Application Note No. 033

Dual-Band Transmit-Receive Switch

RF & Protection Devices

Never stop thinking

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Dual-Band Transmit-Receive Switch

Revision History: 2006-10-11, Rev. 2.0

Previous Version: 2000-07-28

Page	Subjects (major changes since last revision)
All	Document layout change

1 Dual-Band Transmit-Receive Switch

This application note covers transmit-receive switch solutions for dual-band / mode systems and applies specifically to systems where an octave separates the two bands. A GMS and PCN mobile telephone handset example is discussed.

1.1 Function

The 5-port circuit shown in **Figure 1** alternately connects two transmitters (TX) and two receivers (RX) to one antenna port. The two transmission lines shown are designed to be quarter-wave at the higher of the two frequency bands (in this example PCN). Switches S1 to S5 are implemented using PIN diodes. Please see **Table 1** for an explanation of the operating modes of the circuit.

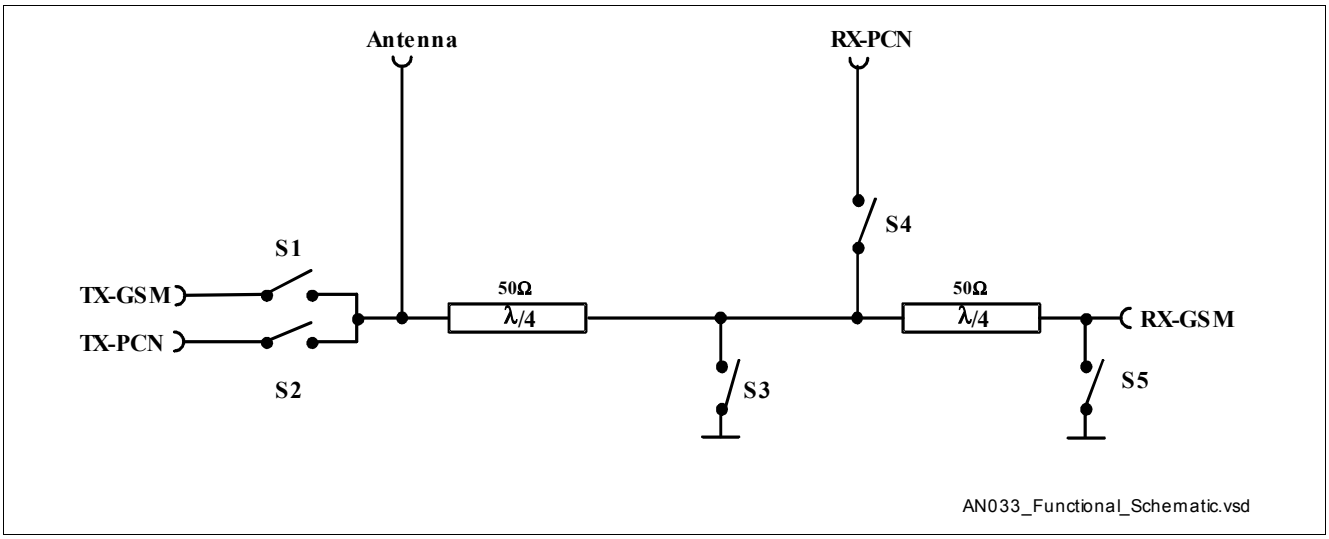

Figure 1 GMS/PCN Dual band TX/RX switch - Functional Schematic

A test circuit was built using 1 mm FR4 for the PCB, on which the lenght of the λ/4 transmission lines was calculated to be 20 mm (Antenna - RX-PCN) and 13.7 mm (RX-PCN - RX-GSM). Its performance can be further improved by filters to improve isolation and suppress harmonic emissions. A full parts list and component placement will be included in the next issue.

Table 1 Operating modes

Mode	S1	S2	S3	S4	S5	Comment
Transmit GSM	ON	OFF	OFF	OFF	ON	Both λ/4 lines for PCN from one λ/4 line for GSM (half the frequency!). The shortcircuit at S5 is thereby transformed into an open-circuit at the antenna port.
Transmit PCN	OFF	ON	ON	OFF	OFF	The λ/4 line between S3 and the antenna port transforms the short circuit at S3 into an open circuit at the antenna port.
Receive GSM	OFF	OFF	OFF	OFF	OFF	The receiver for GSM is connected to the antenna port by both λ/4 lines.
Receive PCN	OFF	OFF	OFF	ON	ON	The shortcircuit at S5 is transformed into an open circuit at S4. The receiver for PCN is connected to the antenna port.

1.2 Schematic

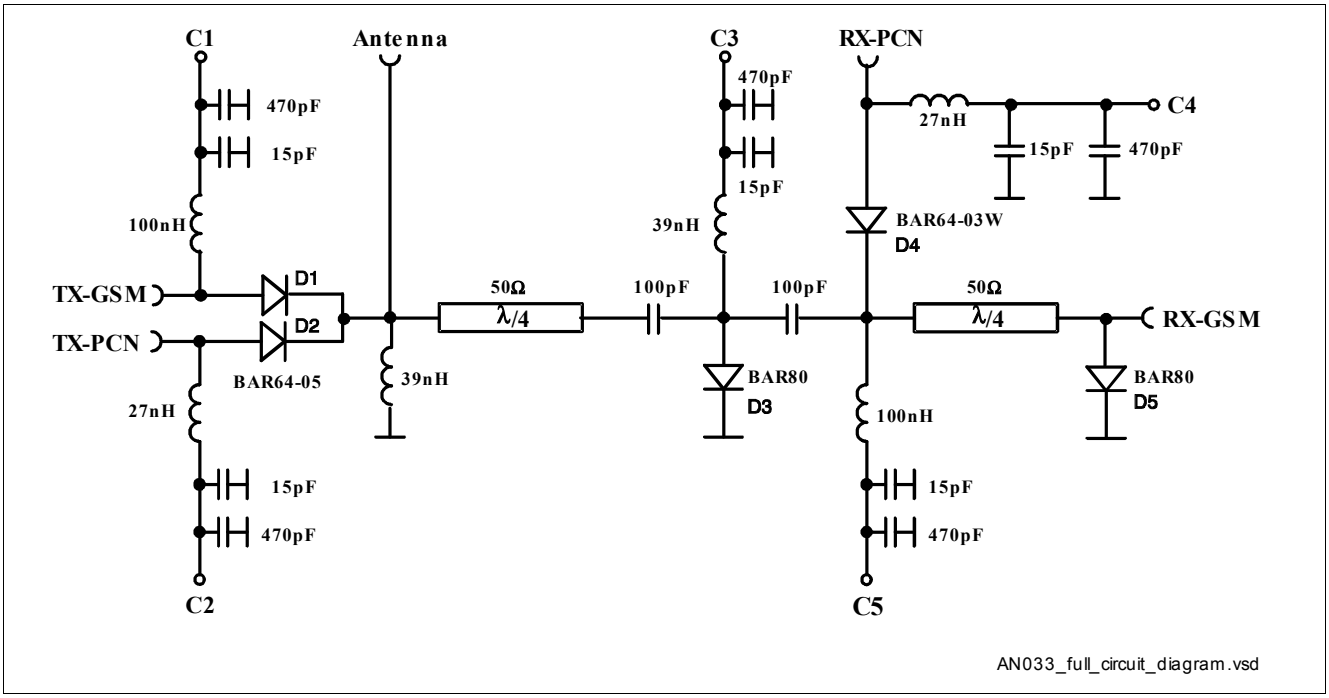

Figure 2 Full circuit diagram

1.3 Layout

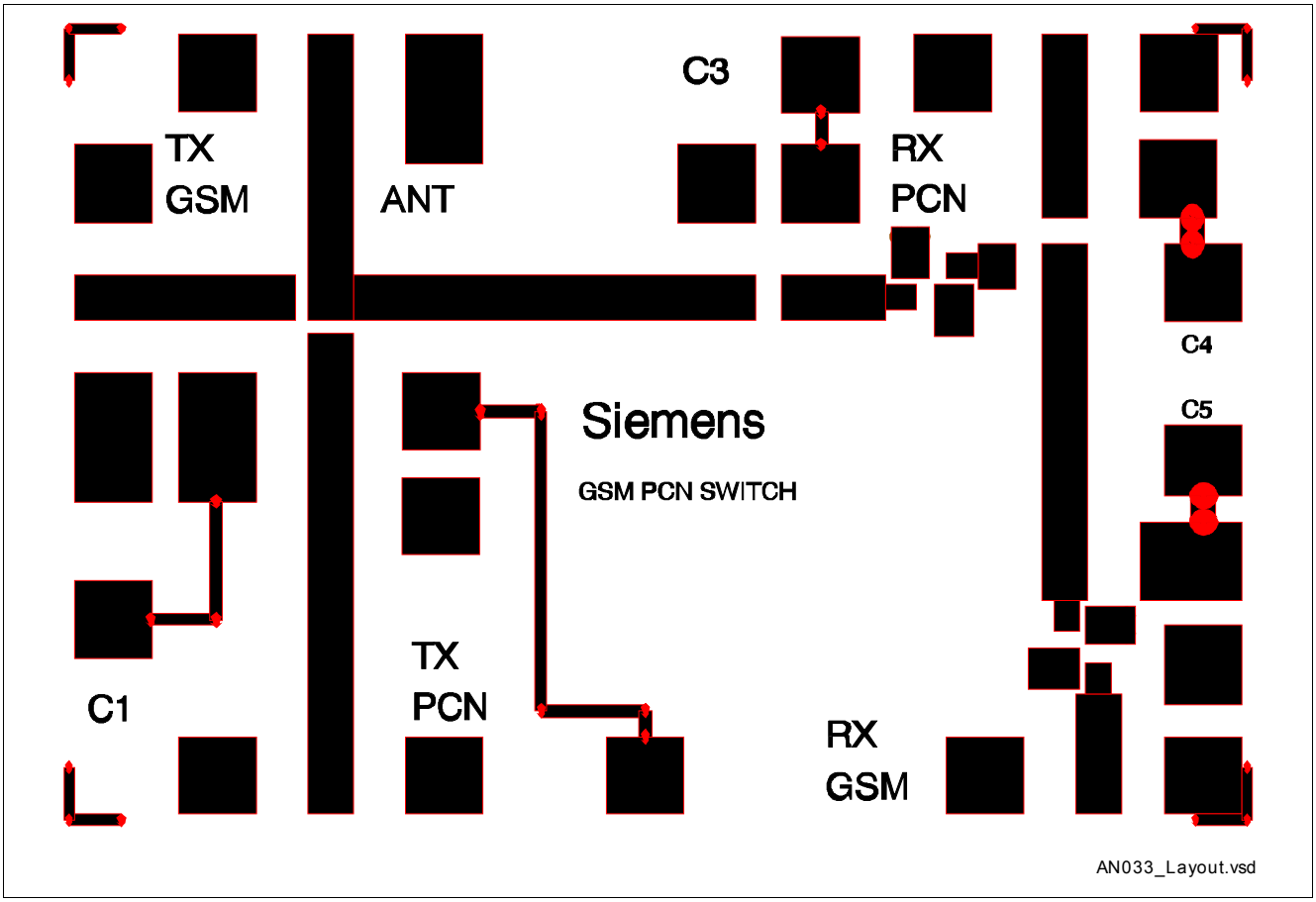

Figure 3 Layout

1.4 Results

Table 2 Results for 28 dBm CW Power

Mode	C1	C2	C3	C4	C5	Result
Transmit GSM	10 mA	-15 V	-15 V	-15 V	10 mA	0.5 dB insertion loss 71 dBc harmonic suppression 50 dBm output IP_3
Transmit PCN	-15 V	10 mA	10 mA	-15 V	-15 V	0.5 dB insertion loss 71 dBc harmonic suppression
Receive GSM	-15 V	-15 V	-15 V	-15 V	-15 V	0.5 dB insertion loss No current consumption
Receive PCN	-15 V	-15 V	-15 V	2 mA	Open	0.67 dB insertion loss Low current consumption

1.5 Numerical computation with Microwave Harmonica

Numerical computation with Microwave Harmonica:

```
*************************************************************************
*                                                                       *
*  Dual-Band Mode Transmit-Receive Switch for GSM / PCN Mobile Telephones  *
*                                                                       *
*  Date: 12/1986                                                        *
*  Author: J. P. Schaffer; WS SD CE, Infineon Technologies AG           *
*                                                                       *
*************************************************************************

LPCN:  20.0MM ; Length of PCM quarter lamda
LGSM:  13.70MM; Length of additional line for GSM quarter lambda
WAP: 1.75MM   ; Width of quarter lambda line
W50: 1.75MM   ; Width of 50 ohm line

BLK    ;Mode TX_GSM
   ONE   100 120     B63ON                       ; BAR63-03W ON STATE
   ONE   200 220     B63OF                       ; BAR63-03W OFF STATE
   CROS  120 580 560 220 W1=W50 W2=W50 W3=W50 W4=W50 SUB
   TRL   580 500     W=W50     P=10MM            SUB
   TRL   560 420     W=WAP     P=LPCN            SUB
   ONE   480 400     B63OF                       ; BAR63-03W OFF STATE
   RES   400   0         R=50
   CAP   420 440     C=100PF
   TWO   440 460   0 B80OF                       ; BAR80 OFF STATE
   CAP   460 480     C=100PF
   TRL   480 320     W=W50     P=LGSM            SUB
   TWO   320 300   0 B80ON                       ; BAR80 ON STATE
   TXGSM:  4POR      100 200 300 500  ; 100=TX_GSM 200=TX_PCN 300=RX_GSM 400=RX_PCN 50
END

BLK    ;Mode TX_PCN
   ONE   100 120     B63OF                       ; BAR63-03W OFF STATE
   ONE   200 220     B63ON                       ; BAR63-03W ON STATE
   CROS  120 580 560 220 W1=W50 W2=W50 W3=W50 W4=W50 SUB
   TRL   580 500     W=W50     P=10MM            SUB
   TRL   560 420     W=WAP     P=LPCN            SUB
   ONE   480 400     B63OF                       ; BAR63-03W OFF STATE
   CAP   420 440     C=100PF
   TWO   440 460   0 B80ON                       ; BAR80 ON STATE
   CAP   460 480     C=100PF
   TRL   480 320     W=W50     P=LGSM            SUB
   TWO   320 300   0 B80OF                       ; BAR80 OFF STATE
   RES   300   0     R=50
   RES   300   0         R=50
   TXPCN:  4POR      100 200 400 500  ; 100=TX_GSM 200=TX_PCN 300=RX_GSM 400=RX_PCN 50
END

BLK    ;Mode RX_GSM
   ONE   100 120     B63OF                       ; BAR63-03W OFF STATE
   ONE   200 220     B63OF                       ; BAR63-03W OFF STATE
   RES   200   0         R=50
   CROS  120 580 560 220 W1=W50 W2=W50 W3=W50 W4=W50 SUB
   TRL   580 500     W=W50     P=10MM            SUB
   TRL   560 420     W=WAP     P=LPCN            SUB
   ONE   480 400     B63OF                       ; BAR63-03W OFF STATE
   CAP   420 440     C=100PF
   TWO   440 460   0 B80OF                       ; BAR80 OFF STATE
   CAP   460 480     C=100PF
   TRL   480 320     W=W50     P=LGSM            SUB
   TWO   320 300   0 B80OF                       ; BAR80 OFF STATE
   RXGSM:  4POR      100 300 400 500  ; 100=TX_GSM 200=TX_PCN 300=RX_GSM 400=RX_PCN 50
END
```

AN033_Numerical_computation1.vsc

Figure 4 Numerical computation 1

```
BLK    ;Mode RX_PCN
   ONE   100 120    B63OF                      ; BAR63-03W OFF STATE
   RES   100   0        R=50
   ONE   200 220    B63OF                      ; BAR63-03W OFF STATE
   CROS  120 580 560 220 W1=W50 W2=W50 W3=W50 W4=W50 SUB
   TRL   580 500    W=W50    P=10MM            SUB
   TRL   560 420    W=WAP    P=LPCN            SUB
   ONE   480 400    B63ON                      ; BAR63-03W ON STATE
   CAP   420 440    C=100PF
   TWO   440 460   0B80OF                      ; BAR80 OFF STATE
   CAP   460 480    C=100PF
   TRL   480 320    W=W50    P=LGSM            SUB
   TWO   320 300   0B80ON                      ; BAR80 ON STATE
   RXPCN:  4POR     200 300 400 500  ; 100=TX_GSM 200=TX_PCN 300=RX_GSM 400=RX_PCN 5
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
*******************************************************************************
```

AN033_Numerical_computation2.vsd

Figure 5 Numerical computation 2

1.6 Computed Frequency Response

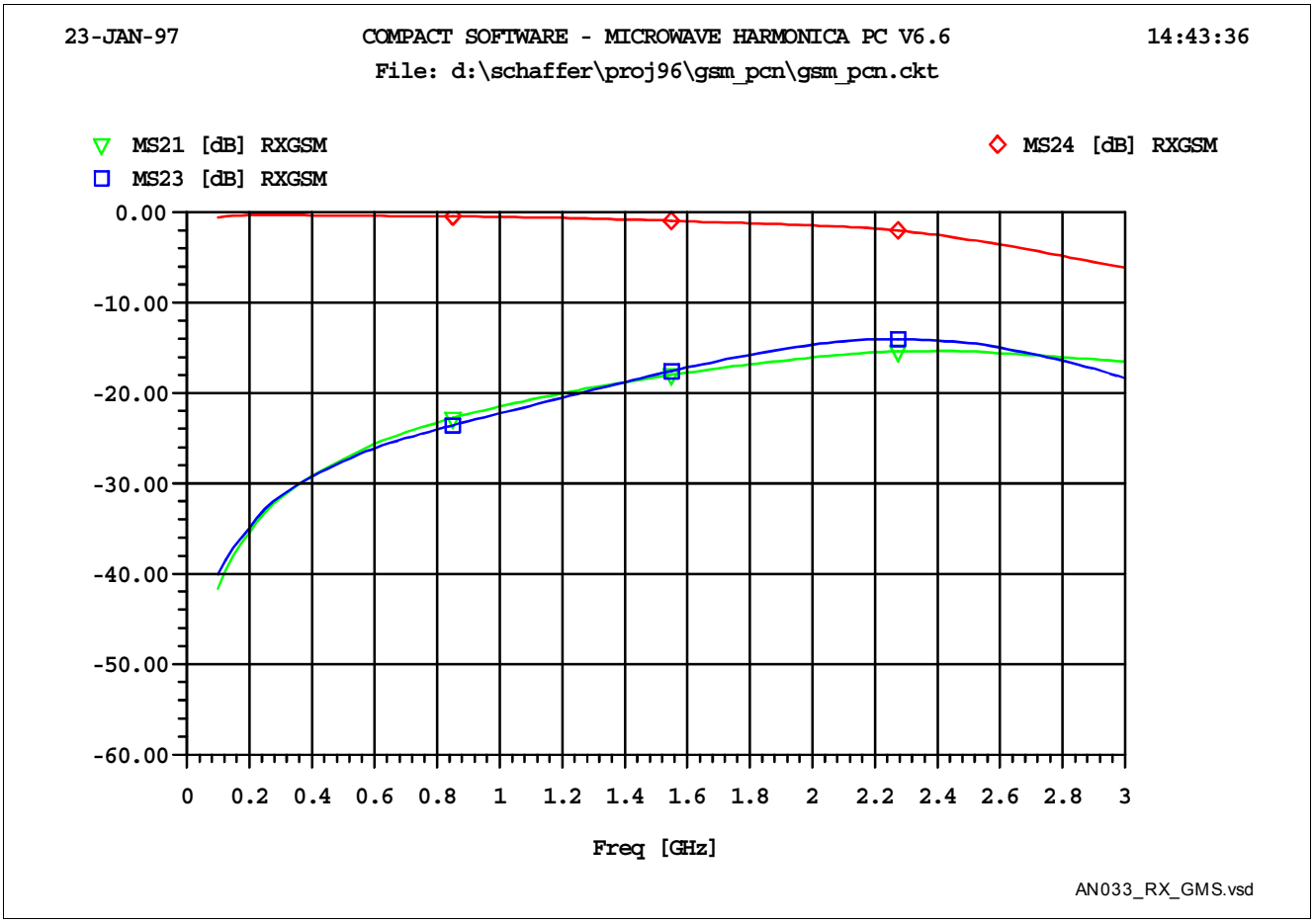

Figure 6 RX-GSM

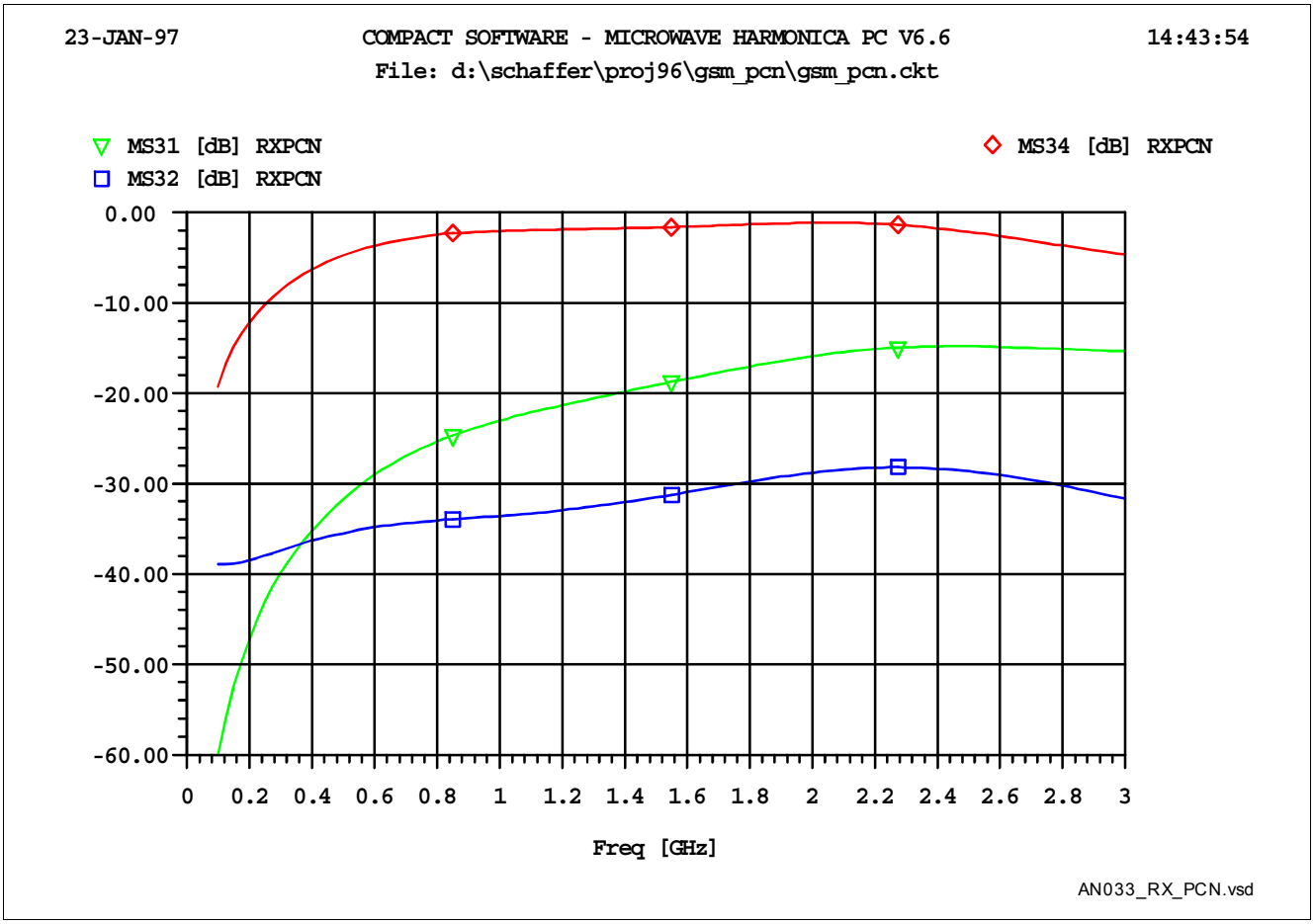

Figure 7 RX-PCN

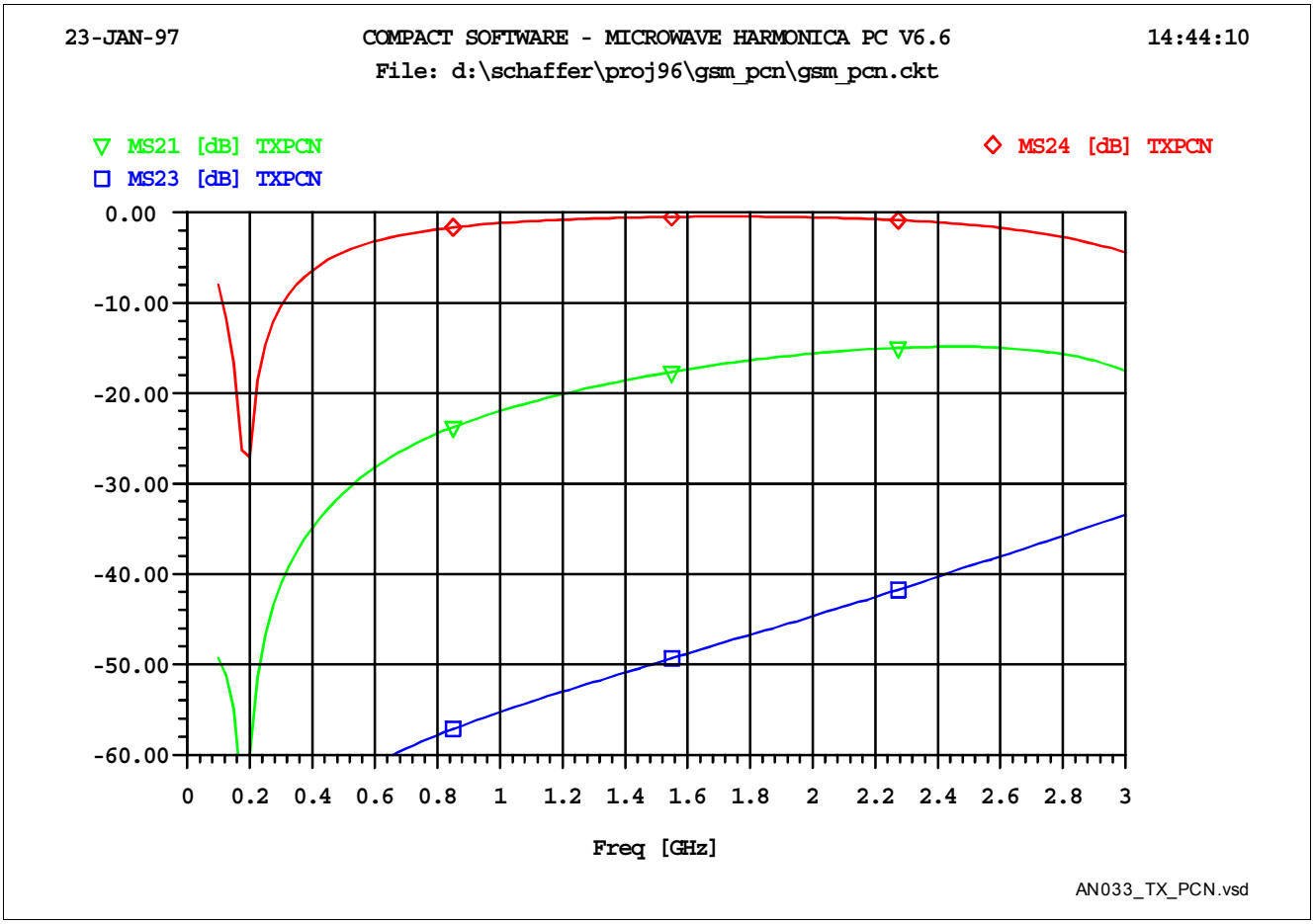

Figure 8 TX-PCN

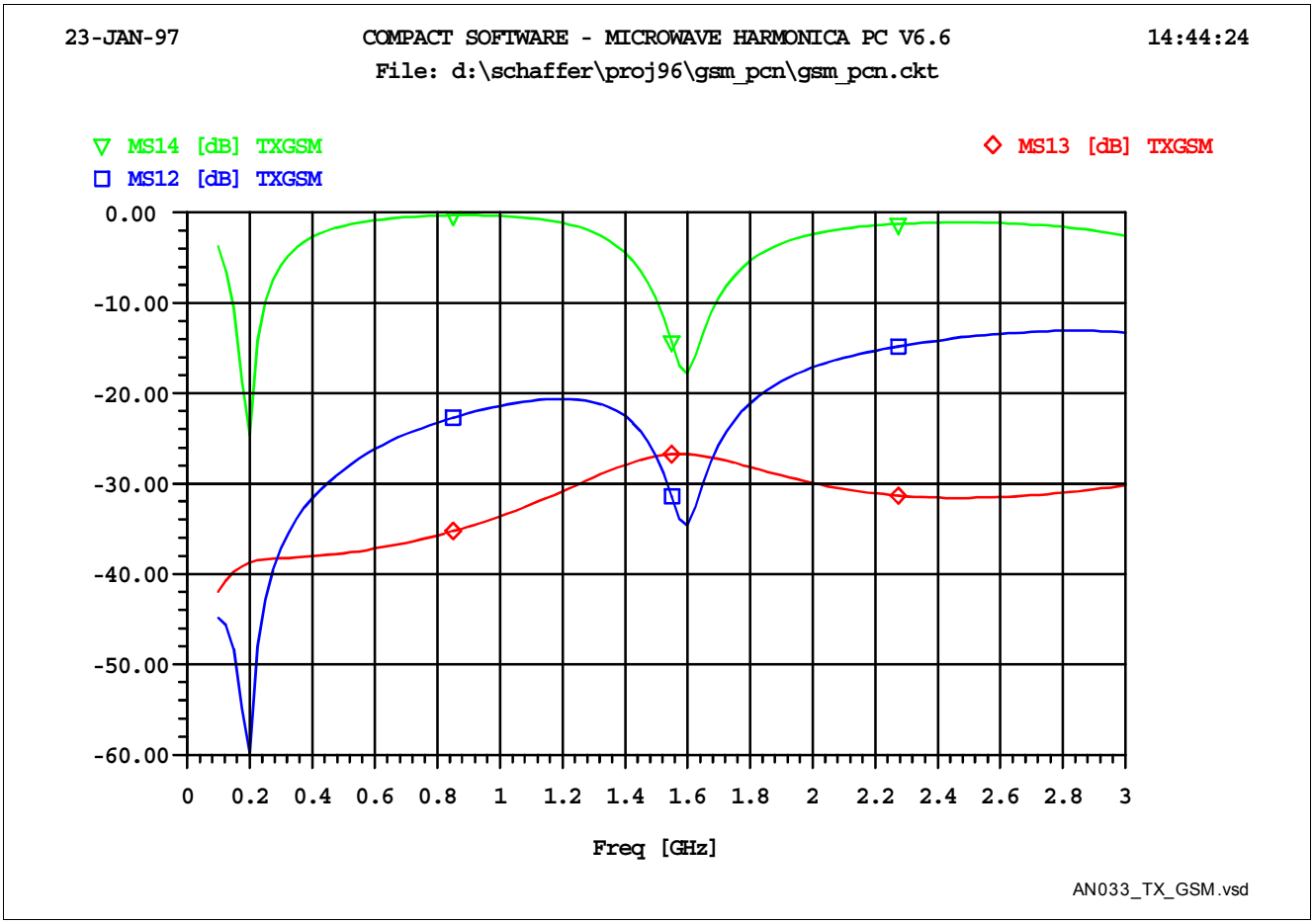

Figure 9 TX-GSM