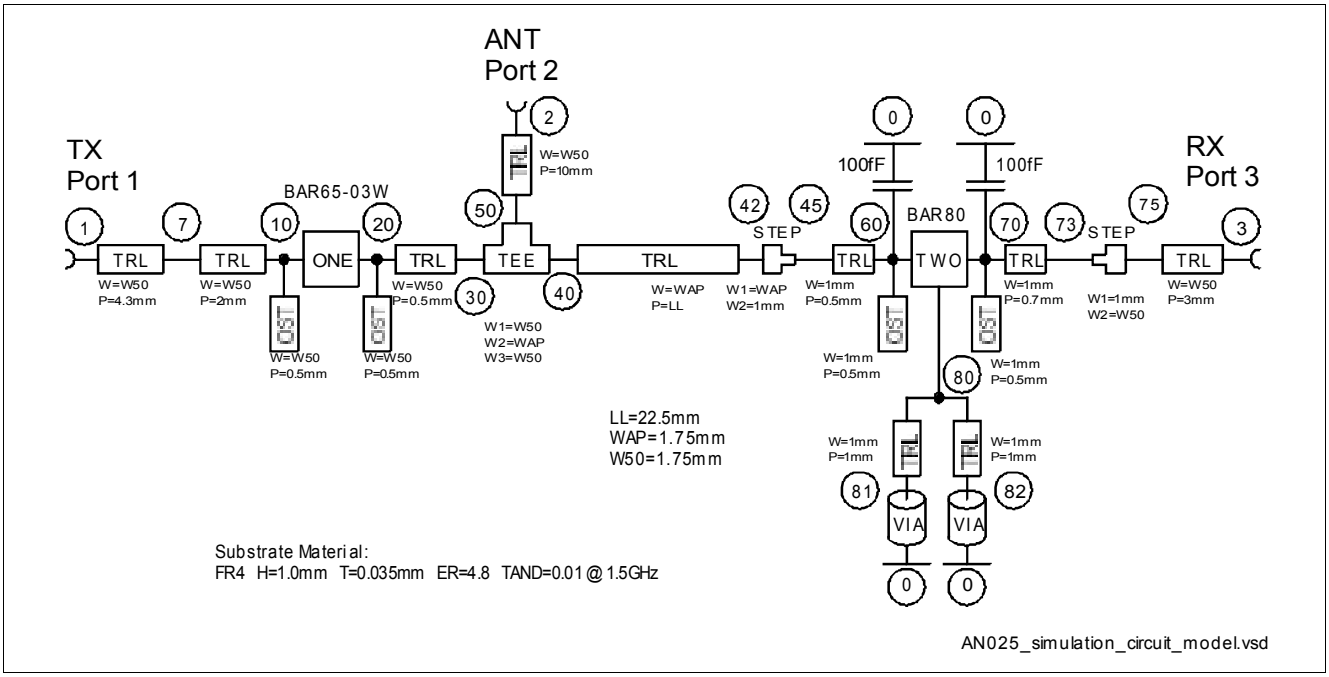

Figure 4 Simulation circuit model

1.7.2 NetList File

```
*********************************************************************
* INFINEON SMALL SIGNAL SEMICONDUCTORS
* APPLICATION NOTE No. 025
* PDC 1500 T/R-SWITCH WITH BAR80/BAR63-03W
*********************************************************************
*                ANT
*               PORT 2
*                 O
*                 |
*           |\ |  |  +---------------------+
*    TX  O--| >|--O--|      LAMBDA/4       |------O-----O    RX
*  PORT 1   |/ |     +---------------------+      |        PORT 3
*          BAR63                                +-----+
*          -03W                                  \   /
*                                          BAR80   \ /
*                                                 ---+---
*                                                    |
*                                               -----+------ GND
*  SUBSTRATE MATERIAL:
*  FR4, H=1MM, T=0.035MM, ER=4.8, TAND=0.01 @ 1.5GHZ
*********************************************************************
*  13.03.96    K. BRENNDOERFER  DF8CA    HL EH PD 1
*  15.10.96    J. P. Schaffer            HL EH PD 1
*********************************************************************
*
*
LL:  22.5MM     ; Length of quarter lambda line
WAP: 1.75MM     ; Width of quarter lambda line
W50: 1.75MM     ; Width of 50 ohm line

BLK     ; SWITCH IN RX-ANT ON,  TX-ANT OFF STATE
   TRL    1   7      W=W50    P=4.3MM        SUB
   TRL    7  10      W=W50    P=2.0MM        SUB
   OST   10          W=W50    P=0.5MM        SUB
   ONE   10  20      B63OF                   ; BAR63-03W OFF STATE
   OST   20          W=W50    P=0.5MM        SUB
   TRL   20  30      W=W50    P=0.5MM        SUB
   TEE   30  40  50  W1=W50   W2=WAP   W3=W50SUB
   TRL   50   2      W=W50    P=10MM         SUB
   TRL   40  42      W=WAP    P=LL      SUB
   STEP  42  45      W1=WAP   W2=1mm         SUB
   TRL   45  60      W=1MM    P=0.7MM        SUB
   OST   60          W=1MM    P=0.5MM        SUB
   CAP   60   0      C=100fF
   TWO   60  70  80  B80OF                   ; BAR80 OFF STATE
   OST   70          W=1MM    P=0.5MM        SUB
   CAP   70   0      C=100fF
   VIA   81          D=0.5MM            SUB
   VIA   81          D=0.5MM            SUB
   TRL   80  81      W=1.5MM  P=1.5MM        SUB
   VIA   82          D=0.5MM            SUB
   VIA   82          D=0.5MM            SUB
   TRL   80  82      W=1.5MM  p=1.5MM        SUB
   TRL   70  73      W=1MM    P=0.7MM        SUB
   STEP  73  75      W1=1mm   W2=W50         SUB
   TRL   75   3      W=W50    P=3MM     SUB
   RXAN:  3POR  1  2  3                          ; 1=TX  2=ANT  3=
END
```

AN025_simulation_Netlist_file1.vsd

Figure 5 Netlist file 1

```
BLK     ; SWITCH IN RX-ANT OFF,  TX-ANT ON STATE
   TRL    1   7      W=W50    P=4.3MM        SUB
   TRL    7  10      W=W50    P=2.0MM        SUB
   OST   10          W=W50    P=0.5MM        SUB
   ONE   10  20      B63ON                   ; BAR63-03W ON STATE
   OST   20          W=W50    P=0.5MM        SUB
   TRL   20  30      W=W50    P=0.5MM        SUB
   TEE   30  40  50  W1=W50   W2=WAP   W3=W50SUB
   TRL   50   2      W=W50    P=10MM         SUB
   TRL   40  42      W=WAP    P=LL      SUB
   STEP  42  45      W1=WAP   W2=1mm         SUB
   TRL   45  60      W=1MM    P=0.7MM        SUB
   OST   60          W=1MM    P=0.5MM        SUB
   CAP   60   0      C=100fF
   TWO   60  70  80  B80ON                   ; BAR80 ON STATE
   OST   70          W=1MM    P=0.5MM        SUB
   CAP   70   0      C=100fF
   VIA   81          D=0.5MM            SUB
   VIA   81          D=0.5MM            SUB
   TRL   80  81      W=1.5MM  P=1.5MM        SUB
   VIA   82          D=0.5MM            SUB
   VIA   82          D=0.5MM            SUB
   TRL   80  82      W=1.5MM  p=1.5MM        SUB
   TRL   70  73      W=1MM    P=0.7MM        SUB
   STEP  73  75      W1=1mm   W2=W50         SUB
   TRL   75   3      W=W50    P=3MM     SUB
   TXAN:  3POR  1  2  3                        ; 1=TX  2=ANT  3=R
END
*

FREQ
   STEP   100MHZ   3GHZ    100MHZ
END

DATA
   SUB:  MS  H=1MM  ER=4.8  TAND=0.01  MET1=CU 35UM
   B80OF:DUMMY              FILE=MWV00u00.S2P
   B80ON:DUMMY              FILE=MWV0010M.S2P
   B63OF:DUMMY              FILE=acv00U00.S1P
   B63ON:DUMMY              FILE=acV0010M.S1P
END
```

AN025_simulation_Netlist_file2.vsd

Figure 6 Netlist file 2

1.7.3 Simulation Results

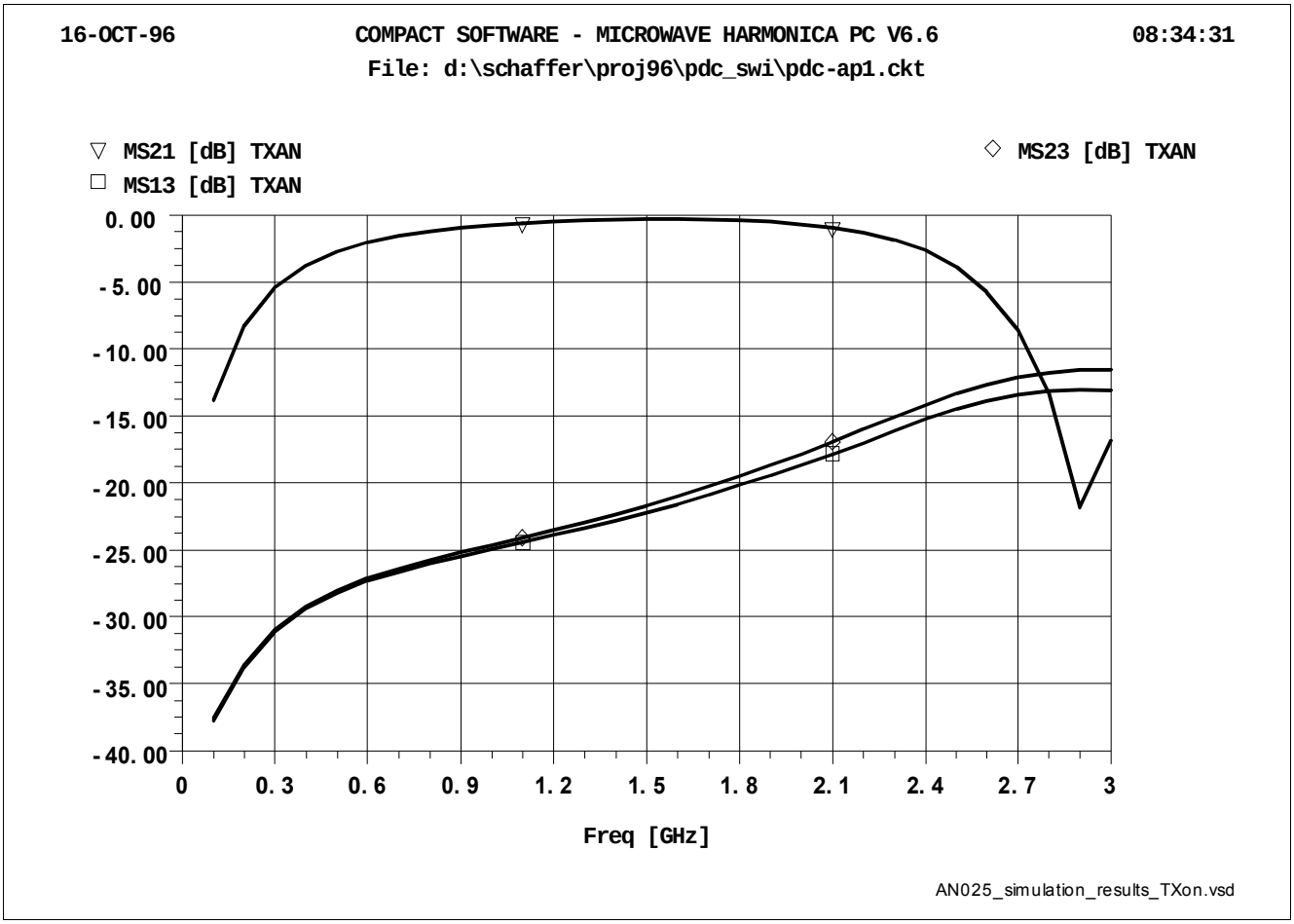

Figure 7 State ‘TX on‘

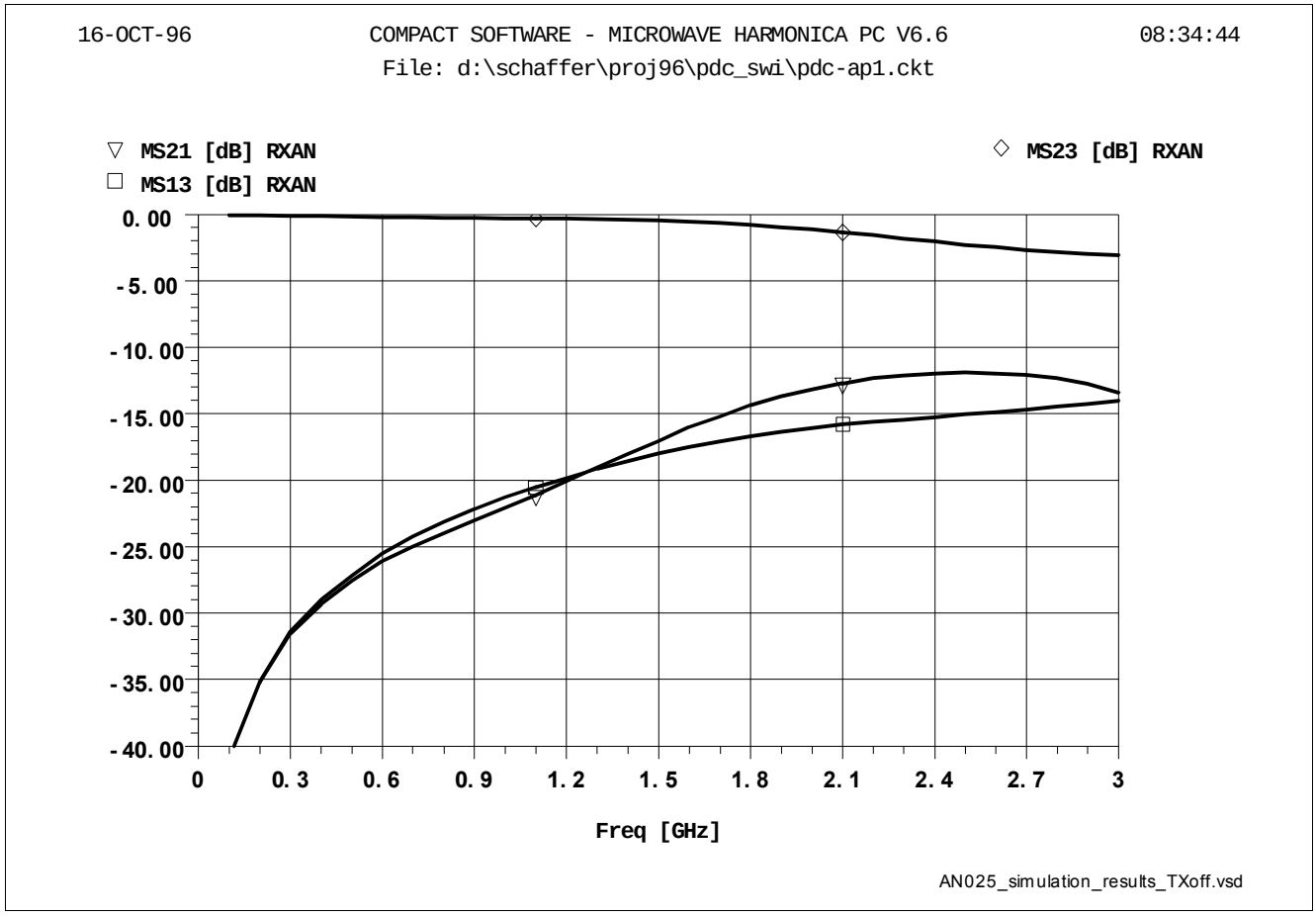

Figure 8 State 'TX off'

1 1400 - 1600 MHz PIN-Diode Transmit-Receive Switch

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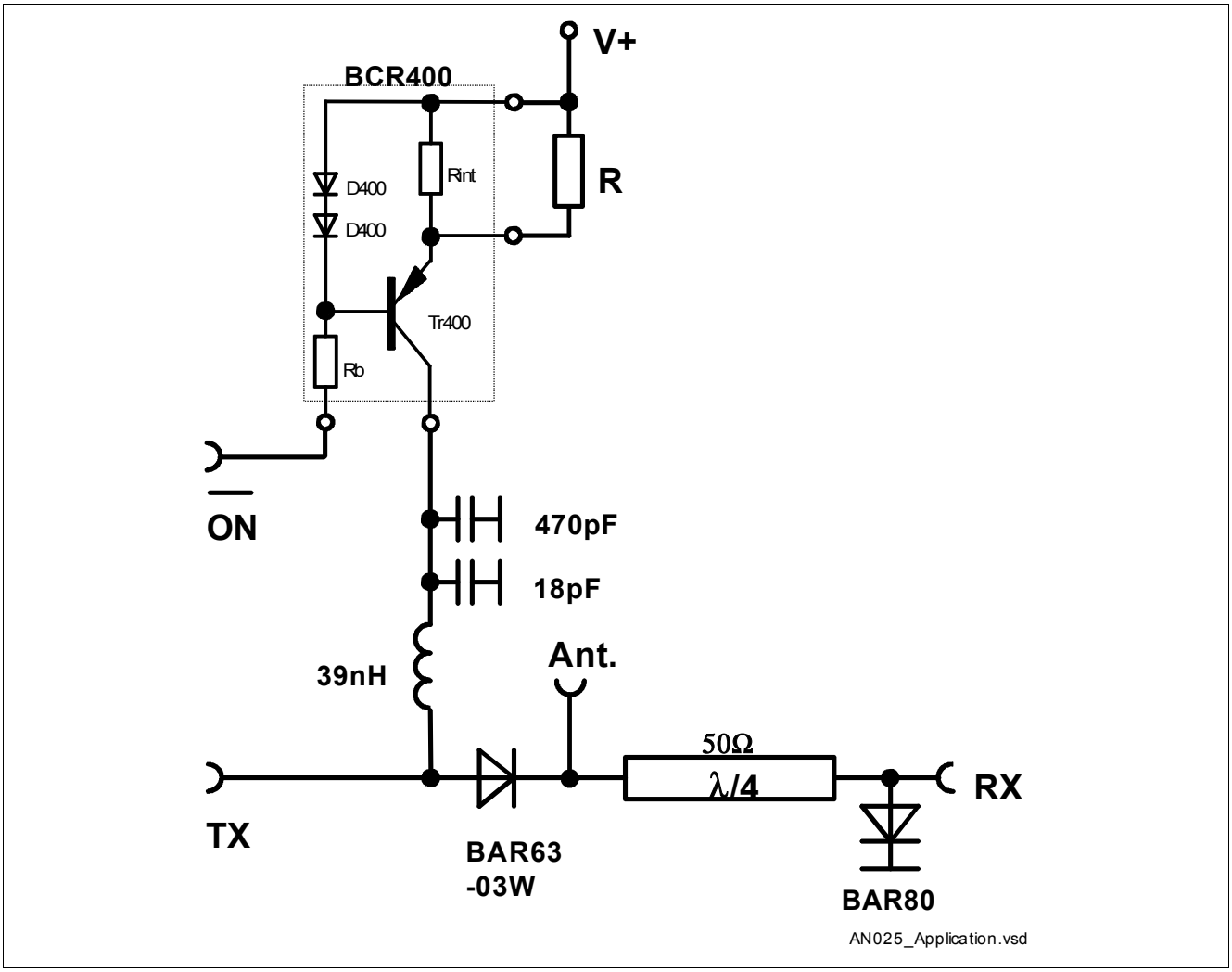

Figure 1 Application

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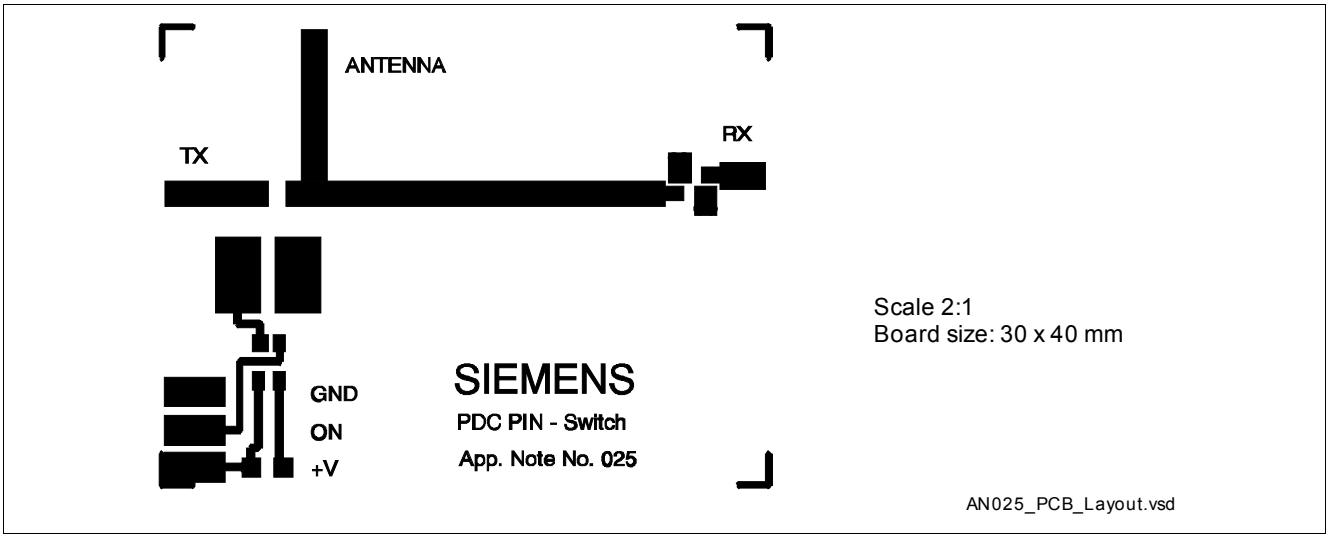

Figure 2 PCB Layout

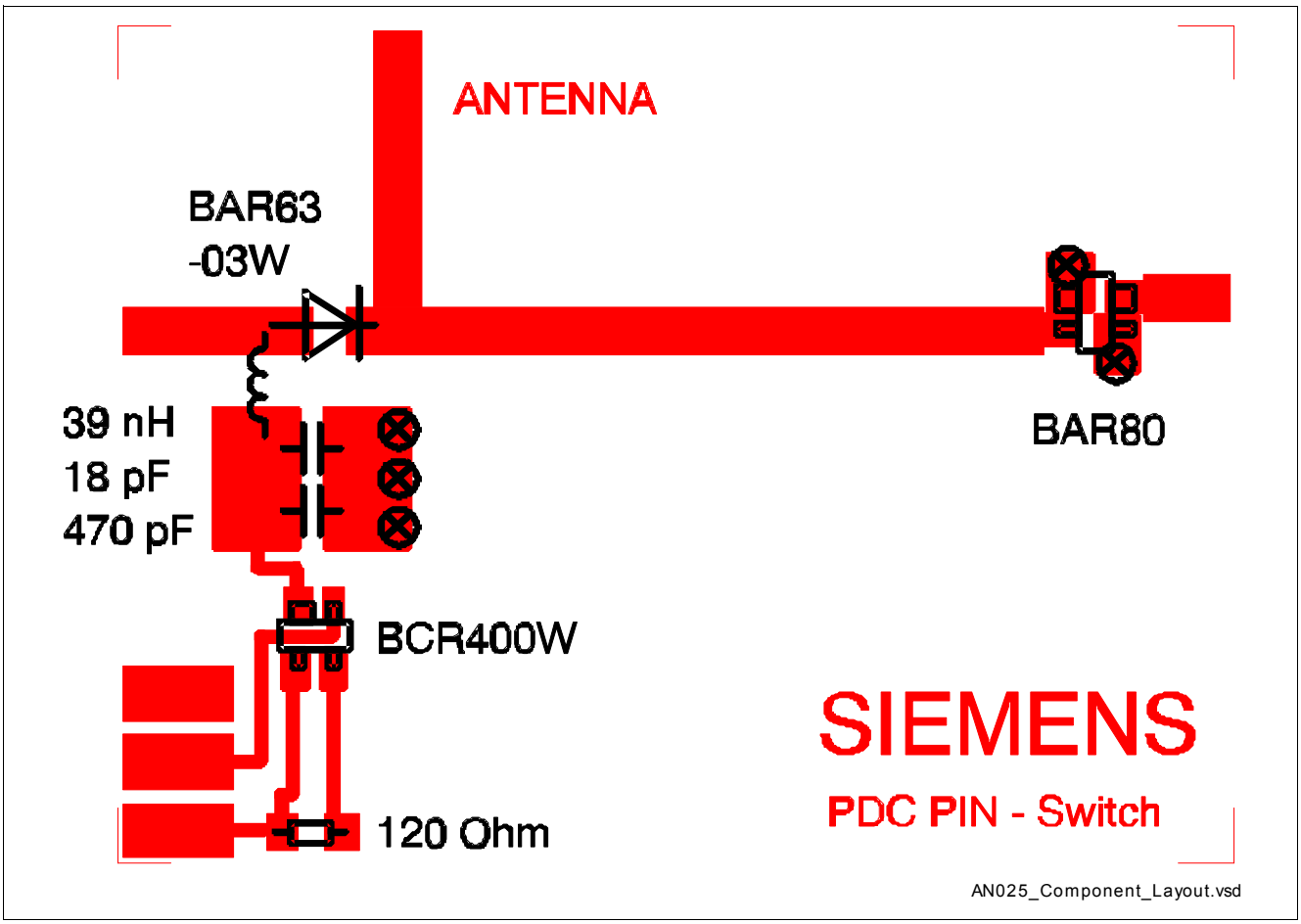

Figure 3 Component Layout

Table 3 Part List

BAR80	PIN diode	MW4	Infineon
BAR63-03W	PIN diode	SOD323	Infineon
BCR400W	Bias controller	SOD343	Infineon
18 pF	Capacitor	0805	S+M
470 pF	Capacitor	0805	S+M
120 Ω	Resistor	0805	S+M
39 nH	Inductor	SIMID 02	S+M
Board	1 mm Epoxy FR4, 30 x 40 mm		

1.7 Simulation Results - Microwave Harmonica V 6.0

1.7.1 Simulated circuit model

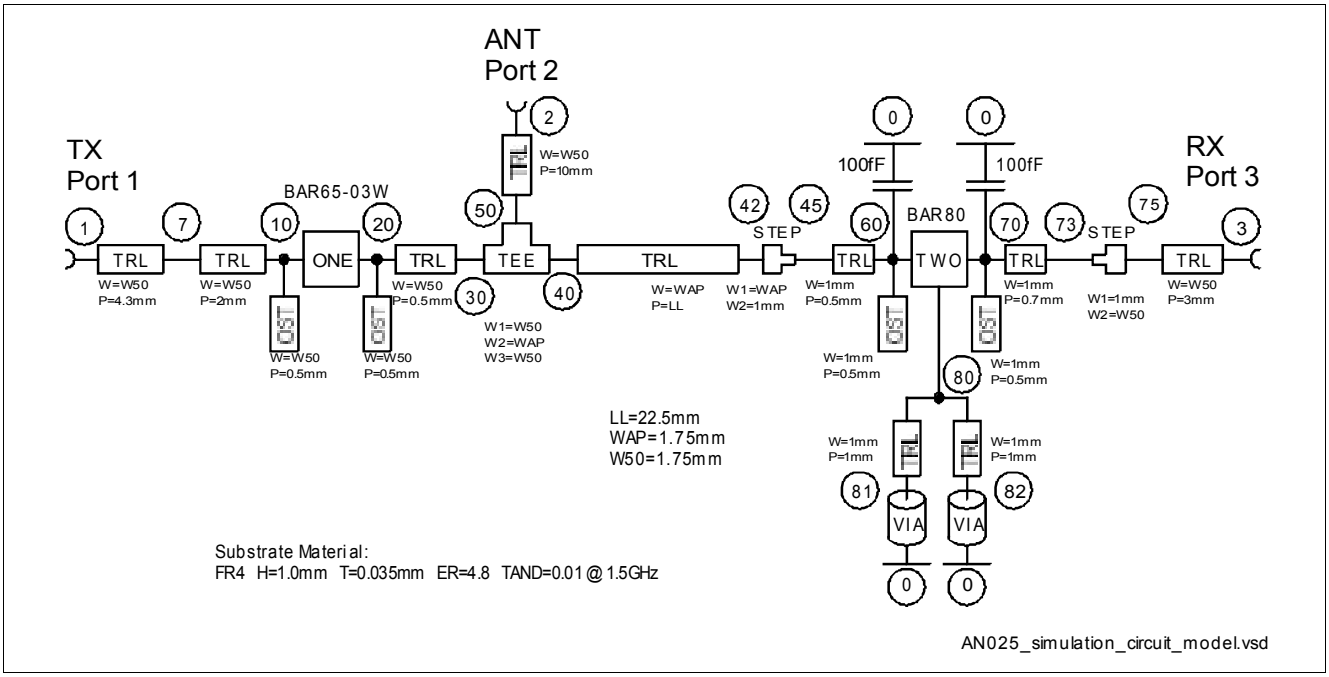

Figure 4 Simulation circuit model

1.7.2 NetList File

```
*********************************************************************
* INFINEON SMALL SIGNAL SEMICONDUCTORS
* APPLICATION NOTE No. 025
* PDC 1500 T/R-SWITCH WITH BAR80/BAR63-03W
*********************************************************************
*                ANT
*               PORT 2
*                 O
*                 |
*           |\ |  |  +---------------------+
*    TX  O--| >|--O--|      LAMBDA/4       |------O-----O    RX
*  PORT 1   |/ |     +---------------------+      |        PORT 3
*          BAR63                                +-----+
*          -03W                                  \   /
*                                          BAR80   \ /
*                                                 ---+---
*                                                    |
*                                               -----+------ GND
*  SUBSTRATE MATERIAL:
*  FR4, H=1MM, T=0.035MM, ER=4.8, TAND=0.01 @ 1.5GHZ
*********************************************************************
*  13.03.96    K. BRENNDOERFER  DF8CA    HL EH PD 1
*  15.10.96    J. P. Schaffer            HL EH PD 1
*********************************************************************
*
*
LL:  22.5MM     ; Length of quarter lambda line
WAP: 1.75MM     ; Width of quarter lambda line
W50: 1.75MM     ; Width of 50 ohm line

BLK     ; SWITCH IN RX-ANT ON,  TX-ANT OFF STATE
   TRL    1   7      W=W50    P=4.3MM        SUB
   TRL    7  10      W=W50    P=2.0MM        SUB
   OST   10          W=W50    P=0.5MM        SUB
   ONE   10  20      B63OF                   ; BAR63-03W OFF STATE
   OST   20          W=W50    P=0.5MM        SUB
   TRL   20  30      W=W50    P=0.5MM        SUB
   TEE   30  40  50  W1=W50   W2=WAP   W3=W50SUB
   TRL   50   2      W=W50    P=10MM         SUB
   TRL   40  42      W=WAP    P=LL      SUB
   STEP  42  45      W1=WAP   W2=1mm         SUB
   TRL   45  60      W=1MM    P=0.7MM        SUB
   OST   60          W=1MM    P=0.5MM        SUB
   CAP   60   0      C=100fF
   TWO   60  70  80  B80OF                   ; BAR80 OFF STATE
   OST   70          W=1MM    P=0.5MM        SUB
   CAP   70   0      C=100fF
   VIA   81          D=0.5MM            SUB
   VIA   81          D=0.5MM            SUB
   TRL   80  81      W=1.5MM  P=1.5MM        SUB
   VIA   82          D=0.5MM            SUB
   VIA   82          D=0.5MM            SUB
   TRL   80  82      W=1.5MM  p=1.5MM        SUB
   TRL   70  73      W=1MM    P=0.7MM        SUB
   STEP  73  75      W1=1mm   W2=W50         SUB
   TRL   75   3      W=W50    P=3MM     SUB
   RXAN:  3POR  1  2  3                          ; 1=TX  2=ANT  3=
END
```

AN025_simulation_Netlist_file1.vsd

Figure 5 Netlist file 1

```
BLK     ; SWITCH IN RX-ANT OFF,  TX-ANT ON STATE
   TRL    1   7      W=W50    P=4.3MM        SUB
   TRL    7  10      W=W50    P=2.0MM        SUB
   OST   10          W=W50    P=0.5MM        SUB
   ONE   10  20      B63ON                   ; BAR63-03W ON STATE
   OST   20          W=W50    P=0.5MM        SUB
   TRL   20  30      W=W50    P=0.5MM        SUB
   TEE   30  40  50  W1=W50   W2=WAP   W3=W50SUB
   TRL   50   2      W=W50    P=10MM         SUB
   TRL   40  42      W=WAP    P=LL      SUB
   STEP  42  45      W1=WAP   W2=1mm         SUB
   TRL   45  60      W=1MM    P=0.7MM        SUB
   OST   60          W=1MM    P=0.5MM        SUB
   CAP   60   0      C=100fF
   TWO   60  70  80  B80ON                   ; BAR80 ON STATE
   OST   70          W=1MM    P=0.5MM        SUB
   CAP   70   0      C=100fF
   VIA   81          D=0.5MM            SUB
   VIA   81          D=0.5MM            SUB
   TRL   80  81      W=1.5MM  P=1.5MM        SUB
   VIA   82          D=0.5MM            SUB
   VIA   82          D=0.5MM            SUB
   TRL   80  82      W=1.5MM  p=1.5MM        SUB
   TRL   70  73      W=1MM    P=0.7MM        SUB
   STEP  73  75      W1=1mm   W2=W50         SUB
   TRL   75   3      W=W50    P=3MM     SUB
   TXAN:  3POR  1  2  3                        ; 1=TX  2=ANT  3=R
END
*

FREQ
   STEP   100MHZ   3GHZ    100MHZ
END

DATA
   SUB:  MS  H=1MM  ER=4.8  TAND=0.01  MET1=CU 35UM
   B80OF:DUMMY              FILE=MWV00u00.S2P
   B80ON:DUMMY              FILE=MWV0010M.S2P
   B63OF:DUMMY              FILE=acv00U00.S1P
   B63ON:DUMMY              FILE=acV0010M.S1P
END
```

AN025_simulation_Netlist_file2.vsd

Figure 6 Netlist file 2

1.7.3 Simulation Results

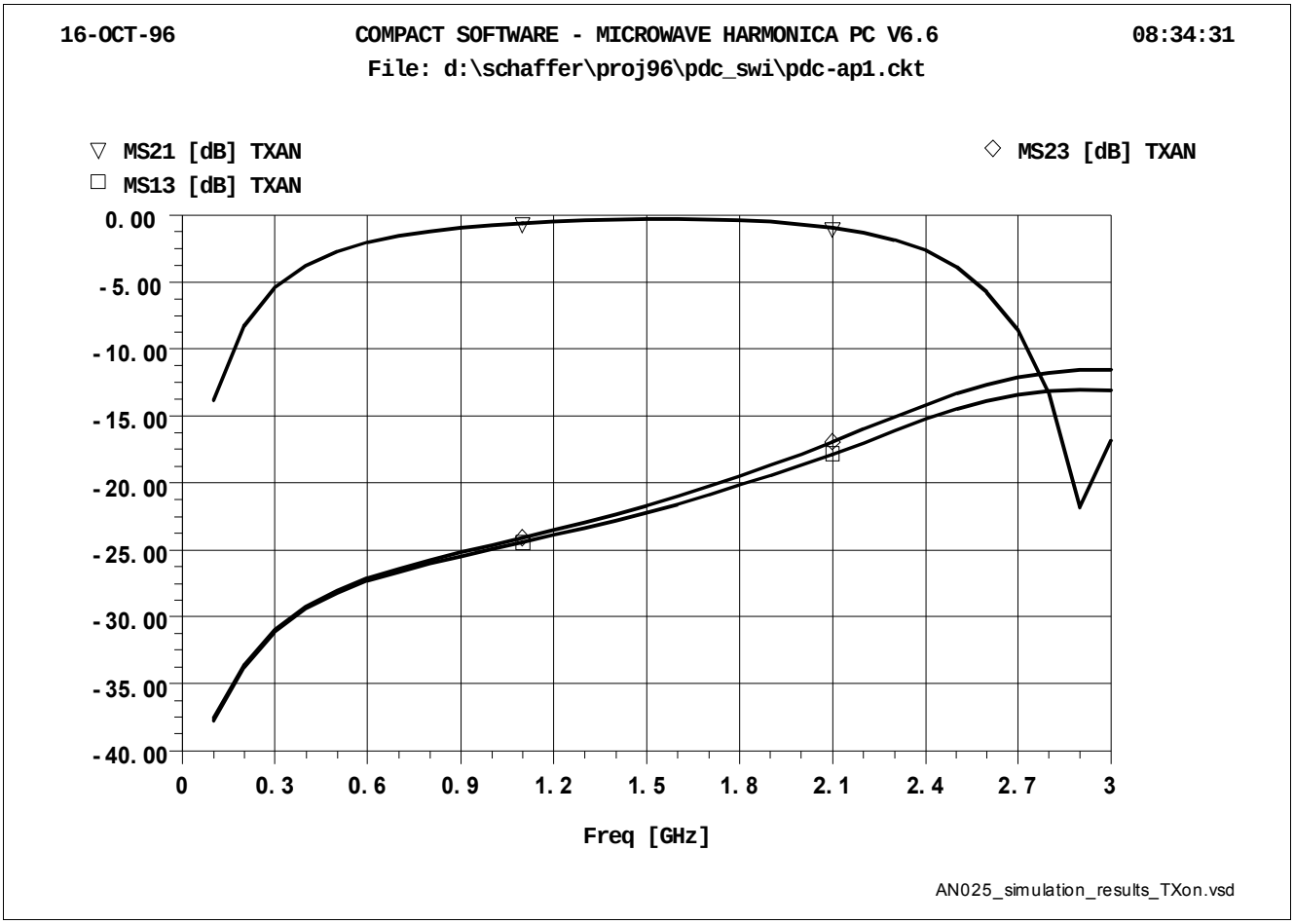

Figure 7 State ‘TX on‘

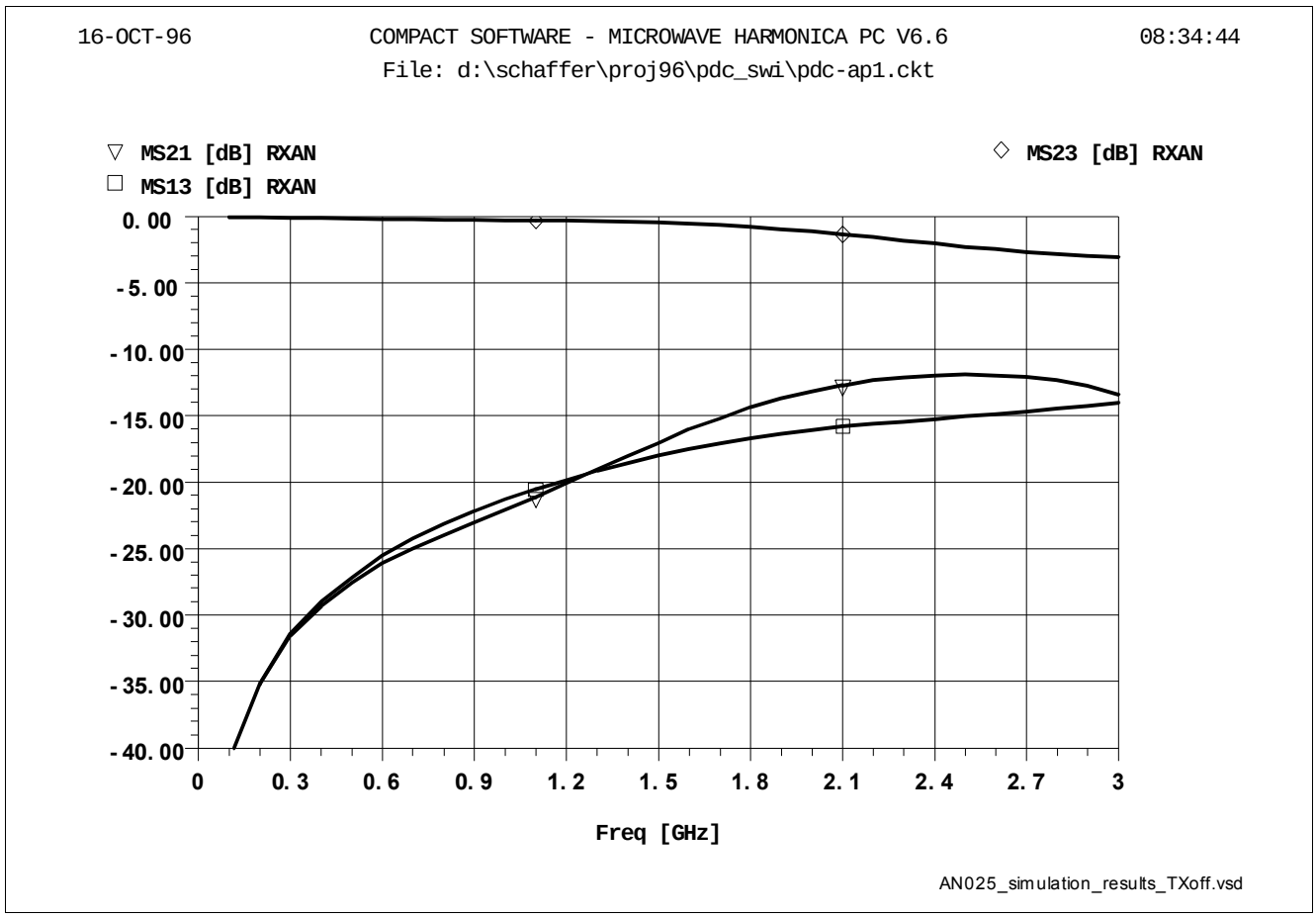

Figure 8 State ‘TX off‘