4937 DI5 RF TUNER MODULE
3X8899 (3X7702)
ADVANCE DATA SHEET

CABLE MODEM APPLICATIONS

1 APPLICATIONS

The 4937 DI5 Tuner Module is specifically designed for subscriber-side cable modem applications.

2 FEATURES

- DOCSIS compatible
- VHF, Hyperband, and UHF
- Band selection and tuning controlled by I^2C bus
- Downstream frequency range from 50 MHz to 860 MHz
- Upstream frequency range from 5 MHz to 42 MHz
- Single 5V power supply

3 INTRODUCTION

The receiver uses a single-conversion approach to 43.75 MHz with the reception frequency range divided into VHF low, VHF high, and UHF. A second conversion to 5.75 MHz is available for QAM demodulators requiring a lower center frequency (3x7702); alternately, the output frequency is 43.75 MHz (3x8899).

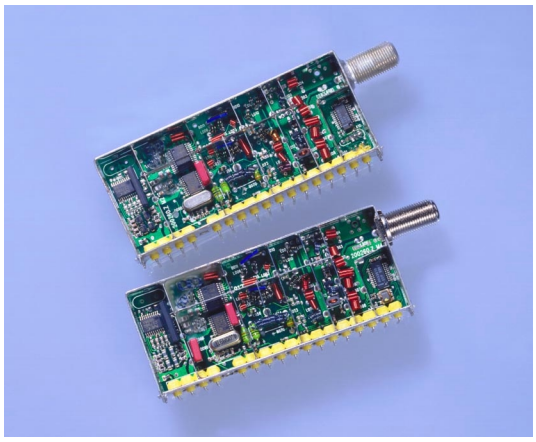


Figure 1 4937 DI5 RF Tuner Modules

Band selection and tuning is done via the I^2C-bus, while a separate three-wire bus and transmit enable control the upstream amplifier.

The common cable input/output is realized by an F-connector (75Ω) per [IPS-sp-406].

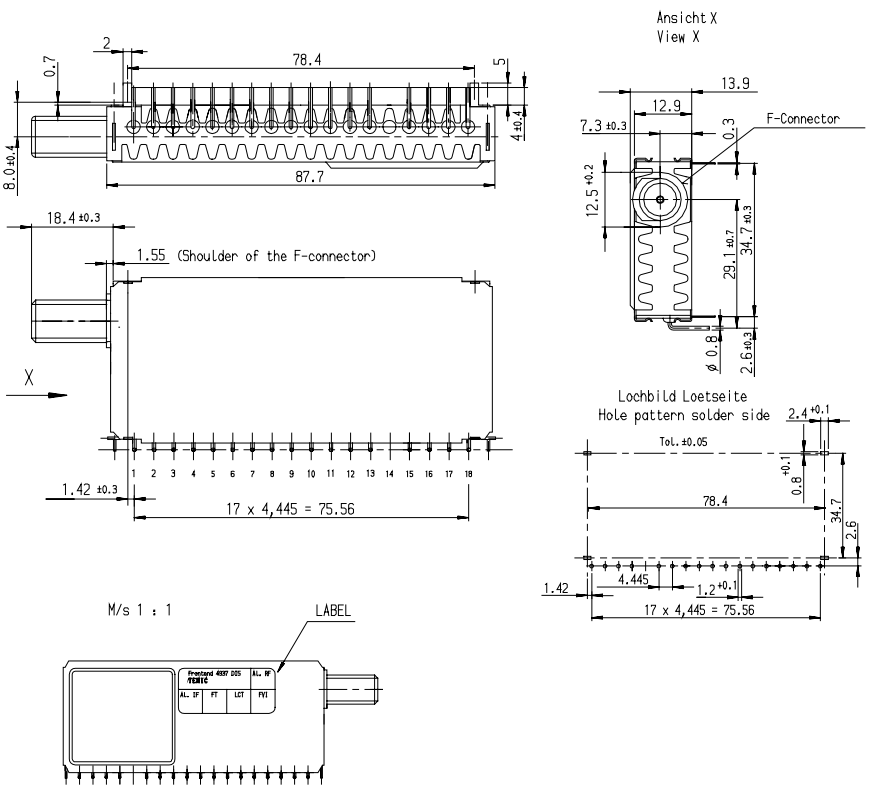
Two automatic gain control (AGC) inputs are available to level the signal into an external demodulator. The tuner's intermediate frequency (IF) output is designed to drive a low-pass image reject filter prior to the QAM demodulator IC.

A DC/DC converter is built in, so that only a single supply voltage of 5V is required.

4 MECHANICAL SPECIFICATIONS

This section contains mechanical specifications for the 4937 DI5 RF Tuner Module.

4.1 MECHANICAL DRAWING



PIN	Connection
1	UPSTREAM IN 1
2	UPSTREAM IN 2
3	VS1 SUPPLY VOLTAGE +5V
4	AS1 I²C BUS UPSTREAM
5	TXENABLE
6	VS2 SUPPLY VOLTAGE +5V
7	AGC RF
8	SCL1 BUS CLOCK UPSTREAM
9	SDA1 BUS DATA UPSTREAM
10	VS3 SUPPLY VOLTAGE +5V
11	SCL2 I²C BUS CLOCK TUNER
12	SDA2 I²C BUS DATA TUNER
13	AS2 I²C BUS TUNER
14	
15	VS4 SUPPLY VOLTAGE +5V
16	AGC IF
17	OUTPUT 1
18	OUTPUT 2

Figure 2 Mechanical Drawing

4.2 MECHANICAL CHARACTERISTICS

Table 1 Mechanical Characteristics

CHARACTERISTIC	DIMENSIONS
Dimensions	According to the drawing in Figure 2
Weight	Approximately 56g
Plug holding strength	Plug according to SCTE spec. IPS-sp-407
Tuner connection	The tuner provides four pins at bottom cover for horizontal mounting and grounding
Screw fixing of F-connector*	Absolute maximum torque strength: 3.39 Nm / only once Absolute maximum cantilever strength: 3.39 Nm Absolute maximum axial strength: 8.99N

* If the tuner is not mounted on the chassis, the frame may be bent during the test. Regardless of mounting, the F-connector will not be pulled out of the frame.

5 FUNCTIONAL SPECIFICATIONS

5.1 ABSOLUTE MAXIMUM RATINGS

Stresses greater than those listed in Table 2 may cause permanent damage to the device. These are stress ratings only; functional operation of the device under conditions other than those listed in Table 3 is not recommended or implied. Exposure to any of the absolute-maximum rating conditions for extended periods of time may affect reliability.

Table 2 Absolute Maximum Specifications

PARAMETER	MIN	MAX	UNIT
Supply voltage		6	V
AGC voltage		6	V
Storage temperature	-30	+70	°C

5.2 OPERATING CHARACTERISTICS

The operating characteristics listed in Table 3 reflect the conditions necessary for optimal performance and operating reliability.

Table 3 Operating Characteristics

PARAMETER	MIN	TYP	MAX	UNIT	CONDITIONS OR LOCATION
Frequency range					
VHF Low	50		162	MHz	
VHF High	156		469	MHz	
UHF	463		860	MHz	
Frequency range, referenced to center frequency of 6 MHz bandwidth					
VHF Low	53		159	MHz	
VHF High	159		466	MHz	
UHF	466		857	MHz	
Tuning resolution					
Standard tuning increment (see Table 8)		62.5		kHz	
Recommended takeover frequencies, referred to center frequency					
VHF Low / VHF High		158		MHz	
UHF		464		MHz	
Output Frequency					
3x7702		5.75		MHz	± 0.05 MHz
3x8899		43.75		MHz	± 0.05 MHz
Input impedance					
VHF/UHF Common		75		Ω	Unbalanced
AGC voltage for maximum gain					
RF			4	V	± 0.1V
IF			4	V	± 0.1V
Power supply voltage					
Voltage V_{S1}		5	± 0.3	V	Pin 3
Voltage condition V_{S1}			150	mA	
Voltage V_{S2}		5	±0.25	V	Pin 6
Voltage condition V_{S2}			200	mA	
Voltage V_{S3}		5	±0.25	V	Pin 10
Voltage condition V_{S3}			200	mA	
Voltage V_{S4}		5	±0.3	V	Pin 15
Voltage condition V_{S4}			100	mA	
Permissible ripple voltage (20 Hz to 100 kHz)			20	mVpp	

PARAMETER	MIN	TYP	MAX	UNIT	CONDITIONS OR LOCATION
Temperature					
Operating temperature	0		60	°C	

6 TUNER DOWNSTREAM DATA

Table 4 Electrical Characteristics

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Frequency range		55		860	MHz
Input signal level		40		80	dBµV
Voltage gain	Measured between antenna input and IF output (pins 17 and 18). The input is loaded with 75Ω and the IF output is loaded with a test circuit (see Figure 5).	60	80	95	dB
Output level at 1 kΩ	The output impedance is about 220Ω. Pins 17 and 18 are not DC decoupled.		1		Vpp
Noise figure	VHF Low		8	10	dB
	VHF High		8	10	dB
	UHF		8	10	dB
VSWR	Antenna input			3	
IF Rejection [Rejection of CW Signal at highest possible IF (46.75 MHz) fed into the tuner input relative to a CW at desired channel center frequency measured at the IF mixer output. Both signals must have the same level at F-connector input.]	VHF Low	50	70		dB
	VHF High	60	80		dB
	UHF	60	80		dB
Upstream rejection	Isolation between upstream output (5 MHz to 42 MHz) and IF mixer out (40.75 MHz to 46.75 MHz)	75			dB
Image rejection	VHF Low	60	70		dB
	VHF High	55	65		dB
	UHF	55	60		dB
RF Tilt	For all AGC settings and over a 6 MHz bandwidth around center frequency			2.5	dB
Signal level for 1 dB gain compression	AGC deactivated with AGC = 4V (pins 7 and 16) for maximum gain	72			dBµV
Phase noise					
VHF Low	Measured at 1 kHz distance from carrier		-71	-55	dBc/Hz
VHF High			-60	-55	dBc/Hz
UHF			-58	-55	dBc/Hz

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VHF Low	Measured at 10 kHz distance from carrier		-95	-80	dBc/Hz
VHF High			-85	-80	dBc/Hz
UHF			-85	-80	dBc/Hz
VHF Low	Measured at 20 kHz distance from carrier		-102	-90	dBc/Hz
VHF High			-92	-85	dBc/Hz
UHF			-90	-85	dBc/Hz
VHF Low	Measured at 100 kHz distance from carrier		-109	-100	dBc/Hz
VHF High			-106	-100	dBc/Hz
UHF			-103	-100	dBc/Hz
Oscillator voltage	F-connector terminated with 75Ω				
<860 MHz				15	dBµV
<1740 MHz				40	dBµV
Intermodulation	With a fully loaded multi-tone signal generator (129 channels), with carrier levels at +15 dBmV, and with AGC set for a 44 dBmV first IF level, distortion levels shall not exceed these limits.				
Composite triple beat				-50	dBc
Composite second order beat				-50	dBc
Group delay	Over any 6 MHz bandwidth centered about the tuned frequency, and for AGC over the range from maximum gain down to -25 dB below maximum gain, the group delay variation as measured between the antenna terminal and the output terminal (Pins 17 and 18) shall not exceed these limits.				
55 MHz to 860 MHz			100	200	ns p-p
PLL Setting time	Charge pump current high		40	100	ms
AGC Range					
RF AGC range (Pin 7)	By varying AGC voltage from +4V to +0.5V, this gain reduction must be possible	40	50		dB
IF AGC range (Pin 16)		26	33		dB

6.1 INFLUENCE OF AGC

The curves in Figure 3 and Figure 4 are measured at +25°C with an input level of 45 dBµV. The values are typical values and can vary within the guaranteed limits.

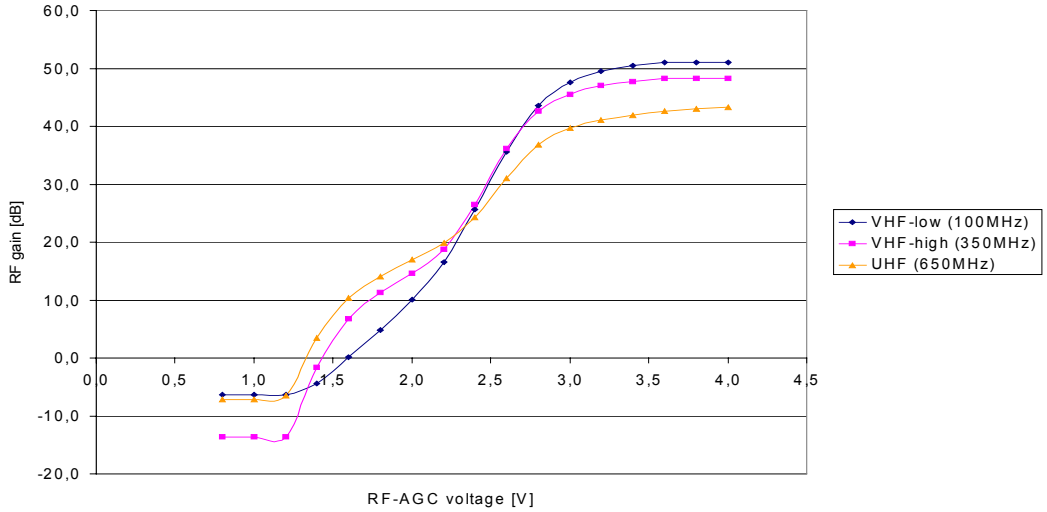


Figure 3 RF Gain vs. AGC Voltage

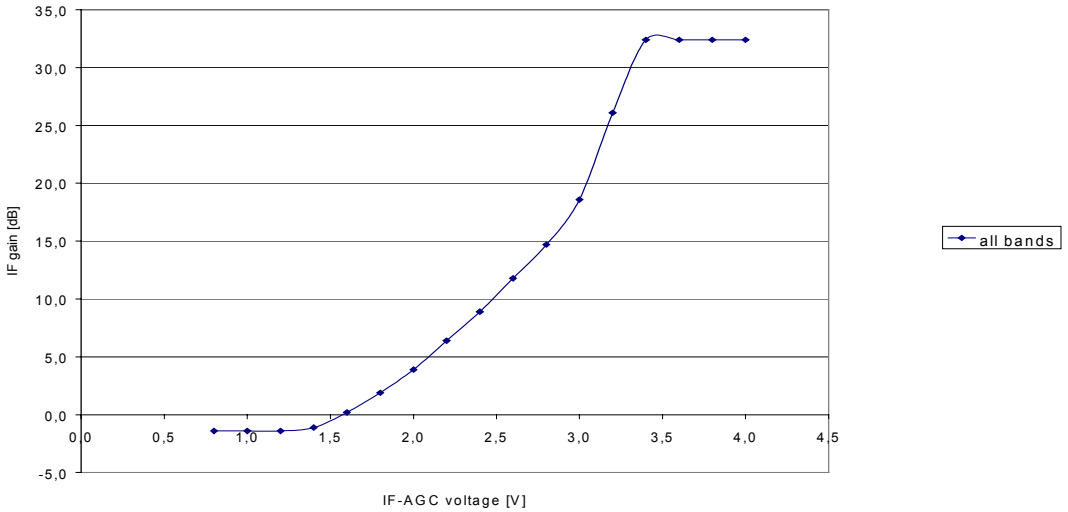


Figure 4 IF Gain vs. AGC Voltage

The noise figure shall not increase by more than the corresponding AGC gain reduction. The input return loss shall be maintained within the specified limits over the entire range of AGC voltage.

7 TUNER UPSTREAM DATA

All data is measured according to the test circuit shown in Figure 6 on page 9. The input impedance between Pins 1 and 2 for this tuner is 50 ohms.

Table 5 Tuner Upstream Data

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input level	Source impedance 75Ω sym		33	35	dBmV
Voltage gain	Gain control word = maximum gain	25	27	29	dB
Gain steps		0.7	1	1.3	dB
Gain range		59			dB
Group delay variation	5 MHz to 42 MHz (3.2 MHz bandwidth)			60	nsec
Amplitude ripple variation					
5 MHz to 42 MHz	1.28 MHz bandwidth			± 0.2	dB
Absolute accuracy of transmitted power	5 MHz to 42 MHz			± 2	dB
TX Transient Spurs					
Gain setting = maximum gain				16	mVp-p
Gain setting < (maximum gain –12)				8	mVp-p
TX Transient duration	TXEN rise/fall time < 0.1 µs			2	µsec
Reverse channel harmonic distortion	V_{out}= +58 dBmV				
5 MHz to 42 MHz	2nd harmonic level, single tone	-53			dBc
5 MHz to 42 MHz	3rd harmonic level, single tone	-54			dBc
54 MHz to 60 MHz			-40	-35	dBmV
60 MHz to 88 MHz			-50	-40	dBmV
88 MHz to 860 MHz			-50	-45	dBmV
Noise floor	Input terminated with 75Ω				
Transmit mode noise	Voltage gain 24 dB		131	150	nV / √Hz
Transmit disable mode noise	TXEN low, voltage gain 24 dB		810		pV / √Hz

8 TUNER MEASUREMENT TEST CONDITIONS

All tuner data are held under the following conditions unless otherwise noted:

- Measurement tolerance 10% or 1 dB
- Ambient temperature + 25°C ± 3°C
- Supply voltages + 5V ± 2%
- AGC voltage + 4V ± 2%

8.1 TEST CIRCUITS

8.1.1 VOLTAGE GAIN, TILT, AND NOISE FIGURE

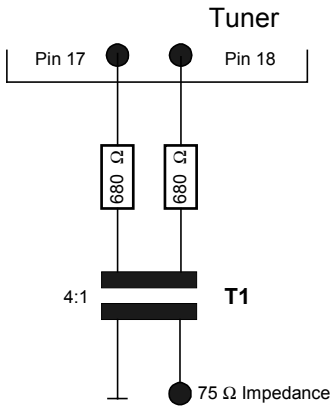


Figure 5 Test Circuit for Voltage Gain, Tilt, and Noise Figure

For the voltage gain, tilt, and noise figure test circuit:

- Loss of test-dummy: 22.6 dB
- T1 = RF – Transformer (ohms - ratio = 1:4)
- Type: MCL T4-1 or equivalent

8.1.2 UPSTREAM CHANNEL

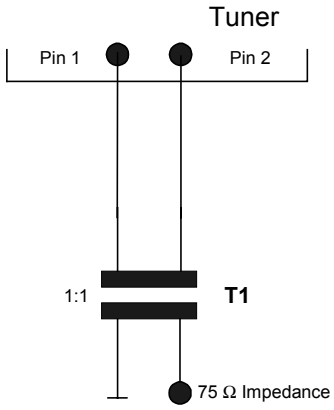


Figure 6 Test Circuit for Upstream Channel

For the upstream channel test circuit:

- Loss of test-dummy: < 1 dB
- T1 = RF – Transformer (ohms - ratio = 1:1)
- Type: MCL T1-1 or equivalent

9 CONTROL

9.1 WRITE DATA FORMAT FOR I²C BUS

Table 6 Write Data Format

	MSB							LSB	ACK
Address byte	1	1	0	0	0	MA1	MA0	R/W[1]	A[2]
Divider byte 1	0	N14	N13	N12	N11	N10	N9	N8	A
Divider byte 2	N7	N6	N5	N4	N3	N2	N1	N0	A
Control byte 1	1	CP	T2	T1	T0	RSA	RSB	OS	A
Control byte 2	P7	P6	P5	P4	P3	P2	P1	P0	A

[1] R/W = 0 is write mode
[2] A = Acknowledge

9.2 ADDRESS SELECTION FOR I²C BUS

Table 7 Address Selection

MA1	MA0	ADDRESS	VOLTAGE AT PIN 11
0	0	C0	(0 to 0.1) V_{S3}
0	1	C2	Open circuit or (0.2 to 0.3) V_{S3}
1	0	C4	(0.4 to 0.6) V_{S3}
1	1	C6	(0.9 to 1) V_{S3}

9.3 OSCILLATOR FREQUENCY AND DIVIDER BYTE CALCULATION

Table 8 Oscillator Frequency and Divider Byte Calculation

RSA	RSB	REFERENCE DIVIDER	MINIMUM TUNING STEP	F_{REF}
1	1	512	62.5 kHz	7.8125 kHz
X	0	640	50.0 kHz	6.25 kHz
0	1	1024	31.25 kHz	3.90625 kHz

Use the following formula to calculate oscillator frequency and divider byte.

$$f_{osc} = f_{ref} \times 8 \times SF$$

Where:

f_{osc} = Local oscillator frequency

f_{ref} = Crystal reference frequency / 512 = 4 MHz / 512 = 7.8125 kHz

SF = Programmable scaling factor

Scaling factor is SF = 16384 × n14 + 8192 × n13 + 4096 × n12 + 2048 × n11 + 1024 × n10 + 512 × n9 + 256 × n8 + 128 × n7 + 64 × n6 + 32 × n5 + 16 × n4 + 8 × n3 + 4 × n2 + 2 × n1 + n0

9.4 CONTROL BYTE (I^2C)

Table 9 Control Byte 1 Settings (Default)

	MSB							LSB	ACK
Control byte 1	1	0	0	0	1	1	1	0	A

Table 10 Control Byte 1 Settings Default Descriptions

CODE	DESCRIPTION	SETTINGS
CP	Charge pump current	1 = Fastest tuning 0 = Better phase noise for distance < 10 kHz to the carrier
OS	Tuning voltage	0 = On 1 = Off
RSA, RSB	Reference divider	See Table 8 on page 10
T0, T1, T2	Test mode bit	See Table 11

Table 11 Test Mode Bit Settings

T2	T1	T0	DEVICE OPERATION
0	0	1	Normal mode
0	1	x	Charge pump is off
1	1	0	Charge pump is sinking current
1	1	1	Charge pump is sourcing current
1	0	0	Internal test mode
1	0	1	Internal test mode

Table 12 Control Byte 2 (Band Selection)

BAND	ACTIVE PORT	P7	P6	P5	P4	P3	P2	P1	P0
UHF	P0	0	X	1	1	X	X	X	X
VHF High	P2	1	X	0	1	X	X	X	X
VHF Low	P1	1	X	1	0	X	X	X	X

Note: X = not used, P3 = used for upstream shutdown (see section 9.6)

9.5 READ DATA FORMAT (I2C)

Table 13 Read Data Format (I^2C)

	MSB							LSB	ACK
Address byte	1	1	0	0	0	MA1	MA0	R/W	A
Status byte	POR	FL	I2	I1	I0	A2	A1	A0	A

Note: MSB is transmitted first.

Table 14 Read Data Format Descriptions

CODE	DESCRIPTION
R/W	1 = Read mode
POR	Power on reset flag (POR = 1 at power on)
FL	In lock flag (FL = 1 when PLL is locked)
I2, I1, I0	Digital levels for I/O ports P0, P1, and P2
A2, A1, A0	Digital output of 5-level ADC for AFC function. Values for correct tuning: A2 = 0, A1= 1, A0 = 0

9.6 PROGRAMMABLE-GAIN AMPLIFIER CONTROL (THREE-WIRE BUS)

Table 15 Pin Map (Three-Wire Bus)

PIN	SYMBOL	DESCRIPTION
4	AS1	Active low enable
5	TXEnable	Hardware shutdown
8	SCL1	Serial clock
9	SDA1	Serial data

A serial data interface controls the programmable-gain amplifier (PGA). It has an active-low enable (AS1) to sample the data, with data clocked in MSB (D7) first on the rising edge of SCL1. Data is stored on the rising edge of AS1. The gain is determined by a 6-bit word (D5 – D0).

Table 16 Data Register (3-Wire Bus)

BIT	MNEMONIC	DESCRIPTION
MSB 7	D7	Software shutdown
6	D6	Test bit
5	D5	Gain control, bit 5
4	D4	Gain control, bit 4
3	D3	Gain control, bit 3
2	D2	Gain control, bit 2
1	D1	Gain control, bit 1

BIT	MNEMONIC	DESCRIPTION
0	D0	Gain control, bit 0

Setting PLL-Port 3 low shuts down the PGA. Port 3 is controlled over the I^2C bus (SDA2; SCL2). Control byte 2 (P3) has to be 1 for shutdown or 0 for normal mode. Hardware shutdown overrides software shutdown (D7) and stored gain settings will be lost. In normal active mode, port 3 must be held high. To bias only the differential output-power-amp between bursts, TXEnable (Pin 5) must be held low. TXEnable must be held high for transmit mode.

Table 17 State Diagram (3-Wire Bus)

SHDN PORT 3	TXEN PIN 5	D7	D6	D5	D4	D3	D2	D1	D0	STATE
1	0	X	X	X	X	X	X	X	X	Shutdown mode
0	0	0	X	X	X	X	X	X	X	Software shutdown mode
0	0	1	X	X	X	X	X	X	X	Transmit disable mode
0	1	1	X	X	X	X	X	X	X	Transmit mode
0	1	1	X	0	0	0	0	0	0	Maximum gain – 63 dB = minimum gain
0	1	1	X	0	0	0	0	0	1	Maximum gain – 62 dB
0	1	1	X	-	-	-	-	-	-	-
0	1	1	X	1	0	0	0	0	1	Maximum gain – 30 dB
0	1	1	X	-	-	-	-	-	-	-
0	1	1	X	1	1	1	1	1	0	Maximum gain – 1 dB
0	1	1	X	1	1	1	1	1	1	Maximum gain

9.7 SERIAL INTERFACE TIMING

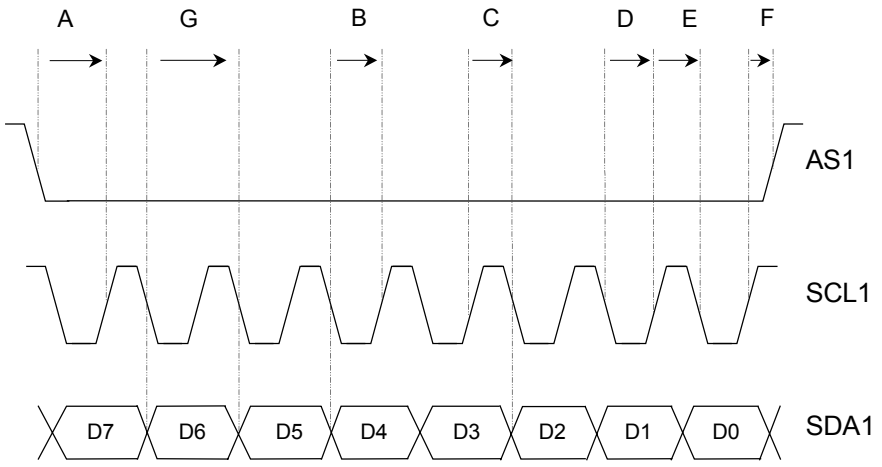


Figure 7 Serial Interface Timing

Table 18 Timing Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS
AS1 to SCL1 rise setup time	A	10			ns
AS1 to SCL1 rise hold time	F	20			ns
SDA1 to SCL1 setup time	B	10			ns
SDA1 to SCL1 hold time	C	20			ns
SDA1 pulse width high	G	50			ns
SDA1 pulse width low	G	50			ns
SCL1 pulse width high	E	50			ns
SCL1 pulse width low	D	50			ns

10 SAFETY AND RELIABILITY

10.1 ELECTROSTATIC DISCHARGE (ESD) PROTECTION

WARNING: The 4937 DI5 Tuner Module contains components that can be damaged by electrostatic discharge.

Observe these precautions:

- Ground yourself before handling the tuner.
- Do not touch the tuner connector pins without ESD protection.

10.2 HIGH VOLTAGE

The tuner meets specifications IEC 801.2 level 2.

10.3 HUMIDITY

Table 19 Local Oscillator Drift

PARAMETER	DRIFT	UNIT	PROCEDURE
VHF Low	± 15	kHz	1. Run 60 hours at 55°C and 20% relative humidity. 2. Run 1 hour at 23°C and 50% relative humidity. 3. Take first measurement. 4. Run 65 hours at +40°C and 95% relative humidity. 5. Take second measurement.
VHF High	± 45	kHz	
UHF	± 75	kHz	

10.4 VIBRATION TEST

After applying vibration of 1.5 mm amplitude, frequency of 10 - 55 -10 Hz (1 minute) each X, Y, Z direction for 2 hours (total 6 hours), tuner shall not have any rattling or loosening and shall comply with the variation to its initial value as listed in Table 20.

Table 20 Vibration Test

PARAMETER	MEASUREMENT	UNIT
Gain variation	< ± 3	dB
Wave variation	< ± 30	%

10.5 MICROPHONY

The microphony test is made with a TV set. The resolution is optimal. With maximum AF output of the TV set, the tuner is free of microphonic effects, provided the unit is installed in a professional manner.

10.6 LOOSE CONTACT TEST OF TUNER ALONE

The test pattern is a color bar. The resolution is 3 MHz. To test, there must be no interruption effects when the edge of the tuner is knocked, provided it is fastened with a ground contact.

10.7 SOLDER LIMITS

See application note APN001.

10.8 NATIONAL REGULATIONS

The tuner meets the requirements of VDE 9872/7.72 and Amtsblatt DBP 069/1981 (FTZ), EN 55013, EN 55020 (if properly mounted into TV set, VCR, or converter).

11 ORDERING INFORMATION

The 4937 DI5 Tuner Modules may be ordered in the packaging units and quantities shown in Table 21 and Table 22. For packaging options and quantities other than those shown, contact one of the offices listed on the last page of this document.

Table 21 Packaging Units

PACKAGING UNITS	4937 TUNER MODELS	
	3X8899	3X7702
Number of Tuner Modules Per Box	72	72
Number of Boxes Per Master Box	40	40

Table 22 Order Quantities

NUMBER OF MASTER BOXES	TOTAL NUMBER OF TUNERS PER MASTER BOX	
	3X8899	3X7702
0.5	1,440	1,440
1.0	2,880	2,880
1.5	4,320	4,320
2.0	5,760	5,760
2.5	7,200	7,200
3.0	8,640	8,640
3.5	10,080	10,080
4.0	11,520	11,520
4.5	12,960	12,960
5.0	14,400	14,400

12 REVISION HISTORY

NAME	DESCRIPTION	ECN NO.	DATE	REV
Hennig			24.11.00	M1
Hennig		011/01	20.02.01	01
Hennig	Change 3x7702 (3x8899) to 3x8899 (3x7702)	050/01	10.07.01	02

Preliminary

NOTICES

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