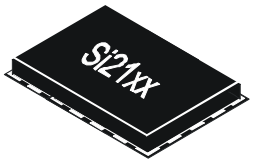
Si2107/08/09/10

SATELLITE RECEIVER FOR DVB-S/DSS

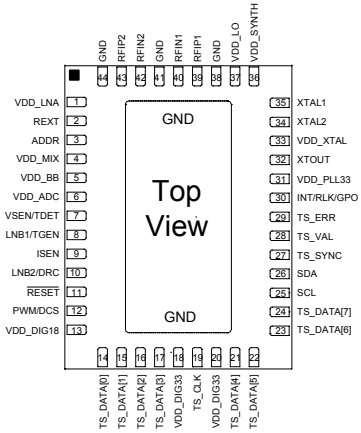
Features

- Single-chip tuner, demodulator, and LNB controller
- DVB-S- and DSS-compliant
- QPSK/BPSK demodulation
- Integrated step-up dc-dc converter for LNB power supply (Si2108/10 only)
- Input signal level: –81 to –18 dBm
- Symbol rate range: 1 to 45 MBaud
- Automatic acquisition and fade recovery
- Automatic gain control
- On-chip blind scan accelerator (Si2109/10 only)
- DiSEqC™ 2.2 support
- Power, C/N, and BER estimators
- I2C bus interface
- 3.3/1.8 V supply, 3.3 V I/O
- Lead-free/RoHS-compliant package



Pin Assignments

Si2107/08/09/10



Applications

- Set-top boxes
- Digital video recorders
- Digital televisions
- Satellite PC-TV
- SMATV trans-modulators (Satellite Master Antenna TV)

Description

The Si2107/08/09/10 are a family of pin-compatible, complete front-end solutions for DSS and DVB-S digital satellite reception. The IC family incorporates a tuner, demodulator, and LNB controller into a single device resulting in significantly reduced board space and external component count. The device supports symbol rates of 1 to 45 MBaud over a 950 to 2150 MHz range. A full suite of features including automatic acquisition, fade recovery, blind scanning, performance monitoring, and DiSEqC Level 2.2 compliant signaling are supported. The Si2108/10 further add short circuit protection, overcurrent protection, and a step-up dc-dc controller to implement a low-cost LNB supply solution. Si2110/09 versions include a hardware channel scan accelerator for fast “blindscan”. An I2C bus interface is used to configure and monitor all internal parameters.

Functional Block Diagram

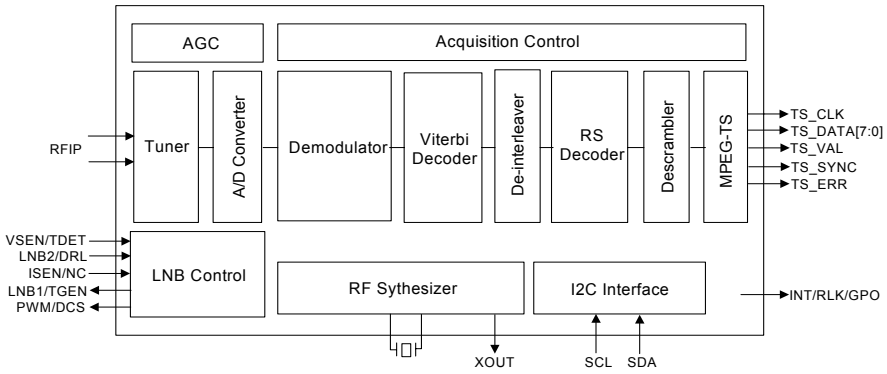


TABLE OF CONTENTS

Section **Page**

1. Electrical Specifications

Table 1. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Ambient temperature	T_A	0	—	70	°C
DC supply voltage, 3.3 V	$V_{3.3}$	3.0	3.3	3.6	V
DC supply voltage, 1.8 V	$V_{1.8}$	1.71	1.8	1.89	V
Note: All minimum and maximum specifications are guaranteed and apply across the recommended operating conditions.					

Table 2. Absolute Maximum Ratings[1, 2]

Parameter	Symbol	Min	Max	Unit
DC supply voltage, 3.3 V	$V_{3.3}$	–0.3	3.9	V
DC supply voltage, 1.8 V	$V_{1.8}$	–0.3	2.19	V
Input voltage - pins 2, 3, 7, 9, 11	V_{IN}	–0.3	$V_{3.3}$ + 0.3	V
Input current - pins 2, 3, 7, 9, 11	I_{IN}	–10	+10	mA
Operating ambient temperature	T_{OP}	–10	+70	°C
Storage temperature	T_{STG}	–55	150	°C
RF input level		—	10	dBm
ESD protection - pins 39–40, 42–43			1	kV
ESD protection - pins 1–38, 41, 44			2	kV

Notes:
1. Permanent damage may occur if the absolute maximum ratings are exceeded. Functional operation should be restricted to the conditions as specified in the operations sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. The Si2107/08/09/10 is a high-performance RF integrated circuit. Handling and assembly of these devices should only be done at ESD-protected workstations.

Table 3. DC Characteristics

($V_{3.3}$ = 3.3 V ±10%, $V_{1.8}$ = 1.8 V ±10%, T_A = 0–70 ºC)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply Current, 3.3 V	$I_{3.3}$	45 Msps, CR 7/8*	—	313	—	mA
		20 Msps, CR 2/3*	—	298	—	mA
Supply Current, 1.8 V	$I_{1.8}$	45 Msps, CR 7/8*	—	292	—	mA
		20 Msps, CR 2/3*	—	217	—	mA
Input high voltage	V_{IH}	SCL(25), SDA(26)	2.3	—	5.5	V
Input low voltage	V_{IL}	SCL(25), SDA(26)	0	—	0.8	V
Input leakage	I_I	SCL(25), SDA(26)	—	—	±10	µA
Output high voltage	V_{OH}		2.4	—	—	V
Output low voltage	V_{OL}		—	—	0.4	V
Output leakage	I_{OL}		—	—	±10	µA

***Note:** LNB dc-dc converter disabled; LNB_EN (CEh[2]) = 0.

Table 4. RF Electrical Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Input power, single channel	$P_{i,ch}$		–81	—	–23	dBm
Aggregate input power	$P_{i,agg}$		—	—	–7	dBm
Input impedance, balanced	Z_{in}	Z_{SOURCE} = 75 Ω	—	75	—	Ω
Return Loss			—	–10	—	dB
Dynamic voltage gain range	Δ_{GV}		—	75	—	dB
Maximum voltage gain	$G_{V(max)}$		—	55	—	dB
Noise figure	NF	Max gain[1]	—	+9.5	+12.5	dB
IP3	IP3[2]	Min gain[3]	+5	+15	—	dBm
LO leakage	L_{LO}	950 to 2150 MHz	—	—	–70	dBm
LO SSB phase noise	N_{LO}	100 kHz offset	—	–97	–94	dBc/Hz
		1 MHz offset	—	–97	–94	dBc/Hz
LO DSB phase noise (integrated)	N_{LO}	10 kHz to 1/2 Baud Rate	—	2.1	2.8	°rms
RF synthesizer spurious		At 20 MHz offset	—	–40	—	dBc/Hz
Reference oscillator phase noise		At 2 kHz offset	—	–130	—	dBc/Hz
LO oscillator settling time	$t_{s,LO}$		—	100	—	µs

Notes:
1. Max gain = +55 dB.
2. IM3 can be calculated as follows: IM3 = 2 x (IP3 – P_{in}).
3. Min gain = –35 dB.

Table 5. Receiver Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF input frequency range	f_{in}		950	—	2150	MHz
Fine tune step size	f_{step}		—	125	—	kHz
Symbol rate range	R_S		1	—	45	MBaud
Carrier offset correction range	f_{car_off}		—	±6	—	MHz

Table 6. LNB Supply Characteristics (Si2108/10 Only)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Supply Voltage	V_{LNB_IN}		8	12	13.2	V
Converter Switch Frequency			237	264	290	kHz
Output HIGH voltage		VHIGH = 1010	17.75	18.625	19.5	V
		VHIGH = 0000	17.0	18.0	19.0	V
Output LOW voltage		VLOW = 0110	12.75	13.375	14.0	V
		VLOW = 0100	12.5	13.25	14.0	V
Low to High Transition Time		13 to 18 V	—	—	1	ms
High to Low Transition Time		18 to 13 V	—	—	1	ms
Line Regulation		V_{CC} = 8 to 13.2 V I_o = 500 mA	—	—	200	ΔmV
Load Regulation		I_o = 50 to 500 mA V_{CC} = 12 V	—	—	200	ΔmV
Load Capacitance Tolerance		DiSEqC 1.x	—	—	0.75	µF
		DiSEqC 2.x	—	—	0.25	µF
Output current limiting		ILIM = 00	400	—	550	mA
		ILIM = 01	500	—	650	mA
		ILIM = 10	650	—	850	mA
		ILIM = 11	800	—	1000	mA
Maximum LNB Supply Current		IMAX = 01	1.4	1.6	1.92	A
Tone Frequency	f_{tone}		20	22	24	kHz
Tone Amplitude			500	650	800	mV
Tone Duty Cycle			40	50	60	%
Tone Rise and Fall Time			3	6	10	µs
Tone Detector Frequency Capture Range			17.6	—	26.4	kHz
Tone Detector Input Amplitude			200	—	1000	mV_{pp}

Note: Specifications based on recommended schematics in Figure 5 and Figure 6.

Table 7. I2C Bus Characteristics

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
SCL Clock Frequency	f_{SCL}		0	—	400	kHz
Bus Free Time between START and STOP Condition	t_{BUF}		1.3	—	—	µs
Hold Time (repeated) START Condition. (After this period, the first clock pulse is generated.)	$t_{HD, STA}$		0.6	—	—	µs
LOW Period of SCL Clock	t_{LOW}		1.3	—	—	µs
HIGH Period of SCL Clock	t_{HIGH}		0.6	—	—	µs
Data Setup Time	$t_{SU, DAT}$		100	—	—	ns
Data Hold Time	$t_{HD, DAT}$		0	—	0.9	µs
SCL and SDA Rise and Fall Time	t_r, t_f		—	—	300	ns
Setup Time for a Repeated START Condition	$t_{SU, STA}$		0.6	—	—	µs
Setup Time for STOP Condition	$t_{SU,STO}$		0.6	—	—	µs
Capacitive Load for each Bus Line	C_B		—	—	400	pF

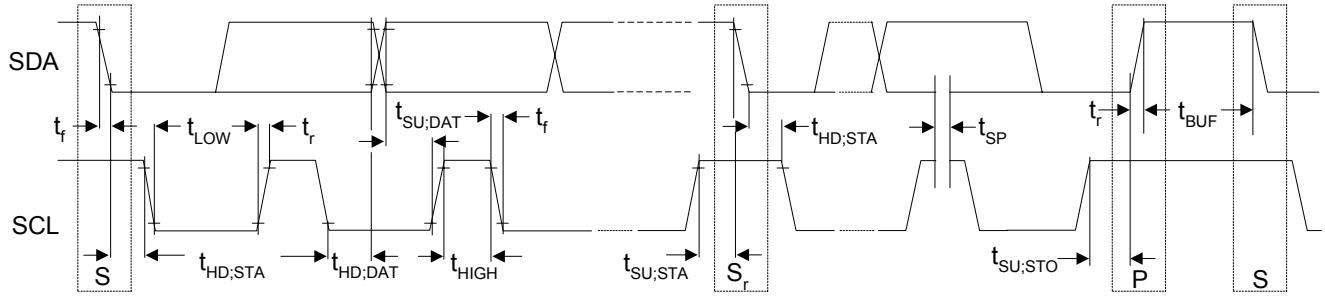


Figure 1. I²C Timing Diagram

Table 8. MPEG-TS Specifications (Rising Launch and Capture)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Clock cycle time	t_{cycle}	Serial mode	11.3	—	28.6	ns
		Parallel mode	77	—	8000	ns
Clock low time	t_{clow}	Serial mode (TSSCR = 11)	5.1	—	6.9	ns
		Serial mode (TSSCR = 00)	12.0	—	15.8	ns
		Parallel mode	39	—	4000	ns
Clock high time	t_{chigh}	Serial mode (TSSCR = 01)	5.1	—	6.9	ns
		Serial mode (TSSCR = 11)	12.0	—	15.8	ns
		Parallel mode	39	—	4000	ns
Hold time	t_{hold}	Normal operation	—	0	—	ns
		Data delayed (TSDD = 1)	—	1.5	—	ns
		Clock Delayed (TSCD = 1)	—	–1.5	—	ns
Setup time	t_{setup}	Normal operation	—	t_{cycle} – 1.5	—	ns
		Data delayed (TSDD = 1)	—	t_{cycle} – 3.0	—	ns
		Clock Delayed (TSCD = 1)	—	t_{cycle}	—	ns
Access time	t_{access}		—	1.5	—	ns

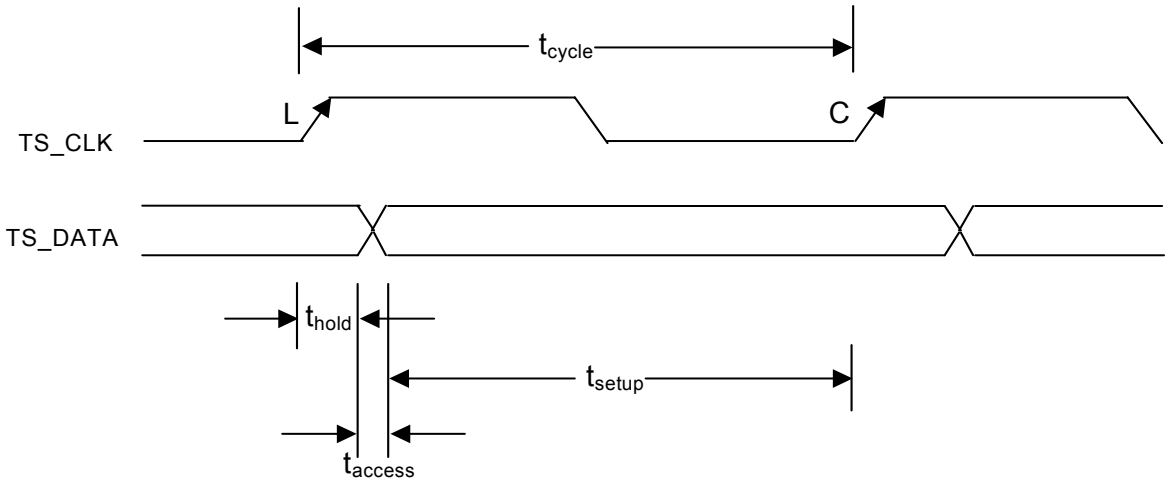


Figure 2. MPEG-TS (Rising Launch and Capture) Timing Diagram

Table 9. MPEG-TS Specifications (Rising Launch, Falling Capture)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Clock cycle time	t_{cycle}	Serial mode	11.3	—	28.6	ns
		Parallel mode	77	—	8000	ns
Clock low time	t_{clow}	Serial mode (TSSCR = 11)	5.1	—	6.9	ns
		Serial mode (TSSCR = 00)	12.0	—	15.8	ns
		Parallel mode	39	—	4000	ns
Clock high time	t_{chigh}	Serial mode (TSSCR = 01)	5.1	—	6.9	ns
		Serial mode (TSSCR = 11)	12.0	—	15.8	ns
		Parallel mode	39	—	4000	ns
Hold time	t_{hold}	Normal operation	—	$t_{cycle}/2$	—	ns
		Data delayed (TSDD = 1)	—	$t_{cycle}/2 + 1.5$	—	ns
		Clock Delayed (TSCD = 1)	—	$t_{cycle}/2 – 1.5$	—	ns
Setup time	t_{setup}	Normal operation	—	$t_{cycle}/2 – 1.5$	—	ns
		Data delayed (TSDD = 1)	—	$t_{cycle}/2 – 3.0$	—	ns
		Clock Delayed (TSCD = 1)	—	$t_{cycle}/2$	—	ns
Access time	t_{access}		—	1.5	—	ns

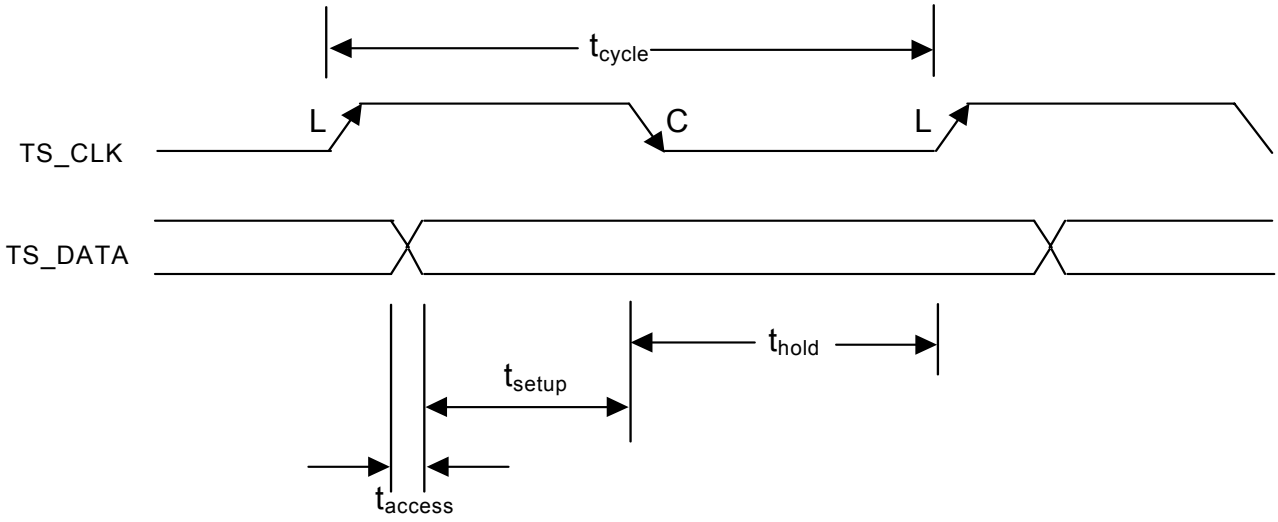


Figure 3. MPEG-TS (Rising Launch, Falling Capture) Timing Diagram

2. Typical Application Schematic

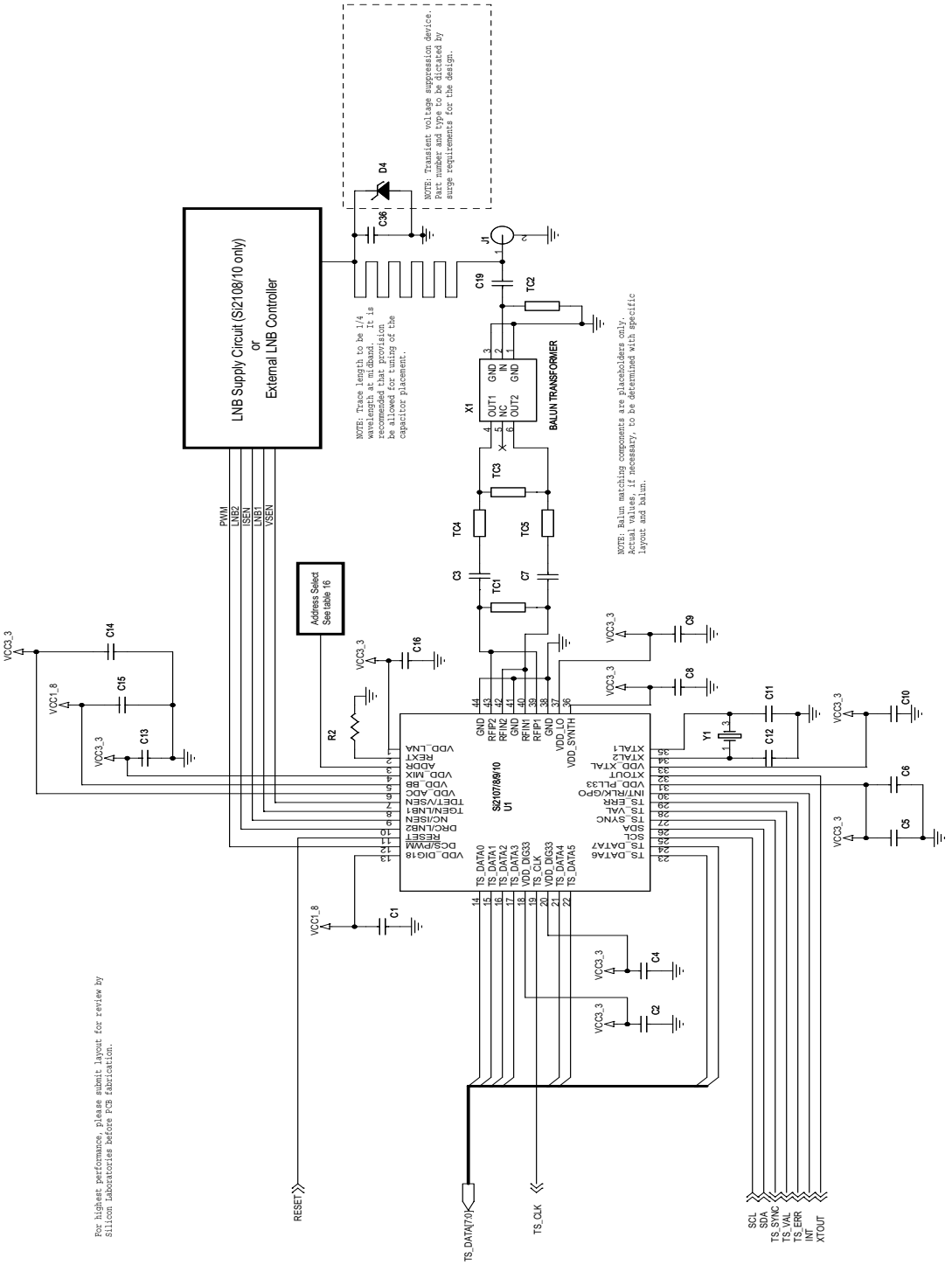


Figure 4. Si2107/08/09/10 Schematic

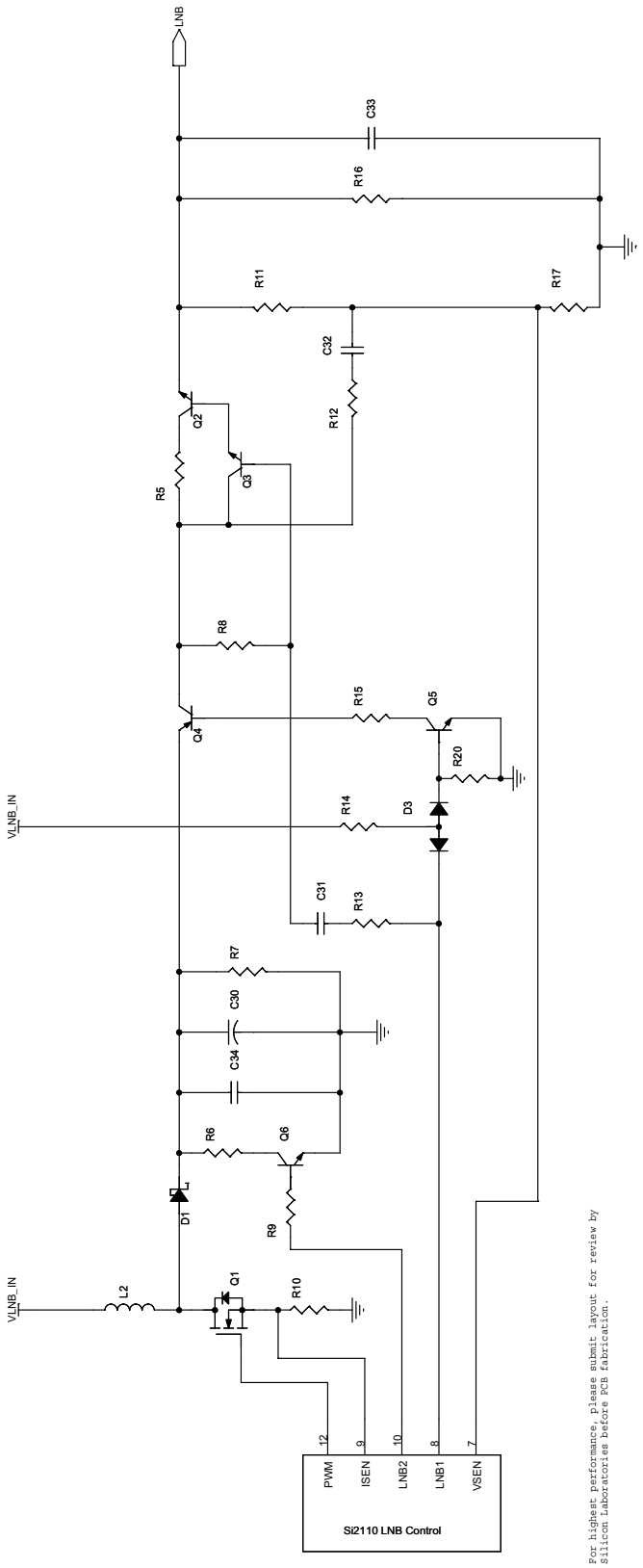


Figure 5. DiSEqC 1.x LNB Supply Circuit

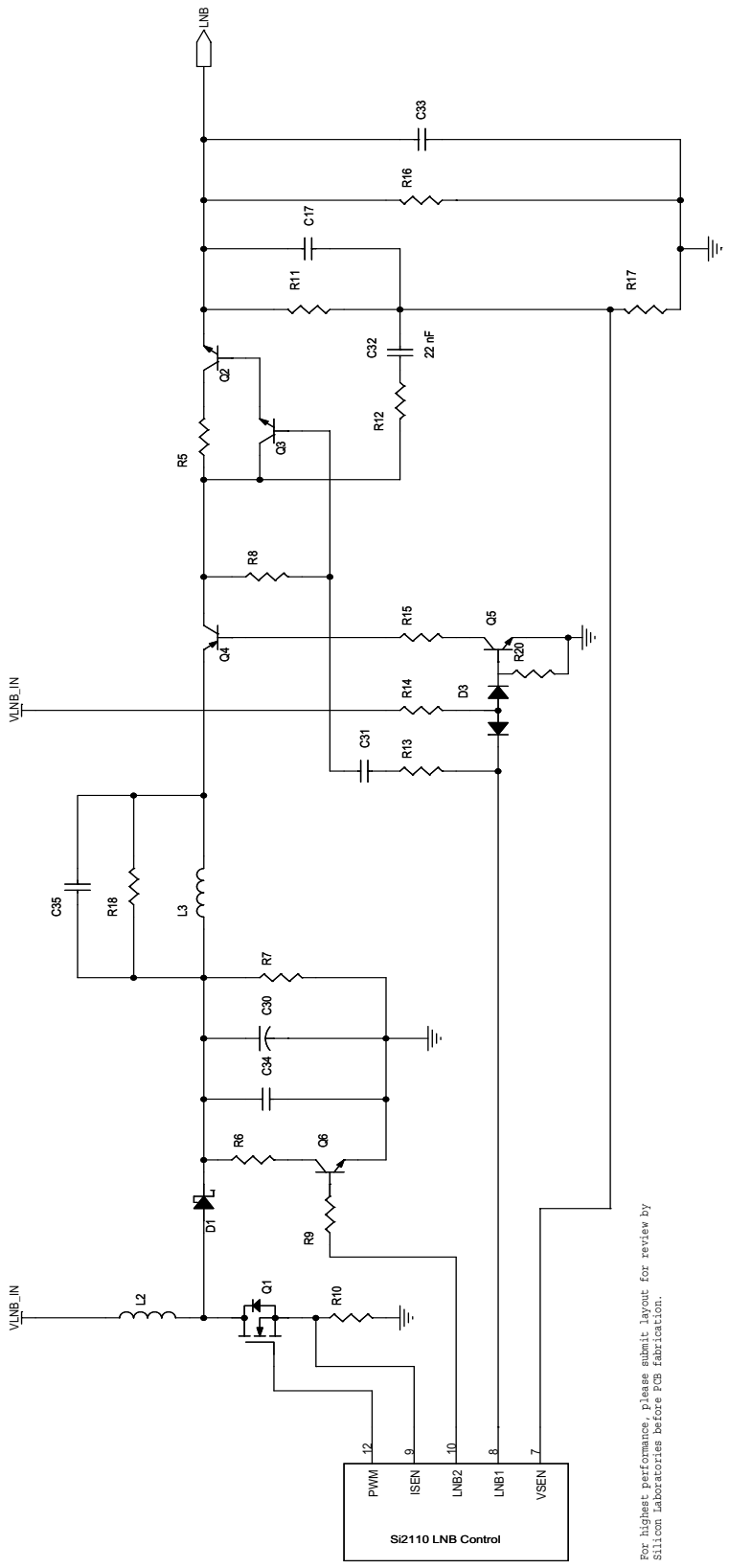


Figure 6. DiSEqC 2.x LNB Supply Circuit

3. Bill of Materials

Table 10. Si2107/08/09/10 Bill of Materials

Component	Description	Vendor
C1,C2,C4,C6,C10,C8,C9, C10,C13,C14,C15,C16	0.1 µF, X7R, ±20%	
C5	0.01 µF, X7R, ±20%	
C3,C7,C11,C12	33 pF, 6 V, NP0, ±10%	
C19,C36	33 pF, 50 V, NP0, ±10%	
D4	Transient voltage suppressor, 20 V[2]	Littlefuse SMCJ20CA
J1	Connector, F-type, 75 Ω, 950-2150 MHz	
R2	4.53 kΩ, 62.5 mW, ±1%	
TC1-5	See Note 1	
X1	Balun transformer	Anaren B0922J7575A00
Y1	20 MHz, 20 pF, 50 ppm, 20 Ω ESR	
U1	Si2107/08/09/10	Silicon Laboratories

Notes:
1. Tuning component values depend on the balun selected and layout. Contact Silicon Laboratories for assistance reviewing layouts and selecting matching components.
2. The transient voltage suppression device should be selected to match the surge requirements of the application.

Table 11. DiSEqC 1.x LNB Supply Bill of Materials (Si2108/10 Only)

Component	Description	Vendor
C30	47 µF, 25 V,Electrolytic,± 20%	
C31	0.47 µF, 25 V, X7R,± 20%	
C32	22 nF, 25 V, X7R, ± 20%	
C33	0.22 µF, 25 V, X7R, ± 20%	
C34	4.7 µF, 25 V, X7R, ± 20%	
D1	CMPSH1-4, 40 V, 1 A ZHCS750TA, 40 V, 750 mA	Central Semiconductor Zetex
D3	MMBD1705, Dual diode, 20 V, 25 mA	Fairchild
L2	DR78098,33 µH,1.2 A, 20% SD0705-330K-R-SL	Datatronic ACT
Q1	ZXMN3B14 FDN337N	Zetex Fairchild
Q2	FMMT618	Zetex
Q3,Q5,Q6	MMBT3904	Fairchild
Q4	FMMT718	Zetex
R5	1.3 Ω, 500 mW, ±5%	
R6	33 Ω, 250 mW, ±5%	
R7	10 kΩ, 62.5 mW, ±5%	
R8	1 kΩ, 250 mW, ±5%	
R9	680 Ω, 125 mW, ±5%	
R10	0.22 Ω, 1 W, ±5%	
R11	22 kΩ, 62.5 mW, ±1%	
R12,R20	20 kΩ, 62.5 mW, ±5%	
R13	33 Ω, 62.5 mW, ±5%	
R14	43 kΩ, 62.5 mW, ±5%	
R15	3 kΩ, 100 mW, ±5%	
R16	2 kΩ, 250 mW, ±5%	
R17	2.2 kΩ, 62.5 mW, ±1%	

Table 12. DiSEqC 2.x LNB Supply Bill of Materials (Si2108/10 Only)

Component	Description	Vendor
C17	1200 pF, 25 V, X7R, ± 20%	
C30	47 µF, 25 V,Electrolytic,± 20%	
C31,C35	0.47 µF, 25 V, X7R,± 20%	
C32	22 nF, 25 V, X7R, ± 20%	
C33	0.22 µF, 25 V, X7R, ± 20%	
C34	4.7 µF, 25 V, X7R, ± 20%	
D1	CMPSH1-4, 40 V, 1 A ZHCS750TA, 40 V, 750 mA	Central Semiconductor Zetex
D3	MMBD1705, Dual diode, 20 V, 25 mA	Fairchild
L2	DR78098,33 µH,1.2 A, 20% SD0705-330K-R-SL	Datatronic ACT
L3	DR78097,100 µH, 500 mA, 20% SD0504-101K-R-SL	Datatronic ACT
Q1	ZXMN3B14 FDN337N	Zetex Fairchild
Q2	FMMT618	Zetex
Q3,Q5,Q6	MMBT3904	Fairchild
Q4	FMMT718	Zetex
R5	1.3 Ω, 500 mW, ±5%	
R6	33 Ω, 250 mW, ±5%	
R7	10 kΩ, 62.5 mW, ±5%	
R8	1 kΩ, 250 mW, ±5%	
R9	680 Ω, 125 mW, ±5%	
R10	0.22 Ω, 1 W, ±5%	
R11	22 kΩ, 62.5 mW, ±1%	
R12,R20	20 kΩ, 62.5 mW, ±5%	
R13	33 Ω, 62.5 mW, ±5%	
R14	43 kΩ, 62.5 mW, ±5%	
R15	3 kΩ, 100 mW, ±5%	
R16	2 kΩ, 250 mW, ±5%	
R17	2.2 kΩ, 62.5 mW, ±1%	
R18	16 Ω, 250 mW, ±5%	

4. Part Versions

There are four pin- and software-compatible versions of this device. All versions include the L-band tuner, DVB-S/DSS demodulator and channel decoder, and LNB signaling controller. Furthermore, the Si2108 and Si2110 integrate an efficient LNB supply regulator while allowing operation with an external LNB supply regulator circuit. The LNB supply controller utilizes a step-up converter architecture. In case operation with an external regulator is desired, Si2107 and Si2109 can be used; these do not integrate the LNB step-up dc-dc controller.

On the other hand, the Si2109 and Si2110 integrate an on-chip “blindscan” accelerator, which allows the implementation of a very fast channel scan, an important feature for end products targeted to free-to-air (FTA) applications in which channel locations are unknown. Si2107 and Si2108 do not integrate this accelerator and are a good fit when symbol rates and frequencies of satellite channels are known, as in the case of pay-TV receivers or for FTA receivers in which the embedded firmware contains the channel tuning information. Table 13 summarizes the differences between part versions.

Table 13. Device Versions

Part Number	DVB-S/DSS Integrated Tuner/ Demodulator with Integrated LNB Messaging	LNB Supply Regulator	On-Chip Blindscan Accelerator
Si2110	Y	Y	Y
Si2109	Y	N	Y
Si2108	Y	Y	N
Si2107	Y	N	N

5. Functional Description

The Si2107/08/09/10 is a family of highly-integrated CMOS RF satellite receivers for DVB-S and DSS applications. The device is an ideal solution for satellite set-top boxes, digital video recorders, digital televisions, and satellite PC-TV. The IC incorporates a tuner, demodulator, and LNB controller into a single device resulting in a significant reduction in board space and external component count. The device supports symbol rates of 1 to 45 Msym/s over a 950 to 2150 MHz range. A full suite of features including automatic acquisition, fade recovery, blind scanning, performance monitoring, and DiSEqC™ Level 2.2 compliant signaling are supported. The Si2110 and Si2108 further add short-circuit protection, overcurrent protection, and a step-up dc-dc controller to implement a low-cost LNB supply. Furthermore, the Si2109 and Si2110 have an on-chip blindscan accelerator. An I2C bus interface is used to configure and monitor all internal parameters.

5.1. Tuner

The tuner is designed to accept RF signals within a 950 to 2150 MHz frequency range. The inputs are matched to a 75 Ω coaxial cable in a single-ended configuration. The tuner block consists of a low-noise amplifier (LNA), variable gain attenuators, a local oscillator, quadrature downconverters, and anti-aliasing filters. The LNA and variable gain stages provide balance between the noise figure and linearity characteristics of the system. When all gain stages are combined, the device provides more than 80 dB of gain range. The desired tuning frequency can be adjusted in intervals of 125 kHz, without the aid of external varactors, using a unique two-stage tuning algorithm that is supplied with the software driver. The rapid settling time of the local oscillator improves channel acquisition and switching performance. The PLL loop filter has been completely integrated into the device resulting in low tuner phase noise, improved spurious response, and reduced BOM cost. An external 20 MHz crystal unit generates the reference frequency for the system.

5.2. Demodulator

The demodulator supports QPSK and BPSK demodulation of channels between 1 to 45 Msym/s. It incorporates the following functional blocks: analog-to-digital converters (ADCs), dc notch filters, I/Q imbalance corrector, decimation filters, matched filters, equalizer, digital automatic gain controls, and a soft-decision decoder. The demodulator supports rapid channel acquisition using an advanced carrier offset estimation algorithm. When combined with the Si2209/10's blind scanning capabilities, the device becomes an ideal solution for the free-to-air (FTA) and common interface (CI) market. Automatic acquisition and fade recovery sequencers are also included to reduce the required amount of software interaction and to simplify the overall design. The output of the demodulator is quantized into a 4-bit number by the soft-decision decoder. The use of soft-decision decoding improves the error correction capabilities of the channel decoder.

5.3. DVB-S/DSS Channel Decoder

The Si2107/08/09/10 integrates a full-channel decoder, which can be configured in either DSS or DVB-S mode and consists of a soft-decision Viterbi decoder, de-interleaver, Reed-Solomon decoder, and energy-dispersal descrambler.

5.3.1. Viterbi decoder

The Viterbi decoder performs maximum likelihood estimation of convolutional codes in compliance with DVB-S and DSS standards. The decoder is capable of detecting code rate, puncturing pattern phase, 90° phase rotation, and I/Q interchange. Supported code rates are listed in Table 14

Table 14. Viterbi Code Rates

DVB-S	DSS
1/2	—
2/3	2/3
3/4	—
5/6	—
—	6/7
7/8	—

The device allows monitoring of the Viterbi bit-error rate (BER) over a finite or infinite measurement window.

5.3.2. Convolutional De-Interleaver

The deinterleaver disassembles the Reed-Solomon (RS) code words, which were interleaved by the modulator, to provide better resilience against burst errors. The Si2110/09 performs deinterleaving according to DVB-S and DSS standards.

5.3.3. Reed-Solomon decoder

The Si2109/10 supports RS codes in compliance with DVB-S and DSS specifications. Both standards use a shortened Reed-Solomon code, which can correct up to eight byte errors per information packet. DVB-S utilizes 204 byte codes. DSS utilizes 146 byte codes.

The device allows monitoring of correctable bit, correctable byte, and uncorrectable packet errors over a finite or infinite measurement window. The device also includes a total BER monitor, which compares received data from a modulated PRBS sequence against the same sequence generated from an on-chip PRBS generator.

5.3.4. Energy-dispersal descrambler

The descrambler removes the energy dispersal scrambling introduced by the DVB-S process. The descrambler is automatically bypassed in DSS mode.

5.4. On-Chip Blindscan Controller (Si2109/10 Only)

The device includes on-chip circuitry to facilitate extremely fast detection of available satellite channels. For each valid DVB-S/DSS channel, the tuning frequency and symbol rate, which can be stored by the host for subsequent tuning, are determined. On Si2107/08 devices, the host needs to provide the channel tuning frequency and symbol rate to the device.

5.5. LNB Signaling Controller

The device supports several LNB signaling methods including dc voltage selection, continuous tone, tone burst, DiSEqC 1.x- and DiSEqC 2.x-compliant messaging, and several combinations of these to allow simultaneous operation with legacy tone/burst and DiSEqC-capable peripherals.

Si2107/09 includes the capability to convert I2C signaling commands to signals that interface to an external LNB supply regulator circuit. In the case of (bi-directional) DiSEqC operation, the device modulates (and demodulates) the PWK data to (and from) an internal message FIFO, which the host uses to write (and read) DiSEqC messages. In the case of transmission, the device can generate either the 22 kHz tone burst directly or generate a tone envelope for when an external LNB supply controller is used, which includes the 22 kHz oscillator.

5.6. On-Chip LNB DC-DC Step-Up Controller (Si2108/10 Only)

Next to the LNB message signaling controller, the device also integrates the LNB supply regulator controller. The supported LNB supply regulator architecture consists of a step-up dc-dc (boost) converter followed by an efficient filter, linefeed, and DiSEqC transmit/receive circuit, which implements a very power-efficient LNB supply solution. This facilitates a complete LNB supply circuit with only a minimal number of external components.

5.7. Crystal Oscillator

The crystal oscillator requires a crystal with a resonant fundamental frequency of 20 MHz to generate the reference frequency for the local oscillator. A single crystal can be shared between two devices by utilizing the master-slave configuration shown in Figure 6.

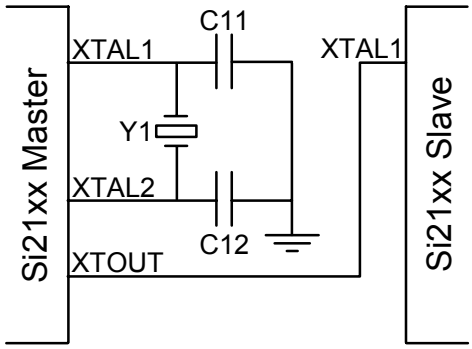


Figure 6. Master-Slave Crystal Sharing

6. Operational Description

The following sections discuss the user-programmable functionality offered by the corresponding register map sections. Refer to Table 19, “Register Summary,” on page 31 and detailed register descriptions starting on page 35.

6.1. System Configuration

The MPEG Transport Stream (TS) output interface carries the decoded satellite data to external devices for further processing. Both DVB-S and DSS receiver modes and associated output data packet formats are supported. Mode selection is controlled via the system mode register, SYSM. QPSK or BPSK demodulation is set via the modulation type (MOD) register.

The MPEG-TS output interface consists of the following output pins:

- TS_DATA[7:0] Data
- TS_CLK Clock
- TS_SYNC Sync/Frame Start Indicator
- TS_VAL Valid Data Indicator
- TS_ERR Uncorrectable Packet Error

The start of a TS frame is indicated by the TS_SYNC signal. The TS_SYNC signal is a pulse that is active during the sync byte in a DVB-S frame or during the first byte of a DSS frame and is active only while TS synchronization exists. In serial mode, the TS_SYNC pulse can be programmed to be active for the whole byte, or the first bit only, by setting the TSSL bit. The polarity of the TS_SYNC pulse can be programmed to be either active high or active low using the TSSP bit.

The TS_VAL output is used to indicate when valid data is present. TS_VAL is active during the MPEG-TS frame packet data and inactive while parity data is being output or when there is no TS synchronization. The polarity of the TS_VAL output can be programmed to be active high or active low using the TSVP bit.

The TS_ERR output indicates that an uncorrectable error has been detected in the RS decoding stage and that the current TS data packet contains uncorrectable errors. The TS_ERR output is active during the entire erred TS frame. The polarity of TS_ERR can be programmed to be active high or active low using the TSEP bit.

All signals on the MPEG-TS output interface can be individually tri-stated using bits TSE_OE, TSV_OE, TSS_OE, TSC_OE, and TSD_OE.

Transport stream data can be output in a parallel byte-wide mode or a serial bit-wide mode for system-level flexibility. Selection of the interface mode is controlled via the TSM bit. In serial mode, data is output on TS_DATA[0] while TS_DATA[7:1] are held low. The direction of the serial data stream may be programmed to output in an MSB or LSB first direction using the TSDF bit. Parity data may be optionally zeroed by setting the TSPG bit. To support board-level timing modifications, the data stream may be delayed by setting TSDD.

The transport stream clock can be programmed such that data is transitioning on its rising or falling edge using the TSCE bit. When operating in serial mode, the transport stream clock mode bit, TSCM, can be used to select either a gapped or continuous clock mode. In the gapped mode, the clock is active only when data is being output. For this, parity information is not considered data when the TSPG is set to output zero data during parity. In the continuous mode, the clock runs without regard to data being output, and the user uses TS_VAL as a data strobe. To support board-level timing modifications, the clock stream may be delayed by register bit TSCD.

In serial mode, the transport stream clock rate range is determined by the TSSCR register. The exact rate is determined during the acquisition process. The range that minimizes the difference between the effective transport stream data rate and the clock rate should be chosen. The recommended settings are listed in Table 15.

Table 15. Serial MPEG-TS Clock Frequency

TSSCR	Baud Rate	Serial Clock Rate
00	40–50 Msps	80–88.5 MHz
01	30–40 Msps	76.8–82.8 MHz
10	19–30 Msps	54.9–59.2 MHz
11	1–19 Msps	35–37.7 MHz

Figure 7 illustrates the parallel data mode. Figure 8 illustrates the continuous and gapped serial data modes.

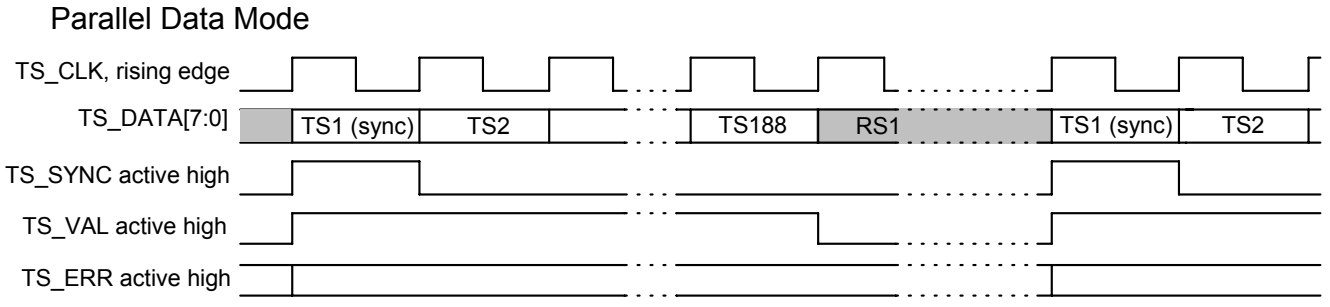


Figure 7. MPEG-TS Parallel Mode

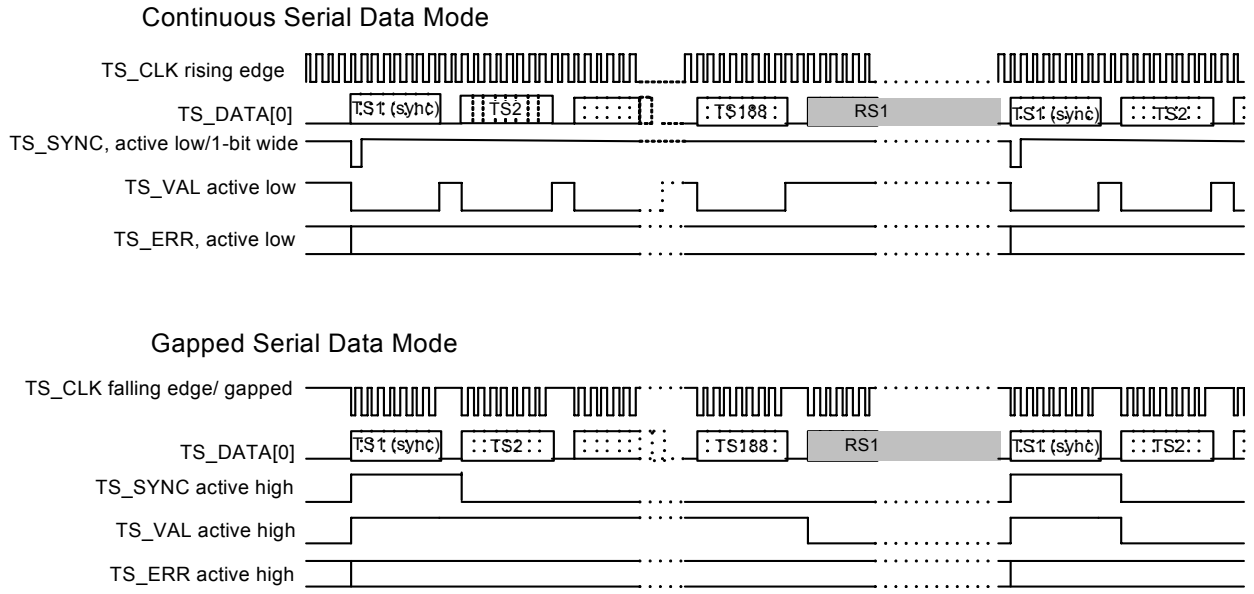


Figure 8. MPEG-TS Serial Modes

The device has one output pin (pin 30), which can be configured as either a receiver lock indicator, general purpose output, or interrupt output, using the pin select register, PSEL. The receiver lock indicator provides a signal output for register bit RCVL. The general purpose output reflects the polarity of register bit GPO. The interrupt output is discussed further in “6.2. Interrupts”.

The user can configure the device such that components of the channel decoder are bypassed. This is controlled by the energy-dispersal descrambler bypass bit, DS_BP, the Reed-Solomon decoder bypass bit, RS_BP, and the convolutional de-interleaver bypass bit, DI_BP. The use of these bypass options is defined for the implementation of a BER test on a known modulated PRBS data sequence as explained later in "6.5. Channel Decoder" on page 24.

6.2. Interrupts

The device is equipped with several sticky interrupt bits to provide precise event tracking and monitoring.

Next to interrupts being signaled via the I2C register map, the user can program one of the device terminals (INT) as a dedicated interrupt pin via the pin select register bit, PSEL. The device contains an extensive collection of interrupt sources that can be individually masked from the INT pin using the corresponding interrupt enable register bits, labeled with suffix “_E”. Thus, the INT output is a logical-OR of all enabled interrupts. Generation of the channel interrupt on pin INT can be masked off by using the interrupt enable bit, INT_EN. Note that interrupt reporting in the register map is not affected by INT_EN.

The interrupt signal polarity can be configured to be active high or active low using the interrupt polarity bit, INTP. The interrupt signal type can be configured to be CMOS output or open-drain/source output using the interrupt type bit, INTT.

Interrupt bits are set by the device to 1 when an interrupt occurs. The host clears an interrupt bit by writing a 1 again, at which time the device resets the interrupt bit to zero. Table 16 illustrates the interrupt sources and their associated status, enable, and interrupt bits.

Table 16. Events, Interrupts, and Status Bits

Event	Interrupt Bit	Enable Bit	Status Bit
Receiver lock	RCVL_I	RCVL_E	RCVL (0 –>1)
Receiver unlock	RCVU_I	RCVU_E	RCVL (1 –> 0)
Tuner lock	TUNL_I	TUNL_E	TUNL (0 –> 1)
AGC lock	AGCL_I	AGCL_E	AGCL (0 –> 1)
AGC threshold	AGCTS_I	AGCTS_E	AGCTS (0 –> 1)
Carrier estimation lock	CEL_I	CEL_E	CEL (0 –> 1)
Symbol rate estimation lock	SRL_I	SRL_E	SRL (0 –> 1)
Symbol timing lock	STL_I	STL_E	STL (0 –> 1)
Symbol timing unlock	STU_I	STU_E	STL (1 –> 0)
Carrier recovery lock	CRL_I	CRL_E	CRL (0 –> 1)
Carrier recovery unlock	CRU_I	CRU_E	CRL (1 –> 0)
Viterbi lock	VTL_I	VTL_E	VTL (0 –> 1)
Viterbi unlock	VTU_I	VTU_E	VTL (1 –> 0)
Frame synchronizer lock	FSL_I	FSL_E	FSL (0 –> 1)
Frame synchronizer unlock	FSU_I	FSU_E	FSL (1 –> 0)
Acquisition fail	AQF_I	AQF_E	AQF (0 –> 1)
C/N measurement complete	CN_I	CN_E	CNS (1 –> 0)
Viterbi BER measurement complete	VTBR_I	VTBR_E	VTBRS (1 –> 0)
RS measurement complete	RSER_I	RSER_E	RSERS (1 –> 0)
Message FIFO empty	FE_I	FE_E	FE (0 –> 1)
Message FIFO full	FF_I	FF_E	FF (0 –> 1)
Message received	MSGR_I	MSGPE_E	MSGR (0 –> 1)
Message parity error	MSGPE_	MSGR_	MSGPE (0 –> 1)
Message receive timeout	MSGTO_I	MSGTO_E	MSGTO (0 –> 1)
Short-circuit detect	SCD_I	SCD_E	SCD (0 –> 1)
Overcurrent detect	OCD_I	OCD_E	OCD (0 –> 1)

6.3. Receiver Status

During receive operation, the host can retrieve information on the status of AGC lock (AGCL), carrier estimation lock (CEL), symbol rate estimation lock (SRL), symbol timing lock (STL), carrier recovery lock (CRL), Viterbi decoder lock (VTL), frame sync lock (FSL), and overall receiver lock (RCVL).

During channel acquisition, the host can retrieve information on error conditions due to: AGC search (AGCF), carrier estimation (CEF), symbol rate search (SRF), symbol timing search (STF), carrier recovery search (CRF), Viterbi code rate search (VTF), frame sync search (FSF), and overall receiver acquisition (AQF),

6.4. Tuning Control

The Si2107/08/09/10 utilizes a unique two-stage tuning algorithm to provide optimal RF reception. The input signal is first mixed down to a low-IF frequency by a coarse tuning stage and then down to baseband by a fine-tune mixer. The user programs both coarse and fine-tuning frequencies using the CTF and FTF registers.

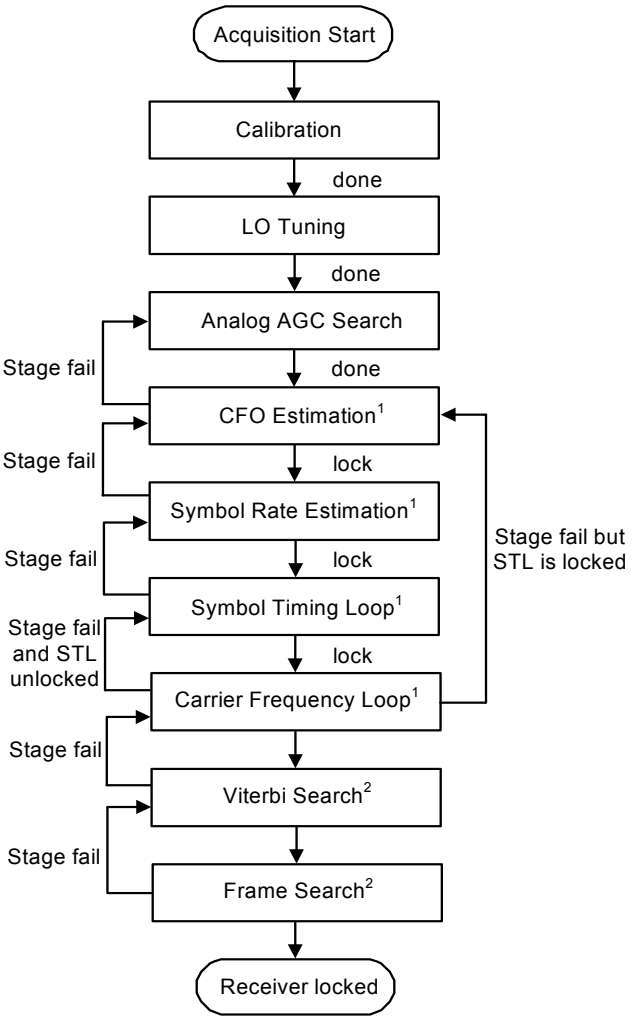
An algorithm (supplied with the reference software driver) is used to automatically calculate the required values. As part of the tuning process, the sample rate, fs, should also be programmed via the ADCSR register. Values between 192 and 207 MHz are supported. An algorithm is supplied with the reference software driver to automatically select the optimal sampling rate.

6.4.1. Automatic Acquisition

The receiver acquisition sequence consists of the following stages: Analog AGC Search, Carrier Offset Estimation, Symbol Rate Estimation, Symbol Timing Recovery, Carrier Recovery, Viterbi Search, and Frame Synchronization. For the receiver to lock, each stage must run to completion or declare lock as shown in Figure 9. If a given stage is unable to achieve lock after exhausting a parameter search range or exceeding the timeout period, it asserts a fail signal.

To initiate the acquisition sequence, the user should program the acquisition start bit, AQS. All search parameters must be specified before initiating the acquisition. Upon completion of the acquisition sequence, the AQS bit is automatically cleared. The acquisition sequence can be aborted at any time by clearing the AQS bit.

The status of the acquisition sequence can be monitored via the registers in the receiver status register map section. A successful acquisition is reported by the assertion of the receiver lock bit, RCVL. A failed acquisition is reported by the assertion of the acquisition fail bit, AQF.



1. Acquisition fail if stage fails n times in a row.
2. Acquisition fail if stage completes parameter range without locking.

Figure 9. Acquisition Sequence (Symbol Rate Estimation Available on Si2109/10 Only)

6.4.2. Carrier Offset Estimation

The desired carrier frequency may be offset from its nominal position due to the imperfections and temperature dependencies of the LNB. The carrier offset estimator uses a search procedure to identify, track, and remove this frequency offset from the system.

Seven different carrier offset estimation search ranges can be programmed from 0.10 to ~6.0 MHz with register CESR. Smaller search ranges result in faster search times.

When carrier offset estimation is complete, the CEL bit is asserted. If an error is detected during carrier offset estimation, the CEF bit is set. Carrier offset estimation commences under the control of the acquisition

sequencer.

After the completion of a search, the estimated carrier offset is stored in the carrier frequency error register, CFER. If no signal is found, the CEF bit is asserted. The value contained in CFER may be optionally transferred to the CFO register to adjust the search center frequency and permit the utilization of a smaller search range for subsequent acquisitions. This relationship can be expressed by the following equation:

$$\text{Search center frequency} = f_{desired} + CFO \times \frac{f_s}{2^{15}} Hz$$

6.4.3. Symbol Rate Estimation (Si2109/10 Only)

The Si2109/10 supports the ability to automatically detect the symbol rate of a channel when it is unknown. This feature is ideal for FTA/CI applications where it is often desirable to rapidly scan (blind scan) and detect the available channels of a given satellite. If symbol rate estimation is not required, the user should program the symbol rate explicitly into the SR register. This is the only mode of operation for Si2107/08.

On Si2109/10, the symbol rate unknown bit, SRUK, can be changed from its default value to activate symbol rate estimation. The search range must then be bounded by programming the symbol rate maximum and minimum registers, SRMX and SRMN. If the symbol rate search is successful, the estimated symbol rate is automatically written to the SR register. Smaller search ranges result in faster search times. Note that the values stored in the symbol rate, symbol rate maximum, and symbol rate minimum registers are sample rate-dependent. This relationship is described by the following equation:

$$\text{Actual Symbol Rate} = \text{Symbol Rate} \times \frac{f_s}{2^{24}} MHz$$

When symbol rate estimation is complete, the SRL bit is asserted. If an error is detected during symbol rate estimation, the SRF bit is also set. The symbol rate estimator commences under the control of the acquisition sequencer.

6.4.4. Carrier Recovery Loop

The carrier recovery loop is responsible for acquiring frequency and phase lock to the incoming signal. When lock is achieved, the carrier recovery lock indicator, CRL, is asserted. If carrier recovery lock is not achieved within a predefined timeout period, the device declares carrier recovery failure by asserting the CRF bit. The carrier recovery loop commences under the control of the acquisition sequencer.

6.4.5. Symbol Timing Loop

The symbol timing recovery loop is responsible for acquiring and tracking the symbol timing of the incoming data signal. When lock is achieved, the symbol timing loop lock indicator, STL, is asserted. If symbol timing lock is not achieved within a predefined timeout period, the device declares symbol timing loop failure by asserting the STF bit. The symbol timing recovery loop commences under the control of the acquisition sequencer.

6.4.6. Automatic Fade Recovery

The device is designed to automatically recover lock in the event of a fade condition. Fade recovery is performed when any stage loses synchronization after receiver lock has been achieved. It is assumed that symbol rate, code rate, and puncturing pattern have not changed; so, these parameters remain fixed during the attempted reacquisition. The fade recovery sequence is shown in Figure 10.

The fade recovery sequence continues until either receiver lock is achieved or a new acquisition is initiated.

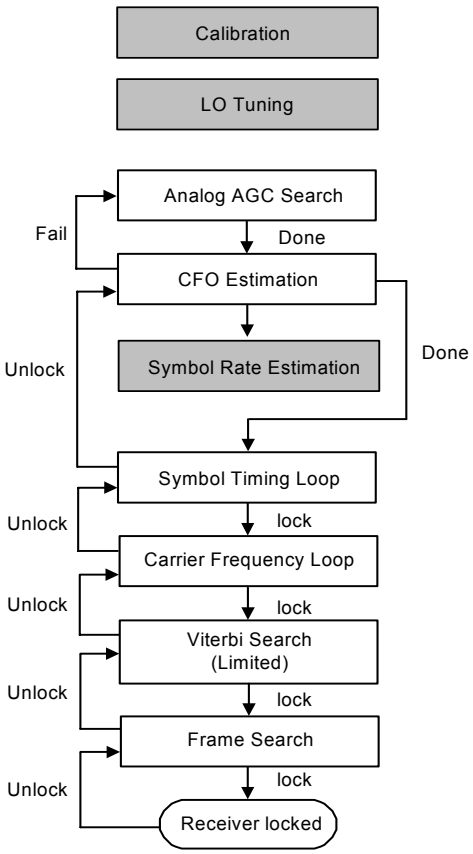


Figure 10. Fade Recovery Sequence

6.4.7. C/N Estimator

A carrier-to-noise estimator is provided to aid in satellite antenna positioning. The C/N measurement mode bit, CNM, controls whether the count is performed over a fixed-length or infinite window. With a fixed-length window, the window size is defined by register CNW. Measurements are stored in a 16-bit saturating register, CNL. Setting the C/N estimator start bit, CNS clears the CNL register and initiates the C/N measurement. When operating in the finite window mode, the CNS bit is automatically cleared when the measurement is complete. The CNS bit must be cleared manually in the infinite mode to stop the count. An external lookup table is used to translate the measurement into a C/N estimate for a given setting of the C/N threshold, CNET, and a given digital AGC setting.

6.5. Channel Decoder

6.5.1. Viterbi Decoder

The Viterbi decoder performs maximum likelihood estimation of convolutional codes in compliance with DVB-S and DSS standards. When lock is achieved, the Viterbi lock indicator, VTL, is asserted. If Viterbi lock is not achieved after exhausting the specified parameter space, the device declares Viterbi search failure by asserting the VTF bit. The Viterbi search commences under the control of the acquisition sequencer.

The device can be programmed to attempt to automatically acquire Viterbi lock using all, one, or a subset of the supported code rates using the VTCS register.

If lock is achieved, the status of the search, including code rate, puncturing pattern phase, 90-degree phase rotation, and I/Q swap, can be monitored in the Viterbi search status registers, VTRS, VTPS, and VTIQS.

6.5.2. Viterbi BER Estimator

The Viterbi BER estimator measures the frequency of bit errors at the input of the Viterbi decoder. The Viterbi BER mode bit, VTERM, controls whether the count is to be performed over a fixed length or infinite window. The window size is defined by VTERW. The BER count is stored in a 16-bit saturating register, VTBRC. Setting the Viterbi BER measurement start bit, VTERS, clears the VTBRC register and initiates the measurement. When operating in the finite window mode, the VTERS bit is automatically cleared when the measurement is complete. The VTERS bit must be cleared manually in the infinite mode to stop the count.

6.5.3. Reed-Solomon Error Monitor

The Reed-Solomon error monitor is capable of counting bit, byte, and uncorrectable packet errors. The error type to be counted is controlled by the Reed-Solomon error type register, RSERT. The Reed-Solomon error mode bit, RSERM, controls whether the count is to be performed over a fixed length or infinite window. The window size is defined by RSERW. The BER count is stored in a 16-bit saturating register, RSERC. Setting the RS BER measurement start bit, RSERS, clears the RSERC register and initiates the measurement. When operating in the finite window mode, the RSERS bit is automatically cleared when the measurement is complete. The RSERS bit must be cleared manually in the infinite mode, to stop the count.

6.5.4. PRBS BER Tester

To facilitate in-system pseudo random bit sequence (PRBS) BER testing, the device provides the ability to synchronize and track test sequences contained in the payload (i.e. not SYNC bytes) of the MPEG data stream. A PRBS test pattern must be encoded, modulated, and injected into the channel to be monitored. The device supports a PRBS $2^{23} - 1$ bits long described by the following polynomial:

$$G(x) = x^{23} + x^{18} + 1$$

To enable PRBS testing, the Reed-Solomon error type register, RSERT, must be appropriately programmed. After the device has synchronized to the incoming PRBS test pattern, errors are reported in the RSERC register.

Measurements can be performed at the output of the Viterbi or Reed-Solomon decoder. To record errors at the output of the Viterbi decoder, the Reed-Solomon decoder and interleaver must be bypassed by setting RS_BP and DI_BP in the “System Configuration” section of the register map. To record errors at the output of the Reed-Solomon block, the RS_BP bit must be cleared.

6.5.5. Frame Synchronizer

The output of the Viterbi decoder is aligned into bytes by detecting sync patterns within the data stream. In DVB-S systems, the sync byte, 47h, occurs during the first byte of a 204 byte RS code block. In DSS systems, a sync byte, 1Dh, is appended to the beginning of each RS encoded 146-byte block, resulting in 147-byte RS code blocks. In DSS mode, sync bytes are discarded before the byte stream is output to subsequent decoding stages. When lock is achieved, the frame synchronization lock bit, FSL, is asserted. If lock is not achieved, the frame synchronizer fail bit, FSF, is asserted.

The frame synchronizer commences under the control of the acquisition sequencer.

Following frame synchronization lock, the device examines the byte stream for a possible 180-degree phase shift. If an inversion is detected, data are inverted prior to being output.

6.6. Automatic Gain Control

The Si2107/08/09/10 is equipped with the ability to adjust signal levels via an automatic gain control (AGC) loop. This ensures that the noise and linearity characteristics of the signal path are optimized at all times. AGC settings can be set at 4 points in the analog signal chain and 2 points in the digital signal chain.

6.6.1. Analog AGC

System gain is distributed into four independent stages as shown in Figure 11. The gain range of all stages combined is over 80 dB. When the AGC search completes, the AGCL bit is asserted. If an error is encountered during the AGC search, the AGCF bit is also set. The AGC search commences under the control of the acquisition sequencer.

The AGC loop works to automatically adjust the gain of each stage to minimize the error between a measured signal power and a desired output level. Signal power is measured at the output of the ADC using an internal rms power calculator. The result is stored in a 7-bit saturating register, AGCPWR. The desired output level is stored in the AGC threshold register, AGCTH. Signal power measurements occur at a frequency dictated by the AGC measurement window size, AGCW. This frequency can be described using the following equation, where fs equals the ADC sampling rate, ADCSR.

$$\text{AGC measurement frequency} = \frac{f_s}{\text{AGCW}} \text{ Hz}$$

When gain adjustments are made, the device allows up to 100 µs for the gain changes to settle before beginning the next measurement.

To facilitate a rapid initial acquisition, Si2107/08/09/10 includes an acquisition mode wherein the measurement window size is reduced by a factor of 64 when compared to the normal tracking mode.

During the AGC search, the device is in acquisition mode, and the gain is adjusted until the measured signal power crosses the desired threshold or a limit is reached. If the signal power crosses the threshold before reaching a limit, the search completes, and the AGCL bit is asserted. If a gain limit is reached, the device asserts both the AGCL bit and the AGCF bit.

In the normal tracking mode, the device continuously measures the input signal power according to the AGC measurement window size. If the absolute value of the difference between the AGCTH and AGCPWR exceeds the value of the AGC tracking threshold, AGCTR, the AGC loop adjusts gain settings until the AGCPWR level matches AGCTH.

The AGC gain offset register, AGCO, provides the ability to apply a static gain offset to the input channel. Silicon Laboratories will provide the recommended values for this register. It is possible to read out the instantaneous settings of each of the four VGAs from the AGC<n>, <n = 1..4>, registers.

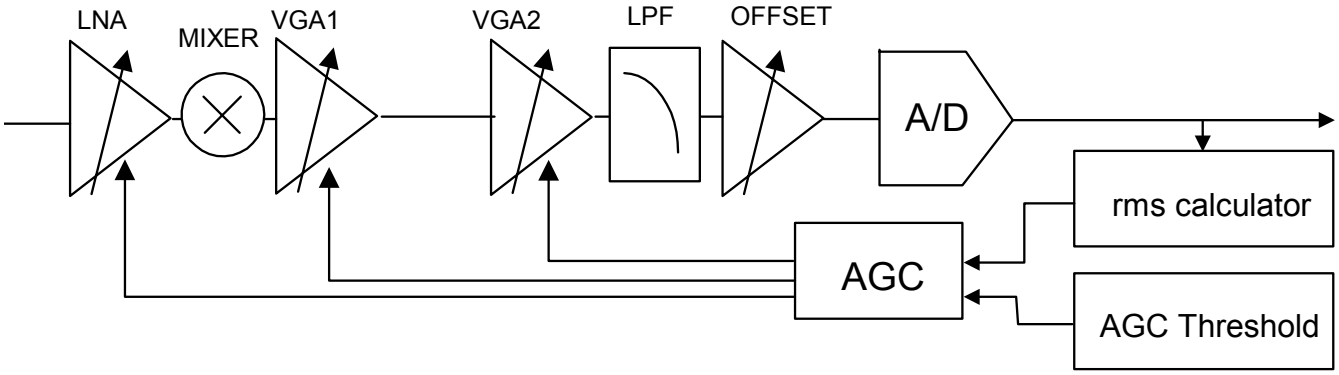


Figure 11. Analog AGC Control Loop

6.6.2. Digital AGC

Downstream of the analog VGAs, after A/D conversion of the signal, there are two points at which the digital gain can be programmed. Digital AGC1 is used to change signal power after removal of adjacent channels by the (digital) anti-aliasing filter.

By default, DAGC1 is enabled and periodically adjusts the gain of the I & Q data streams based on a comparison of the measured complex RMS level and a target value. The target value can be selected with the DAGC1T register. Two levels are provided to allow operation with additional headroom for signal peaks during signal acquisition. The gain function of DAGC1 can be disabled using DAGC1_EN; then, no gain is applied to I & Q data streams. The signal measurement and gain adjustment normally operate continuously, allowing the gain to track the input level. The measurement window can be adjusted by register DAGC1W. The automatic updating of the gain can be frozen by register bit DAGC1HOLD. This holds the gain to the last setting. The value of the gain can be read from the DAGC1 register. It is possible to override the internal AGC algorithm and provide host-based control of AGC1 by appropriately programming register bit DAGC1HOST.

Digital AGC2 (DAGC2) is intended to optimally scale the soft decision outputs of the demodulator prior to Viterbi decoding. This allows it to compensate for signal level variations after matched filtering and equalization. Normally, operation is continuous, but tracking can be disabled using register bit DAGC2_TDIS. This holds the gain to the last setting.

During AGC operation, the average power of the signal is compared to a threshold set by register DAGC2T. The signal power is measured over a finite window specified by DAGC2W. The gain applied to the signal to make the input match the programmed threshold can be read from register DAGC2GA.

6.7. LNB Signaling Controller

All device versions provide LNB signaling capability. The device supports several LNB signaling methods including dc voltage selection, continuous tone, tone burst, DiSEqC 1.x- and DiSEqC 2.x-compliant messaging. A description of each method follows.

6.7.1. DC Voltage Selection

A constant dc voltage of 18 or 13 V is typically used to switch the LNB between horizontal and vertical polarity or clockwise and counterclockwise polarization. The LNBV bit is used to select the desired voltage.

When an external LNB supply regulator is used, the DCS pin is driven high or low depending on the selection of high or low voltage.

6.7.2. Tone Generation

Tone-related information is communicated to external devices via the TGEN pin. The tone format select bit, TFS, specifies whether the output of TGEN is an internally-generated tone or a tone envelope. The frequency of the internal tone generator is governed by the following equation:

$$f_{tone} = \frac{100}{[32 \times (TFQ[7:0] + 1)]} \text{ MHz}$$

Frequencies between 20 and 24 kHz are supported. The default value of TFQ results in a nominal tone frequency of 22 kHz. When tone envelope output is selected, a high signal on TGEN corresponds to "tone on" while a low signal corresponds to "tone off." When operating in the “Manual LNB messaging mode”, the TT bit directly controls the output of the tone or tone envelope.

6.7.2.1. Continuous Tone

A continuous tone is typically used to select between the high and low band of an incoming satellite signal. The LNBCT bit can be set to one to generate a continuous tone.

6.7.2.2. Tone Burst

The tone burst signaling method can be used to facilitate the control of a simple two-way switch. Two types of tone burst are available, as shown in Figure 12. An unmodulated tone burst persists for 12.5 ms. A modulated tone burst lasts for the same duration but consists of a sequence of nine 0.5 ms pulses and 1 ms gaps. Tone burst selection is controlled via the LNBB bit. The tone burst command can optionally be disabled to support systems that do not use tone burst signaling by setting the burst disable bit, BRST_DS, to one. This disables the tone/burst generation as part of the DiSEqC signaling sequence when the device uses “Automatic LNB messaging mode” as described below.

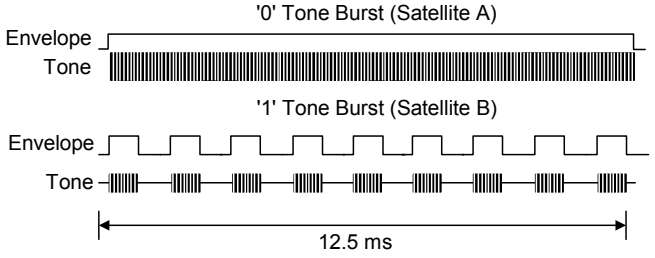


Figure 12. Tone Burst Modulation

6.7.3. DiSEqC™

The DiSEqC signaling method extends the functionality of the legacy 22 kHz tone by superimposing a command protocol and adding an optional return channel. A DiSEqC command normally consists of a framing byte, an address byte, a command byte, and, optionally, one or more data bytes. This format is illustrated in Figure 13.

FRAMING	P	ADDRESS	P	COMMAND	P	DATA	P

Figure 13. DiSEqC Message Format

The length of a message is specified by MSGL. When the message length is set to one byte, the message is modulated using tone burst modulation. When the message length is set to two or more bytes, the message is modulated using DiSEqC-compliant modulation, and the odd parity bit is automatically added. The DiSEqC modulation scheme is illustrated in Figure 14.

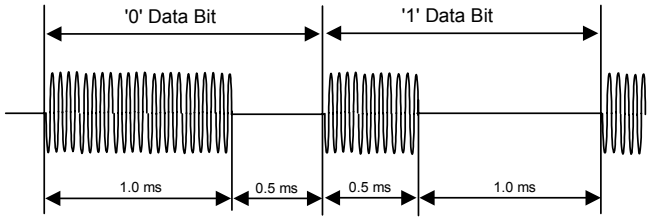


Figure 14. DiSEqC Compliant Modulation

6.7.3.1. DiSEqC 1.x One-Way Communication

Messages are programmed directly into the device using a message FIFO that consists of six byte wide registers, FIFO1–6. The messages must be written in a first-in-first-out manner such that the first byte of a message is stored in FIFO1; the second byte is stored in FIFO2, and so on. If messages are longer than six bytes, the device asserts the FIFO empty indicator, FE, as soon as the sixth byte has been read. The LNB control module then takes its next byte from FIFO1 and continues the process. The message length must also be reprogrammed to indicate how many more bytes remain to be sent. The interval between FIFO reads is typically 13.5 ms.

To support cascaded DiSEqC devices, it may be necessary to repeat commands. Repeated commands should be separated by at least 100 ms to ensure that the far-end device is connected to the signaling path. To facilitate the required 100 ms delay, a four byte command can be inserted between repeated commands.

6.7.3.2. DiSEqC 2.x two-way communication

Two-way communication is supported via DiSEqC 2.x-compliant messages. When the seventh bit in the framing byte of an outgoing message is set to 1, the device anticipates a response and monitors the line for up to 150 ms for an incoming message. If no message is detected during the 150 ms monitoring period, the MSGTO bit is asserted to indicate the time-out condition. A DiSEqC reply message typically consists of a single framing byte and optionally one or more data bytes as shown in Figure 15.

FRAMING	P	DATA	P	DATA	P

Figure 15. DiSEqC Reply Format

When a complete message has been received (one or more bytes followed by 4 ms of silence), the MSGR bit is asserted. Should parity errors exist in the received message, the MSGPE flag is also asserted. If the received message is longer than 6 bytes, the FIFO full bit, FF, is asserted to indicate that a byte has been written to FIFO6. The LNB control module writes the next byte to FIFO1. The length of the received message is recorded in the MSGRL register.

6.7.4. LNB Signaling Modes

6.7.4.1. Automatic LNB Messaging Mode

The Si2107/08/09/10 LNB Signaling Controller can fully manage the generation and sequencing of all LNB commands. The device is configured in this mode by appropriately programming the LNB Messaging mode register, LNBM. To initiate a message sequence, the user should first program LNB voltage selection (LNBV), continuous tone enable (LNBCT), tone burst type (LNBB), and DiSEqC message parameters (MMSG, MSGL, and FIFO1..6). Subsequently, the LNB sequence start bit, LNBS, must be set to start the automated transmission sequence. The device automatically allocates the required delays between each signaling method. Prior dc voltage levels and continuous tones, if present, persist until the sequence is initiated. A typical sequence is shown in Figure 16.

Multiple messages can be sent in a sequential manner by setting the MMSG bit. When this bit is set, the LNB control module delays continuous tone and tone burst commands until all messages in the sequence have been sent. After the current message is transmitted, the MMSG bit is automatically cleared. The tone burst can be disabled as part of this sequence depending on the setting of BRST_DS.

When the sequence has completed, the device clears the LNB sequence start bit, LNBS, automatically. Note that, when operating in this mode, the DRC pin is high while transmitting and low while receiving.

6.7.4.2. Step-by-Step LNB Messaging Mode

By appropriately programming the LNB Messaging Mode register, LNBM, the device allows for individual control of each signaling method by the host. In this mode, the LNB voltage, LNBV, and LNB continuous tone enable, LNBCT, take effect once they are set without waiting for the user to set the LNB sequence start bit, LNBS.

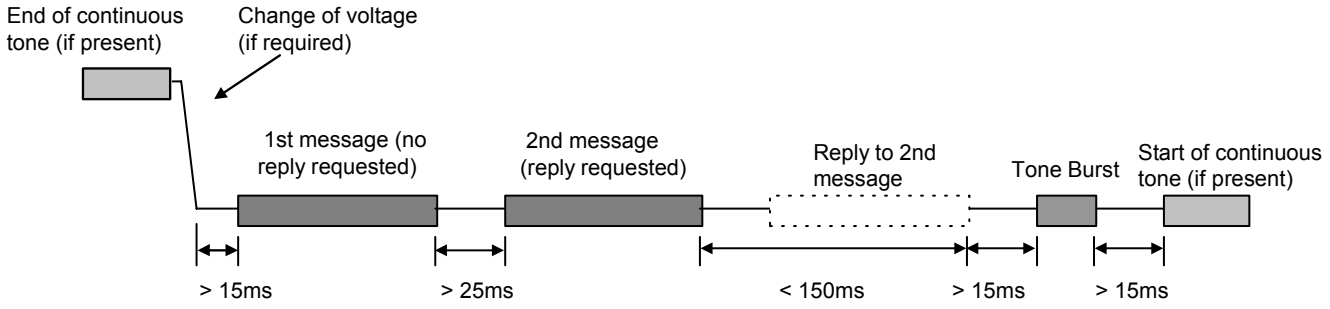


Figure 16. LNB Signaling Sequence

The DiSEqC message uses the LNBS bit to start transmission and behaves the same as in Automatic LNB Messaging Mode. However, the guard intervals between each signaling method (LNB voltage change, DiSEqC message, tone burst, and continuous tone resumption) are controlled by the host.

In this mode, the tone burst should be implemented by using a 1-byte DiSEqC message of all 0s or all 1s programmed into FIFO1. The device uses appropriate modulation for the tone burst; i.e., when FIFO1 is programmed to 00h (rather than a DiSEqC-compliant modulation for a '00h' byte), no tone is generated. Also, the device does not expect a reply if FIFO1 is programmed to FFh; i.e., the assertion of bit7 is not considered a request for the peripheral to reply in step-by-step LNB messaging mode.

6.7.4.3. Manual LNB Messaging Mode

The manual LNB messaging mode provides the maximum level of signaling flexibility but at the expense of increased software interaction. The device is configured in this mode by appropriately programming the LNBM register. The continuous tone, tone burst, and messaging controls are not functional in this mode. When the tone format bit, TFS, is programmed for use of the internal oscillator, assertion of the TT bit modulates the output of the internal tone generator on the TGEN pin, and the TR bit records the envelope of a tone presented to the TDET pin.

When the tone format select bit, TFS, is programmed to use an external oscillator, the TT bit directly controls the output of the TGEN pin, and the TR bit directly reflects the input of the TDET pin. In this mode, the tone direction control bit, TDIR, directly controls the output of the DRC pin.

6.8. On-Chip LNB DC-DC Step-Up Controller (Si2108/10 Only)

In addition to the LNB signaling controller present on all device versions, Si2108 and Si2110 devices contain an internal supply controller circuit. This internal dc-dc controller can be enabled via register bit LNB_EN. The internal circuit requires the connection of an external circuit with a specified bill-of-materials, and this combination generates the selected LNB voltage with superimposed one-way or two-way LNB signaling communications. Si2108/10 devices include short-circuit protection, overcurrent protection, and a step-up dc-dc controller to implement a low-cost LNB power supply using minimal external components. The required circuit for DiSEqC1.x operation is illustrated in Figure 5 on page 11. A circuit for DiSEqC2.x operation is shown in Figure 6 on page 12.

When the LNB supply circuit is populated, the Si2108/10 detects a connection to ground on the ISEN pin via R10 during reset and configures the LNB pins for dc-dc converter control instead of providing the interfaces to an external LNB supply regulator discussed in the previous section. See Table 17.

Table 17. LNB Pin Configuration

Pin	LNB Supply Circuit	
	Connected	Unconnected
7	VSEN	TDET
10	LNB2	DRC
9	ISEN	NC
8	LNB1	TGEN
12	PWM	DCS

The LNB supply controller is disabled by default. To use the supply, it must be enabled by setting the LNB enable bit, LNB_EN. If the LNB supply circuit is connected, the TFS bit is ignored; the internal LNB supply controller uses its internal oscillator to generate the 22 kHz tone. The TFQ setting can still be used to modify the nominal frequency as explained earlier.

Selection of high or low voltage outputs the corresponding PWM control signal for the boost converter. Since Japan uses a different LNB supply voltage than the rest of the world (R.O.W.), the device can be configured to either generate 13 V/18 V (R.O.W.) or 12 V/15 V (Japan) dc levels via register bit LNBLVL. To compensate for long cable lengths, a 1 V boost can be applied to both levels by setting the COMP bit.

The nominal level of both the low- and high-output voltages can be further fine-tuned using the VLOW and VHIGH registers. Register bit LNBV selects whether to output high or low dc voltage to the LNB. During operation, the voltage level of the line can be monitored via the VMON register.

The maximum current draw of the LNB supply can be set using the IMAX register. The overcurrent threshold of the LNB supply may be set via the ILIM register. If the output current exceeds this value, the external LNB power supply is automatically disabled, and the overcurrent detect bit, OCD, is asserted. The device attempts to restore normal operation after 1 s by supplying power to the line. During the recovery period, overcurrent detection is disabled for the time specified by the OLOT register.

Short circuit protection circuitry operates in conjunction with overcurrent detection to rapidly identify short-circuit conditions. If the output is shorted to ground, the external LNB power supply is automatically disabled, and the short-circuit detect bit, SCD, is asserted. The device attempts to restore normal operation after one second by supplying power to the line. During the recovery period, short-circuit detection is disabled for the time specified by the SLOT register.

The LNB supply circuit is protected from an overvoltage condition by design. In the event that the LNB supply circuit is accidentally connected to a voltage source greater than the intended output voltage, it remains operational. The LNB supply circuit resumes normal operation when the connection to the external voltage source has been removed.

7. I2C Control Interface

The I2C bus interface is provided for configuration and monitoring of all internal registers. The Si2107/08/09/10 supports the 7-bit addressing procedure and is capable of operating at rates up to 400 kbps. Individual data transfers to and from the device are 8-bits. The I2C bus consists of two wires: a serial clock line (SCL) and a serial data line (SDA). The device always operates as a bus slave. Read and write operations are performed in accordance with the I2C-bus specification and the following sequences.

The first byte after the START condition consists of the slave address (SLAVE ADR, 7-bits) of the target device. The slave address is configured during a hard reset by setting the voltage on the ADDR pin. Possible slave addresses and their corresponding ADDR voltages are listed in Table 18.

Table 18. I2C Slave Address Selection

Fixed Address	LSBs	ADDR Voltage (V)
11010	00	$V_{3.3}$ (pullup)
11010	01	2/3 x $V_{3.3}$ ±10%
11010	10	1/3 x $V_{3.3}$ ±10%
11010	11	0 (pulldown)

Four addresses are available, allowing up to four devices to share the same I2C bus. The R/W bit determines the direction of data transfer. During a read operation, data is sent from the device to the bus master. During a write, data is sent from the bus master to the device. The field labeled “DATA (ADR)” must contain the 8-bit address of the target register. The data to be transferred to or from the target register must be placed in the following 8-bit “DATA” field. When the auto-increment feature is enabled, INC_DS, the target register address, is automatically incremented for subsequent data transfers until a STOP condition ends the operation.

Some registers in the device are larger than the 8-bit DATA field permitted by I2C. These registers are split into 8-bit addressable chunks that are uniquely identified by a positional suffix. The suffix L indicates the low-byte; the suffix M indicates the middle-byte (for 24-bit registers only), and the suffix H indicates the high-byte.

To read a multibyte register as a single unit, the low byte must be read first. This forces the device to sample and hold the contents of the remaining bytes until the multibyte read is complete. If a STOP condition occurs before the operation is complete, the buffered data is discarded.

To write a multibyte register as a single unit, the low byte must be written first. All bytes must be transferred to the device before the multibyte value is recorded. If a STOP condition occurs before the operation is complete, the buffered data is discarded.

The slave address consists of a fixed part and a programmable part. The voltage of the ADDR pin is used to set the two least significant bits of the address during device power-up according to the table below. This enables up to four devices to share the same I2C bus.

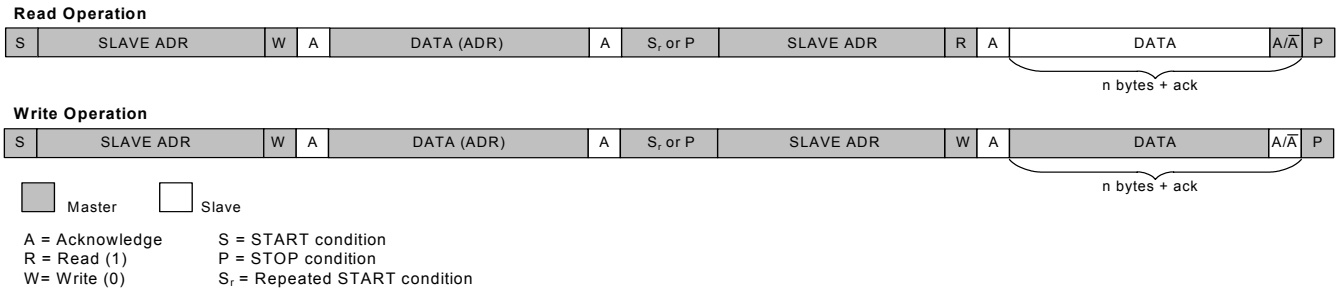


Figure 17. I2C Interface Protocol

8. Control Registers

The control registers can be divided into three main classes: Initialization, Run-time, and Status. Initialization registers (“I”) need only be programmed once following device power-up. Run-time registers (“RT”) are the primary registers for device control. Status registers (“S”) provide device state information. The corresponding category of each register is indicated in the rightmost column of Table 19.

Table 19. Register Summary

Name	I2C Addr.	D7	D6	D5	D4	D3	D2	D1	D0	
System Configuration										
Device ID	00h	DEV[3:0]				REV[3:0]				S
System Mode	01h			INC_DS	MOD[1:0]		SYSM[2:0]			I
TS Ctrl 1	02h	TSEP	TSVP	TSSP	TSSL	TSCM	TSCE	TSDF	TSM	I
TS Ctrl 2	03h			TSPCS	TSCD	TSDD	TSPG	TSSCR[1:0]		I
Pin Ctrl 1	04h	INT_EN	INTT	INTP	TSE_OE	TSV_OE	TSS_OE	TSC_OE	TSD_OE	I
Pin Ctrl 2	05h						GPO	PSEL[1:0]		I
Bypass	06h			DS_BP	RS_BP	DI_BP				I
Interrupts										
Int En 1	07h	RCVL_E	AGCL_E	CEL_E	SRL_E	STL_E	CRL_E	VTL_E	FSL_E	I
Int En 2	08h	RCVU_E	AGCTS_E	STU_E	CRU_E	VTU_E	FSU_E		AQF_E	I
Int En 3	09h	CN_E	VTBER_E	RSER_E	MSGPE_E	FE_E	FF_E	MSGR_E	MSGTD_E	I
Int En 4	0Ah							SCD_E	OCD_E	I
Int Stat 1	0Bh	RCVL_I	AGCL_I	CEL_I	SRL_I	STL_I	CRL_I	VTL_I	FSL_I	S
Int Stat 2	0Ch	RCVU_I	AGCTS_I	STU_I	CRU_I	VTU_I	FSU_I		AQF_I	S
Int Stat 3	0Dh	CN_I	VTBR_I	RSER_I	MSGPE_I	FE_I	FF_I	MSGR_I	MSGTO_I	S
Int Stat 4	0Eh							SCD_I	OCD_I	S
Receiver Status										
Lock Stat 1	0Fh		AGCL	CEL	SRL	STL	CRL	VTL	FSL	S
Lock Stat 2	10h	RCVL								S
Acq Stat	11h	AQF	AGCF	CEF	SRF	STF	CRF	VTF	FSF	S
Tuning Control										
Acq Ctrl 1	14h	AQS								RT
ADC SR	15h	ADCSR[7:0]								RT
Coarse Tune	16h	CTF[7:0]								RT

Table 19. Register Summary (Continued)

Name	I2C Addr.	D7	D6	D5	D4	D3	D2	D1	D0	
Fine Tune L	17h	FTF[7:0]								RT
Fine Tune H	18h		FTF[14:8]							RT
CE Ctrl	29h						CESR[2:0]			I
CE Offset L	36h	CFO[7:0]								RT
CE Offset H	37h	CFO[15:8]								RT
CE Err L	38h	CFER[7:0]								RT
CE Err H	39h	CFER[15:8]								RT
SR Ctrl	3Ah		SRUK							RT
Sym Rate L	3Fh	SR[7:0]								RT
Sym Rate M	40h	SR[15:8]								RT
Sym Rate H	41h	SR[23:16]								RT
SR Max	42h	SRMX[7:0]								RT
SR Min	43h	SRMN[7:0]								RT
CN Ctrl	7Ch	CNS					CNM	CNW[1:0]		I
CN TH	7Dh	CNET[7:0]								I
CN L	7Eh	CNL[7:0]								RT
CN H	7Fh	CNL[15:8]								RT
Channel Decoder										
VT Ctrl 1	A0h			VTCS[5:0]						I
VT Ctrl 2	A2h					VTERS	VTERM	VTERW[1:0]		RT
VT Stat	A3h	VTRS[2:0]						VTPS	VTIQS	S
VT BER Cnt L	ABh	VTBRC[7:0]								RT
VT BER Cnt H	ACh	VTBRC[15:8]								RT
RS Err Ctrl	B0h				RSERS	RSERM	RSERW	RSERT[1:0]		RT
RS Err Cnt L	B1h	RSERC[7:0]								RT
RS Err Cnt H	B2h	RSERC[15:8]								RT
DS Ctrl	B3h							DST_DS	DSO_DS	I
PRBS Ctl	B5h	PRBS_ START	PRBS_ INVERT	PRBS_ SYNC				PRBS_HEADER_SIZE		RT

Table 19. Register Summary (Continued)

Name	I2C Addr.	D7	D6	D5	D4	D3	D2	D1	D0	
Automatic Gain Control										
AGC Ctrl 1	23h			AGCW[1:0]						I
AGC Ctrl 2	24h	AGCTR[3:0]				AGCO[3:0]				I
AGC 1–2 Gain	25h	AGC2[3:0]				AGC1[3:0]				I
AGC 3–4 Gain	26h	AGC4[3:0]				AGC3[3:0]				I
AGC TH	27h		AGCTH[6:0]							I
AGC PL	28h		AGCPWR[6:0]							S
DAGC 1 Ctrl	75h		DAGC1_EN	DAGC1W[1:0]		DAGC1T	DAGC1HOLD	DAGC1HOST		I
DAGC1 L	76h	DAGC1[7:0]								I
DAGC1 H	77h	DAGC1[15:8]								I
DAGC2 Ctrl	78h		DAGC2[3:0]				DAGC2W[1:0]		DAGC2TDIS	I
DAGC2 TH	79h	DAGC2T[7:0]								I
DAGC2Lvl L	7Ah	DAGC2GA[7:0]								I
DAGC2Lvl H	7Bh	DAGC2GA[15:8]								I
LNB Supply Controller										
LNB Ctrl 1	C0h	LNBS	LNBV	LNBCT	LNBB	MMSG	MSGL[2:0]			RT
LNB Ctrl 2	C1h	LNBM[1:0]					BRST_DS	TFS		RT
LNB Ctrl 3	C2h	TDIR	TT	TR						RT
LNB Ctrl 4	C3h	TFQ[7:0]								RT
LNB Stat	C4h	FE	FF	MSGPE	MSGR	MSGTO	MSGRL[2:0]			S
Msg FIFO 1	C5h	FIFO1[7:0]								RT
Msg FIFO 2	C6h	FIFO2[7:0]								RT
Msg FIFO 3	C7h	FIFO3[7:0]								RT
Msg FIFO 4	C8h	FIFO4[7:0]								RT
Msg FIFO 5	C9h	FIFO5[7:0]								RT
Msg FIFO 6	CAh	FIFO6[7:0]								RT
LNB S Ctrl1	CBh	VLOW[3:0]				VHIGH[3:0]				I
LNB S Ctrl2	CCh	ILIM[1:0]		IMAX[1:0]		SLOT[1:0]		OLOT[1:0]		I
LNB S Ctrl3	CDh	VMON[7:0]								S

Table 19. Register Summary (Continued)

Name	I2C Addr.	D7	D6	D5	D4	D3	D2	D1	D0	
LNB S Ctrl4	CEh	LNBL				LNB_EN	COMP	LNBLVL	LNBMD	I
LNB S Stat	CFh							SCD	OCD	S

Register 00h. Device ID Register

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DEV[3:0]				REV[3:0]			

Bit	Name	Function
7:4	DEV[3:0]	**Device ID.** 0h = Si2110 1h = Si2109 2h = Si2108 3h = Si2107
3:0	REV[3:0]	**Revision.** Current revision = 3h

Register 01h. System Mode

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	INC_DS	MOD[1:0]		SYSM[2:0]		

Bit	Name	Function
7:6	Reserved	Program to zero.
5	INC_DS	**I2C Automatic Address Increment Disable.** 0 = Enabled (default) 1 = Disabled
4:3	MOD[1:0]	**Modulation Selection.** 00 = BPSK Demodulation 01 = QPSK Demodulation (default) 10 = Reserved 11 = Reserved
2:0	SYSM[2:0]	**System Mode.** 000 = DVB-S (default) 001 = DSS 010–111 = Reserved

Register 02h. Transport Stream Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	TSEP	TSVP	TSSP	TSSL	TSCM	TSCE	TSDF	TSM

Bit	Name	Function
7	TSEP	**Transport Stream Error Polarity.** 0 = Active high (default) 1 = Active low
6	TSVP	**Transport Stream Valid Polarity.** 0 = Active high (default) 1 = Active low
5	TSSP	**Transport Stream Sync Polarity.** 0 = Active high (default) 1 = Active low
4	TSSL	**Transport Stream Start Length.** 0 = Byte wide (default) 1 = Bit wide **Note:** This bit is ignored in parallel mode.
3	TSCM	**Transport Stream Clock Mode.** 0 = Gapped mode (default) 1 = Continuous mode
2	TSCE	**Transport Stream Clock Edge.** 0 = Data transitions on rising edge (default) 1 = Data transitions on falling edge
1	TSDF	**Transport Stream Serial Data Format.** 0 = MSB first (default) 1 = LSB first **Note:** This bit is ignored in parallel mode
0	TSM	**Transport Stream Mode.** 0 = Serial (default) 1 = Parallel

Register 03h. Transport Stream Control 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0		TSPCS	TSCD	TSDD	TSPG	TSSCR[1:0]	

Bit	Name	Function
7:6	Reserved	Program to zero.
5	TSPCS	**Transport Stream Parallel Clock Smoother.** Smoothens TS_CLK to ~50% duty cycle. 0 = Smoothing disabled 1 = Smoothen clock to ~50% duty cycle (default)
4	TSCD	**Transport Stream Clock Delay.** Adds delay to TS_CLK to adjust clock-data timing relationship. 0 = Normal operation (default) 1 = Delay clock relative to data
3	TSDD	**Transport Stream Data Delay.** Adds delay to TS_DATA, TS_SYNC, TS_VAL, TS_ERR output to adjust clock-data timing relationship. 0 = Normal operation (default) 1 = Delay data relative to clock
2	TSPG	**Transport Stream Parity Gate.** 0 = Normal operation (default) 1 = Zero data lines during parity
1:0	TSSCR[1:0]	**Transport Stream Serial Clock Rate.** 00 = 80–88.5 MHz (default) 01 = 76.8–82.8 MHz 10 = 54.9–59.2 MHz 11 = 35–37.7 MHz

Register 04h. Pin Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	INT_EN	INTT	INTP	TSE_OE	TSV_OE	TSS_OE	TSC_OE	TSD_OE

Bit	Name	Function
7	INT_EN	**Interrupt Pin Enable.** 0 = Disabled (default) 1 = Enabled
6	INTT	**Interrupt Pin Type.** 0 = CMOS (default) 1 = Open drain/source
5	INTP	**Interrupt Polarity.** 0 = Active low (default) 1 = Active high
4	TSE_OE	**Transport Stream Error Output Enable.** 0 = Enabled 1 = Tri-state (default)
3	TSV_OE	**Transport Stream Valid Output Enable.** 0 = Enabled 1 = Tri-state (default)
2	TSS_OE	**Transport Stream Sync Output Enable.** 0 = Enabled 1 = Tri-state (default)
1	TSC_OE	**Transport Stream Clock Output Enable.** 0 = Enabled 1 = Tri-state (default)
0	TSD_OE	**Transport Stream Data Output Enable.** 0 = Enabled 1 = Tri-state (default)

Register 05h. Pin Control 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	1	0	0	GPO	PSEL[1:0]	

Bit	Name	Function
7:3	Reserved	Program to zero (except bit D5, which is programmed to 1).
2	GPO	**General Purpose Output Control.** Controls output of pin 30 when PSEL = 10 0 = Output logic zero. (default) 1 = Output logic 1.
1:0	PSEL[1:0]	**Pin Select (Pin 30).** 00 = Interrupt (default) 01 = Receiver lock indicator 10 = General Purpose Output 11 = Reserved

Register 06h. Bypass

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	DS_BP	RS_BP	DI_BP	0	0	0

Bit	Name	Function
7:6	Reserved	Program to zero.
5	DS_BP	**Descrambler Bypass.** 0 = Normal operation (default) 1 = Bypass **Note:** This bit is ignored in DSS mode; the descrambler is automatically bypassed.
4	RS_BP	**Reed-Solomon Bypass.** 0 = Normal operation (default) 1 = Bypass
3	DI_BP	**Deinterleaver Bypass.** 0 = Normal operation (default) 1 = Bypass
2:0	Reserved	Program to zero.

Register 07h. Interrupt Enable 1

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	RCVL_E	AGCL_E	CEL_E	SRL_E	STL_E	CRL_E	VTL_E	FSL_E

Bit	Name	Function
7	RCVL_E	**Receiver Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
6	AGCL_E	**AGC Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
5	CEL_E	**Carrier Estimator Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
4	SRL_E	**Symbol Rate Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled **Note:** Available on Si2109/10 only.
3	STL_E	**Symbol Timing Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
2	CRL_E	**Carrier Recovery Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
1	VTL_E	**Viterbi Search Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
0	FSL_E	**Frame Sync Lock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled

Register 08h. Interrupt Enable 2

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	RCVU_E	AGCTS_E	STU_E	CRU_E	VTU_E	FSU_E	0	AQF_E

Bit	Name	Function
7	RCVU_E	**Receiver Unlock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
6	AGCTS_E	**AGC Tracking Threshold Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
5	STU_E	**Symbol Timing Unlock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
4	CRU_E	**Carrier Recovery Unlock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
3	VTU_E	**Viterbi Search Unlock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
2	FSU_E	**Frame Sync Unlock Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
1	Reserved	Program to zero.
0	AQF_E	**Acquisition Fail Interrupt Enable.** 0 = Disabled (default) 1 = Enabled

Register 09h. Interrupt Enable 3

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	CN_E	VTBER_E	RSER_E	MSGPE_E	FE_E	FF_E	MSGR_E	MSGTD_E

Bit	Name	Function
7	CN_E	**C/N Estimator Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
6	VTBER_E	**Viterbi BER Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
5	RSER_E	**Reed-Solomon Error Measurement Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
4	MSGPE_E	**LNB Message Parity Error Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
3	FE_E	**LNB Transmit FIFO Empty Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
2	FF_E	**LNB Receive FIFO Full Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
1	MSGR_E	**LNB Receive Message Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
0	MSGTD_E	**LNB Receive Timeout Interrupt Enable.** 0 = Disabled (default) 1 = Enabled

Register 0Ah. Interrupt Enable 4

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	0	0	0	0	SCD_E	OCD_E

Bit	Name	Function
7:2	Reserved	Program to zero.
1	SCD_E	**Short Circuit Detect Interrupt Enable.** 0 = Disabled (default) 1 = Enabled
0	OCD_E	**Over Current Detect Interrupt Enable.** 0 = Disabled (default) 1 = Enabled

Register 0Bh. Interrupt Status 1

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	RCVL_I	AGCL_I	CEL_I	SRL_I	STL_I	CRL_I	VTL_I	FSL_I

Bit	Name	Function
7	RCVL_I	**Receiver Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
6	AGCL_I	**AGC Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
5	CEL_I	**Carrier Estimator Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
4	SRL_I	**Symbol Rate Lock Interrupt.** 0 = Disabled (default) 1 = Enabled **Note:** Available on Si2109/10 only.
3	STL_I	**Symbol Timing Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
2	CRL_I	**Carrier Recovery Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
1	VTL_I	**Viterbi Search Lock Interrupt.** 0 = Disabled (default) 1 = Enabled
0	FSL_I	**Frame Sync Lock Interrupt.** 0 = Disabled (default) 1 = Enabled

Register 0Ch. Interrupt Status 2

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	RCVU_I	AGCTS_I	STU_I	CRU_I	VTU_I	FSU_I	0	AQF_I

Bit	Name	Function
7	RCVU_I	**Receiver Unlock Interrupt.**
6	AGCTS_I	**AGC Tracking Threshold Interrupt.** 0 = Normal operation (default) 1 = Event recorded
5	STU_I	**Symbol Timing Unlock Interrupt.** 0 = Normal operation (default) 1 = Event recorded
4	CRU_I	**Carrier Recovery Unlock Interrupt.** 0 = Normal operation (default) 1 = Event recorded
3	VTU_I	**Viterbi Search Unlock Interrupt.** 0 = Normal operation (default) 1 = Event recorded
2	FSU_I	**Frame Sync Unlock Interrupt.** 0 = Normal operation (default) 1 = Event recorded
1	Reserved	Program to zero.
0	AQF_I	**Acquisition Fail Interrupt.** 0 = Normal operation (default) 1 = Event recorded

Register 0Dh. Interrupt Status 3

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	CN_I	VTBR_I	RSER_I	MSGPE_I	FE_I	FF_I	MSGR_I	MSGTO_I

Bit	Name	Function
7	CN_I	**C/N Estimator Interrupt.** 0 = Normal operation (default) 1 = Event recorded
6	VTBR_I	**Viterbi BER Interrupt.** 0 = Normal operation (default) 1 = Event recorded
5	RSER_I	**Reed-Solomon Error Measurement Complete Interrupt.** 0 = Normal operation (default) 1 = Event recorded
4	MSGPE_I	**LNB Message Parity Error Interrupt.** 0 = Normal operation (default) 1 = Event recorded
3	FE_I	**LNB Transmit FIFO Empty Interrupt.** 0 = Normal operation (default) 1 = Event recorded
2	FF_I	**LNB Receive FIFO Full Interrupt.** 0 = Normal operation (default) 1 = Event recorded
1	MSGR_I	**LNB Receive Message Interrupt.** 0 = Normal operation (default) 1 = Event recorded
0	MSGTO_I	**LNB Receive Timeout Interrupt.** 0 = Normal operation (default) 1 = Event recorded

Register 0Eh. Interrupt Status 4

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	0	0	0	0	SCD_I	OCD_I

Bit	Name	Function
7:2	Reserved	Program to zero.
1	SCD_I	**Short Circuit Detect Interrupt.** 0 = Normal operation (default) 1 = Event recorded
0	OCD_I	**Over Current Detect Interrupt.** 0 = Normal operation (default) 1 = Event recorded

Register 0Fh. Lock Status 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	AGCL	CEL	SRL	STL	CRL	VTL	FSL

Bit	Name	Function
7	Reserved	Program to zero.
6	AGCL	**AGC Lock Status.** 0 = Pending (default) 1 = Complete
5	CEL	**Carrier Estimation Status.** 0 = Pending (default) 1 = Complete
4	SRL	**Symbol Rate Estimation Status.** 0 = Pending (default) 1 = Complete **Note:** Available on Si2109/10 only.
3	STL	**Symbol Timing Lock Status.** 0 = Unlocked (default) 1 = Locked
2	CRL	**Carrier Lock Status.** 0 = Unlocked (default) 1 = Locked
1	VTL	**Viterbi Lock Status.** 0 = Unlocked (default) 1 = Locked
0	FSL	**Frame Sync Lock Status.** 0 = Unlocked (default) 1 = Locked

Register 10h. Lock Status 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	RCVL	0	0	0	0	0	0	0

Bit	Name	Function
7	RCVL	**Receiver Lock Status.** 0 = Unlocked (default) 1 = Locked
6:0	Reserved	Program to zero.

Register 11h. Acquisition Status

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	AQF	AGCF	CEF	SRF	STF	CRF	VTF	FSF

Bit	Name	Function
7	AQF	**Receiver Acquisition Status.** 0 = Normal operation (default) 1 = Acquisition failed
6	AGCF	**AGC Search Status.** 0 = Normal operation (default) 1 = Gain control limit reached
5	CEF	**Carrier Estimation Search Status.** 0 = Normal operation (default) 1 = Carrier offset not found
4	SRF	**Symbol Rate Search Status.** 0 = Normal operation (default) 1 = Search failed **Note:** Available on Si2109/10 only.
3	STF	**Symbol Timing Search Status.** 0 = Normal operation (default) 1 = Search failed
2	CRF	**Carrier Search Status.** 0 = Normal operation (default) 1 = Search failed
1	VTF	**Viterbi Search Status.** 0 = Normal operation (default) 1 = Search failed
0	FSF	**Frame Sync Search Status.** 0 = Normal operation (default) 1 = Search failed

Register 14h. Acquisition Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	AQS	0	0	0	0	0	0	0

Bit	Name	Function
7	AQS	**Automatic Acquisition Start.** Writing a one to this bit initiates the acquisition sequence. This bit is automatically cleared when the acquisition sequence completes.
6:0	Reserved	Program to zero.

Register 15h. ADC Sampling Rate

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	ADCSR[7:0]							

Bit	Name	Function
7:0	ADCSR[7:0]	**ADC Sampling Rate.** f_s = ADCSR x 1 MHz Default: C8h (200 MHz)

Register 16h. Coarse Tune Frequency

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CTF[7:0]							

Bit	Name	Function
7:0	CTF[7:0]	**Coarse Tune Frequency.** Calculation of the coarse tune value is determined by the reference software driver. f_{coarse} = CTF x 10 MHz Default: 00h

Register 17h. Fine Tune Frequency L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	FTF[7:0]							

Bit	Name	Function
7:0	FTF[7:0]	**Fine Tune Frequency (Low Byte).** $f_{fine} = FTF \times \frac{f_s}{2^{14}}$ where FTF is stored as a 2s complement value. Calculation of the fine tune value is determined by the reference software driver. Default: 00h

Register 18h. Fine Tune Frequency H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	FTF[14:8]						

Bit	Name	Function
7	Reserved	Program to zero.
6:0	FTF[14:8]	**Fine Tune Frequency (High Byte).** See Register 17h.

Register 23h. Analog AGC Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	AGCW[1:0]		0	0	0	0

Bit	Name	Function
7:6	Reserved	Program to zero.
5:4	AGCW[1:0]	**AGC Measurement Window.** **Acquisition** / **Tracking** 00 = 1024 (default) / 65536 samples (default) 01 = 2048 / 131072 samples 10 = 4096 / 262144 samples 11 = 8192 / 524288 samples
3:0	Reserved	Program to zero.

Register 24h. AGC Control 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	AGCTR[3:0]				AGCO[3:0]			

Bit	Name	Function
7:4	AGCTR[3:0]	**AGC Tracking Threshold.** Specifies the maximum difference between AGCPWR (28h) and AGCTH (27h) before making a gain adjustment. Default: 1000.
3:0	AGCO[3:0]	**AGC Gain Offset.** Applies a static gain offset to the input channel. 0000 = +0 dB (default) 0001 = +1 dB … 1110 = +14 dB 1111 = +15 dB

Register 25h. Analog AGC 1–2 Gain

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	AGC2[3:0]				AGC1[3:0]			

Bit	Name	Function
7:4	AGC2[3:0]	**Analog Gain stage 2 setting.** Default: 0h
3:0	AGC1[3:0]	**Analog Gain stage 1 setting.** Default: 0h

Register 26h. Analog AGC 3–4 Gain

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	AGC4[3:0]				AGC3[3:0]			

Bit	Name	Function
7:4	AGC4[3:0]	**Analog Gain stage 4 setting** Default: 0h
3:0	AGC3[3:0]	**Analog Gain stage 3 setting** Default: 0h

Register 27h. AGC Threshold

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	AGCTH[6:0]						

Bit	Name	Function
7	Reserved	Program to zero.
6:0	AGCTH[6:0]	**AGC Threshold.** The value specified in this register corresponds to the desired AGC power level. The AGC loop adjusts the gain of the system to drive the AGC power level to this value. Default: 20h.

Register 28h. AGC Power Level

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	AGCPWR[6:0]						

Bit	Name	Function
7	Reserved	Program to zero.
6:0	AGCPWR[6:0]	**AGC Power Level.** Represents the measured input power level after the ADC in rms format. The measurement window is set by AGCW (23h[6:4]). This register saturates at full scale. Default: 00h.

Register 29h. Carrier Estimation Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	0	0	1	CESR[2:0]		

Bit	Name	Function
7:4	Reserved	Program to zero.
3	Reserved	Program to one.
2:0	CESR[2:0]	**Carrier Estimation Search Range.** 000 = Reserved 001 = ± f_s / 32 (± 6.3 MHz typ.) (default) 010 = ± f_s / 64 (± 3.1 MHz typ.) 011 = ± f_s / 128 (± 1.6 MHz typ.) 100 = ± f_s / 256 (± 0.8 MHz typ.) 101 = ± f_s / 512 (± 0.4 MHz typ.) 110 = ± f_s / 1024 (± 0.2 MHz typ.) 111 = ± f_s / 2048 (± 0.1 MHz typ.)

Register 36h. Carrier Estimator Offset L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CFO[7:0]							

Bit	Name	Function
7:0	CFO[7:0]	**Carrier Frequency Offset (Low Byte).** Designed to store a residual carrier frequency offset for future acquisitions. Used during carrier offset estimation to adjust the center frequency. $\text{Search center frequency} = f_{desired} + CFO \times \frac{f_s}{2^{15}}\ \text{Hz}$ **Note:** CFO is a 16-bit Twos complement number. Default: 00h

Register 37h. Carrier Estimator Offset H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CFO[15:8]							

Bit	Name	Function
7:0	CFO[15:8]	**Carrier Frequency Offset (High Byte).** See register 36h.

Register 38h. Carrier Frequency Offset Error L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CFER[7:0]							

Bit	Name	Function
7:0	CFER[7:0]	**Carrier Frequency Offset Error (Low Byte).** Stores the carrier frequency offset that is identified during the carrier offset estimation stage. $$\text{Offset} = -\text{CFER} \times \frac{f_s}{2^{15}} \text{ Hz}$$ **Note:** CFER is a 16-bit Twos complement number. Default: 00h

Register 39h. Carrier Frequency Offset Error H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CFER[15:8]							

Bit	Name	Function
7:0	CFER[15:8]	**Carrier Frequency Offset Error (High Byte).** See register 38h.

Register 3Ah. Symbol Rate Control (Si2109 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	SRUK	0	0	0	0	0	0

Bit	Name	Function
7	Reserved	Program to zero.
6	SRUK	**Symbol Rate Unknown.** 0 = Symbol rate is known. (default) 1 = Symbol rate is unknown.
5:0	Reserved	Program to zero.

Register 3Fh. Symbol Rate L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	SR[7:0]							

Bit	Name	Function
7:0	SR[7:0]	**Symbol Rate (Low Byte).** $\text{Symbol rate} = SR \times \frac{f_s}{2^{24}}\ \text{Hz}$ Default: 00h.

Register 40h. Symbol Rate M

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	SR[15:8]							

Bit	Name	Function
7:0	SR[15:8]	**Symbol Rate (Mid Byte).** See register 3Fh.

Register 41h. Symbol Rate H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	SR[23:16]							

Bit	Name	Function
7:0	SR[23:16]	**Symbol Rate (High Byte).** See register 3F.

Register 42h. Symbol Rate Maximum (Si2109 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	SRMX[7:0]							

Bit	Name	Function
7:0	SRMX[7:0]	**Symbol Rate Estimation Maximum.** $\text{Max symbol rate} = \text{SRMX} \times \frac{f_s}{2^{16}} \text{Hz}$ Default: 00h.

Register 43h. Symbol Rate Minimum (Si2109 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	SRMN[7:0]							

Bit	Name	Function
7:0	SRMN[7:0]	**Symbol Rate Estimation Minimum.** $\text{Min symbol rate} = \text{SRMN} \times \frac{f_s}{2^{16}} \text{Hz}$ Default: 00h.

Register 75h. Digital AGC 1 Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	DAGC1_EN	DAGC1W[1:0]		DAGC1T	DAGC1HOLD	DAGC1HOST	0

Bit	Name	Function
7	Reserved	Program to 0 (device may change the value of this bit during operation)
6	DAGC1_EN	**Enable digital AGC 1** 0 = Disabled 1 = Enabled (default)
5:4	DAGC1W[1:0]	**Digital AGC Measurement Window** 00 = 256 samples 01 = 512 samples 10 = 1024 samples (default) 11 = 2048 samples
3	DAGC1T	**Select AGC threshold** 0 = –15 dBFS (default) 1 = –9 dBFS
2	DAGC1HOLD	**Hold previous computed gain value on DAGC1** 0 = Update gain after each calculation (default) 1 = Do not update gain value
1	DAGC1HOST	**Host-controlled DAGC1** 0 = Gain is determined by DAGC1 module. Digital AGC1 gain register is read-only. (Default) 1 = Gain is determined by host and specified in Digital AGC1 Gain Register (76h & 77h).
0	Reserved	Program to 0.

Register 76h. Digital AGC 1 Gain L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DAGC1[7:0]							

Bit	Name	Function
7:0	DAGC1[7:0]	**Gain of digital AGC 1 (low-byte).** Default: 00h

Register 77h. Digital AGC 1 Gain H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DAGC1[15:8]							

Bit	Name	Function
7:0	DAGC1[15:8]	**Gain of digital AGC 1 (high-byte).** Default: 00h

Register 78h. Digital AGC 2 Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	Reserved	DAGC2[3:0]				DAGC2W[1:0]		DAGC2TDIS

Bit	Name	Function
7	Reserved	Program to 0 (device may change the value of this bit during operation)
6:3	DAGC2[3:0]	**Digital AGC2 gain factor** Default: 0h
2:1	DAGC2W[1:0]	**Digital AGC2 Measurement window** **Acquisition** **Tracking** 00 = 16 samples (default) 1024 samples (default) 01 = 32 samples 2048 samples 10 = 64 samples 4096 samples 11 = 128 samples 8192 samples
0	DAGC2TDIS	**Digital AGC2 Automatic Tracking Disable** 1 = Disable automatic tracking. Freeze applied to gain. 0 = Enable automatic tracking. (default)

Register 79h. Digital AGC 2 Threshold

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DAGC2T[7:0]							

Bit	Name	Function
7:0	DAGC2T[7:0]	**Digital AGC2 Threshold** Default: B5h

Register 7Ah. Digital AGC 2 Level L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DAGC2GA[7:0]							

Bit	Name	Function
7:0	DAGC2GA[7:0]	**Digital AGC2 Gain Auto (low byte).** Digital AGC2 gain applied to meet threshold Default: 00h

Register 7Bh. Digital AGC 2 Level H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	DAGC2GA[15:8]							

Bit	Name	Function
7:0	DAGC2GA[15:8]	**Digital AGC2 Gain Auto (high byte).** See register 7Ah. Default: 00h

Register 7Ch. C/N Estimator Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CNS	0	0	0	0	CNM	CNW[1:0]	

Bit	Name	Function
7	CNS	**C/N Estimator Start.** Writing a one to this bit initiates an C/N estimator and clears the result stored in CNE_LEVEL. This bit is automatically cleared to zero when the measurement period elapses.
6:3	Reserved	Program to zero.
2	CNM	**C/N Estimator Mode.** 0 = Finite window 1 = Infinite window (default)
1:0	CNW[1:0]	**C/N Measurement Window.** 00 = 1024 samples 01 = 4096 samples (default) 10 = 16384 samples 11 = 65536 samples

Register 7Dh. C/N Estimator Threshold0

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CNET[7:0]							

Bit	Name	Function
7:0	CNET[7:0]	**C/N Estimator Threshold.** This value defines a noise threshold for the C/N estimator. Default 13h.

Register 7Eh. C/N Estimator Level L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CNL[7:0]							

Bit	Name	Function
7:0	CNL[7:0]	**C/N Estimator Level (Low Byte).** The value in this register is to be used with an external lookup table to estimate the C/N of the input signal. Default: 00h.

Register 7Fh. C/N Estimator Level H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	CNL[15:8]							

Bit	Name	Function
7:0	CNL[15:8]	**C/N Estimator Level (High Byte).** See Register 7Eh.

Register A0h. Viterbi Search Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	VTCS[5:0]					

Bit	Name	Function
7:6	Reserved	Program to zero.
5:0	VTCS[5:0]	**Viterbi Code Rate Search Parameter Enable.** The code rates to be used in the Viterbi search are selected by writing a one into the appropriate bit position. The list below illustrates the relationship between bit position and code rate. Bit 5 = 7/8 code rate (MSB) Bit 4 = 6/7 code rate Bit 3 = 5/6 code rate Bit 2 = 3/4 code rate Bit 1 = 2/3 code rate Bit 0 = 1/2 code rate (LSB) Default: All code rates selected (3Fh).

Register A2h. Viterbi Search Control 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	Reserved				VTERS	VTERM	VTERW[1:0]	

Bit	Name	Function
3	VTERS	**Viterbi BER Measurement Start** Writing a 1 to this bit initiates the Viterbi BER measurement.
2	VTERM	**Viterbi BER Measurement Mode** 0 = finite window (default) 1 = infinite window
1:0	VTERW[1:0]	**Viterbi BER Measurement Window** 00 = 2^{13} bits (default) 01 = 2^{17} bits 10 = 2^{21} bits 11 = 2^{25} bits

Register A3h. Viterbi Search Status

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	VTRS[2:0]			Reserved			VTPS	VTIQS

Bit	Name	Function
7:5	VTRS[2:0]	**Viterbi Current Code Rate Indicator.** 000 = 1/2 code rate (default) 001 = 2/3 code rate 010 = 3/4 code rate 011 = 5/6 code rate 100 = 6/7 code rate 101 = 7/8 code rate 11x = Undefined
4:2	Reserved	Program to 0.
1	VTPS	**Viterbi Constellation Rotation Phase Status.** 0 = Not rotated (default) 1 = Rotated by 90 degrees
0	VTIQS	**Viterbi I/Q Swap Status.** 0 = Not swapped (default) 1 = Swapped

Register ABh. Viterbi BER Count L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	VTBRC[7:0]							

Bit	Name	Function
7:0	VTBRC[7:0]	**Viterbi BER Counter (Low Byte).** Stores the number of the Viterbi bit errors detected within the specified measurement window. This register saturates when it reaches the limit of its range. Default: 00h

Register ACh. Viterbi BER Count H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	VTBRC[15:8]							

Bit	Name	Function
7:0	VTBRC[15:8]	**Viterbi BER Counter (High Byte).** See Register ABh.

Register B0h. Reed-Solomon BER Error Monitor Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	Reserved			RSERS	RSERM	RSERW	RSERT[1:0]	

Bit	Name	Function
7:5	Reserved	Program to zero.
4	RSERS	**Reed-Solomon BER Measurement Start.** Writing a 1 to this bit initiates the Reed-Solomon BER measurement.
3	RSERM	**Reed-Solomon Measurement Mode.** 0 = Finite window (default) 1 = Infinite window
2	RSERW	**Reed-Solomon Measurement Window.** 0 = 2^{12} frames (default) 1 = 2^{16} frames
1:0	RSERT[1:0]	**Reed-Solomon Error Type.** 00 = Corrected bit errors (default) 01 = Corrected byte errors 10 = Uncorrected packets 11 = PRBS errors

Register B1h. Reed-Solomon Error Monitor Count L

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	RSERC[7:0]							

Bit	Name	Function
7:0	RSERC[7:0]	**Reed-Solomon Error Counter (Low Byte).** Stores the number of RS or PRBS errors detected within the specified window. This register saturates when it reaches the limit of its range. Default: 00h

Register B2h. Reed-Solomon Error Monitor Count H

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	RSERC[15:8]							

Bit	Name	Function
7:0	RSERC[15:8]	**Reed-Solomon Error Counter (High Byte).** See Register B1h.

Register B3h. Descrambler Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	0	0	0	0	DST_DS	DSO_DS

Bit	Name	Function
7:2	Reserved	Program to zero.
1	DST_DS	**Descrambler Transport Error Insertion Disable.** 0 = Enabled (default) 1 = Disabled
0	DSO_DS	**Descrambler Inverted SYNC Overwrite Disable.** 0 = Enabled (default) 1 = Disabled

Register B5h. PRBS Control

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	PRBS_START	PRBS_INVERT	PRBS_SYNC	0	0	0	PRBS_HEADER_SIZE	

Bit	Name	Function
7	PRBS_START	Start PRBS synchronization. 1 = Start PRBS synchronization Default = 0
6	PRBS_INVERT	Invert PRBS output. 1 = PRBS inverted. Default = 0
5	PRBS_SYNC	**Synchronization achieved for PRBS test.** 0 = Not synchronized. 1 = Synchronized Default = 0
4:2	Reserved	Read returns zero.
1:0	PRBS_HEADER_SIZE	Packet header size (DVB-S/DSS) 00 = 1/0 (Default) 01 = 2/1 10 = 3/2 11 = 4/3

Register C0h. LNB Control 1

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	LNBS	LNBV	LNBCT	LNBB	MMSG	MSGL[2:0]		

Bit	Name	Function
7	LNBS	**LNB Start.** Writing a 1 to this bit initiates an LNB signaling sequence. This bit is automatically cleared to zero when the sequence is complete. **Note:** Not available in manual LNB mode.
6	LNBV	**LNB DC Voltage Selection.** 0 = 11/13 V (Japan/R.O.W.) (default) 1 = 15/18 V (Japan/R.O.W.) Selection between Japan and R.O.W. LNB supply levels via register LNBLVL(CEh[1]) **Note:** Available on Si2108/10 only.
5	LNBCT	**Continuous Tone Selection.** 0 = Normal operation (default) 1 = Send continuous tone **Note:** Not available in manual LNB mode.
4	LNBB	**Tone Burst Selection.** 0 = Unmodulated tone burst (default) 1 = Modulated tone burst **Note:** For use in automatic LNB mode only. Use a 1-byte DiSEqC message for tone burst implementation in step-by-step LNB mode.
3	MMSG	**More Messages.** 0 = Normal operation (default) 1 = Indicates more DiSEqC messages to be sent This bit is automatically cleared to zero when the sequence is complete. **Note:** For use in automatic LNB mode only.
2:0	MSGL[2:0]	**Message Length.** 000 = No message (default) 001 = One byte 010 = Two bytes 011 = Three bytes 100 = Four bytes 101 = Five bytes 110 = Six bytes 111 = Longer than six bytes. **Notes:** **1.** When message length is set to one byte, tone burst modulation is used. When message length is set to two or more bytes, DiSEqC modulation is used. **2.** Not available in manual LNB mode.

Register C1h. LNB Control 2

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	LNBM[1:0]		0	0	0	BRST_DS	TFS	0

Bit	Name	Function
7:6	LNBM[1:0]	**LNB Signaling Mode.** 00 = Automatic (default) 01 = Step-by-step 10 = Manual 11 = Reserved
5:3	Reserved	Program to zero.
2	BRST_DS	**Tone Burst Disable.** 0 = Enabled (default) 1 = Disabled **Note:** For use in automatic LNB mode only, in conjunction with LNBB (C0h[4])
1	TFS	**Tone Format Select.** 0 = Tone generation/detection (default) 1 = Envelope generation/detection
0	Reserved	Program to zero.

Register C2h. LNB Control 3

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	TDIR	TT	TR	0	0	0	0	0

Bit	Name	Function
7	TDIR	**Tone Direction Control.** Controls output of DRC pin. 0 = Low (logic zero) (default) 1 = High (logic one) **Note:** This bit is only active in manual LNB mode.
6	TT	**Tone Transmit.** Controls output of TGEN pin. 0 = Tone off / Low (logic zero) (default) 1 = Tone on / High (logic one) **Note:** This bit is only active in manual LNB mode.
5	TR	**Tone Receive.** Detects input on TDET pin. 0 = No tone or low signal detected (default) 1 = Tone or high signal detected **Note:** This bit is only active in manual LNB mode.
4:0	Reserved	Program to zero.

Register C3h. LNB Control 4

Bit	D7	D6	D5	D4	D3	D2	D1	D1
Name	TFQ[7:0]							

Bit	Name	Function
7	TFQ[7:0]	**LNB Tone Frequency Control.** Used to set the frequency of the LNB tone according to the following equation: Frequency = 100 MHz/[32 x (TFQ+1)] 00000000–01111011 = Reserved 01111100–10011011 = valid range 10011100–11111111 = Reserved Default: 8Dh = 22 kHz

Register C4h. LNB Status

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	FE	FF	MSGPE	MSGR	MSGTO	MSGRL[2:0]		

Bit	Name	Function
7	FE	**Message FIFO Empty**. 0 = Normal operation (default) 1 = Message FIFO empty
6	FF	**Message FIFO Full** 0 = Normal operation (default) 1 = Message FIFO full
5	MSGPE	**Message Parity Error** 0 = Normal operation (default) 1 = Parity error detected
4	MSGR	**Message Received** 0 = Normal operation (default) 1 = Message received
3	MSGTO	**Message Timeout** 0 = Normal operation (default) 1 = Message reply not received within 150 ms
2:0	MSGRL[2:0]	**Received Message Length** 000 = No message (default) 001 = One byte 010 = Two bytes 011 = Three bytes 100 = Four bytes 101 = Five bytes 110 = Six bytes 111 = Longer than six bytes

Register C5-CAh. Message FIFO 1–6

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	FIF0x[7:0]							

Bit	Name	Function
7:0	FIFO1–6[7:0]	**Message FIFO** Contains message to be transmitted or message received

Register CBh. LNB Supply Control 1 (Si2108 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	VLOW[3:0]				VHIGH[3:0]			

Bit	Name	Function
7:4	VLOW[3:0]	**LNB Supply Low Voltage** Low voltage = Vlow_nom + VLOW[3:0] x 0.0625V + Vboost, where Vlow_nom is determined by the LNBLVL(CEh[1]) register bit, and Vboost is determined by the COMP(CEh[2]) register bit. Default: 8h resulting in low voltage = Vlow_nom + 0.5 V + Vboost.
3:0	VHIGH[3:0]	**LNB Supply High Voltage** High voltage = Vhigh_nom + VHIGH[3:0] x 0.0625V + Vboost, where Vhigh_nom is determined by the LNBLVL(CEh[1]) register bit, and Vboost is determined by the COMP(CEh[2]) register bit. Default: 8h resulting in High voltage = Vhigh_nom + 0.5 V + Vboost.

Register CCh. LNB Supply Control 2 (Si2108 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	ILIM[1:0]		IMAX[1:0]		SLOT[1:0]		OLOT[1:0]	

Bit	Name	Function
7:6	ILIM[1:0]	**Average Current Limit.** 00 = 400 – 550 mA (default) 01 = 500 – 650 mA 10 = 650 – 850 mA 11 = 800 – 1000 mA
5:4	IMAX[1:0]	**Peak Current Limit.** 00 = 1.2 A (default) 01 = 1.6 A 10 = 2.4 A 11 = 3.2 A
3:2	SLOT[1:0]	**Short Circuit Lockout Time.** 00 = 15 µs 01 = 20 µs (default) 10 = 30 µs 11 = 40 µs
1:0	OLOT[1:0]	**Overcurrent Lockout Time.** 00 = 2.5 ms 01 = 3.75 ms 10 = 5.0 ms (default) 11 = 7.5 ms
Note: Register CCh is lockable via LNBL (CEh[7]). When locked, this register is read-only.		

Register CDh. LNB Supply Control 3 (Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	VMON[7:0]							

Bit	Name	Function
7:0	VMON[7:0]	**LNB Voltage Monitor.** LNB output voltage = VMON x 0.0625 + 6 V

Register CEh. LNB Supply Control 4 (Si2108 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	LNBL	Reserved			LNB_EN	COMP	LNBLVL	LNBMD

Bit	Name	Function
7	LNBL	**LNB Supply Lock.** Writing a one to this bit locks the contents of Register CCh. This bit can only be cleared by a device reset.
6:4	Reserved	Program to zero.
3	LNB_EN	**LNB Supply Enable.** 0 = Disabled (default) 1 = Enabled
2	COMP	**LNB Cable Compensation Boost.** 0 = Normal operation (default) 1 = LNB output voltage increased +1 V
1	LNBLVL	**Select LNB supply levels for Japan or R.O.W.** 0 = high voltage levels for R.O.W. i.e. Vhigh_nom = 17.5 V & Vlow_nom = 11.5 V (default) 1 = low voltage levels for Japan i.e. Vhigh_nom = 14.5 V & Vlow_nom = 11.5 V. **Note:** The resulting nominal output voltages are: 12/15 V (Japan) and 13/18 V (R.O.W.) when using the default settings for the VLOW (CBh[7:4]) and VHIGH (CBh[3:0]) register bits.
0	LNBMD	**LNB Mode Detect.** Detected supply mode (read-only) 0 = External LNB supply circuit 1 = Internal LNB supply circuit

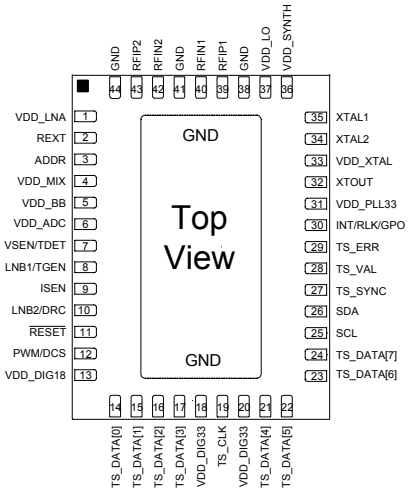
Register CFh. LNB Supply Status (Si2108 and Si2110 only)

Bit	D7	D6	D5	D4	D3	D2	D1	D0
Name	0	0	0	0	0	0	SCD	OCD

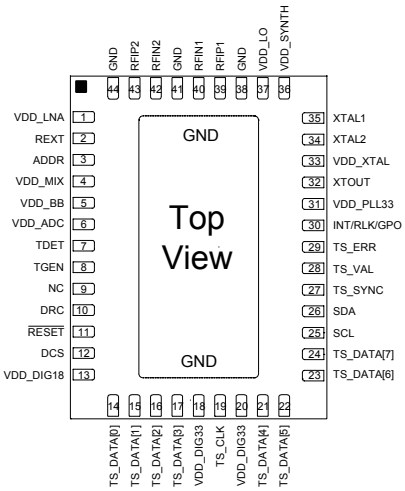
Bit	Name	Function
7:2	Reserved	Program to zero.
1	SCD	**Short-Circuit Detect Flag.** 0 = Normal operation (default) 1 = Short-circuit detected
0	OCD	**Overcurrent Detect Flag.** 0 = Normal operation (default) 1 = Overcurrent detected.

9. Pin Descriptions

Si2108/10



Si2107/09



Pin Number	Name	I/O	Description
1	VDD_LNA	I	**Supply Voltage.** LNA power supply. Connect to 3.3 V.
2	REXT	I/O	**External Reference Resistor.** Connect 4.53 kΩ to GND.
3	ADDR	I/O	**I2C Address Select.**
4	VDD_MIX	I	**Supply Voltage.** Mixer power supply. Connect to 3.3 V
5	VDD_BB	I	**Supply Voltage.** Baseband power supply. Connect to 1.8 V.
6	VDD_ADC	I	**Supply Voltage.** ADC power supply. Connect to 3.3 V.
7	VSEN/TDET	I	**Voltage Sense/Tone Detect.** VSEN (Si2108/10 only)—Line voltage of LNB supply circuit. TDET—Detect input of external tone or tone envelope.
8	LNB1/TGEN	O	**LNB Control 1/Tone Generation.** LNB1 (Si2108/10 only)—Required connection to LNB supply circuit. TGEN—Outputs tone or tone envelope.
9	ISEN	I	**Current Sense (Si2108/10 only).** Monitors current of LNB supply circuit. When LNB supply circuit is not populated or when using Si2107/09, leave pin unconnected.
10	LNB2/DRC	I/O	**LNB Control 2/Direction Control.** LNB2 (Si2108/10 only)—required connection to LNB supply circuit. DRC—Outputs signal to indicate message transmission (HIGH) or reception (LOW).
11	RESET	I	**Device Reset.** Active low.

12	PWM/DCS	O	**PWM/DC Voltage Select.** PWM (Si2108/10 only)—Connected to gate of power MOSFET for LNB supply circuit. DCS—Outputs signal to indicate 18 V (HIGH) or 13 V (LOW) LNB supply voltage selection.
13	VDD_DIG18	I	**Supply voltage.** Digital power supply. Connect to 1.8 V.
14–17, 21–24	TS_DATA[7:0]	O	**Transport Stream Data Bus.** Serial data is output on TS_DATA[0].
18, 20	VDD_DIG33	I	**Supply Voltage.** Digital power supply. Connect to 3.3 V.
19	TS_CLK	O	**Transport Stream Clock.**
25	SCL	I	**I2C Clock.**
26	SDA	I/O	**I2C Data.**
27	TS_SYNC	O	**Transport Stream Sync.**
28	TS_VAL	O	**Transport Stream Valid.**
29	TS_ERR	O	**Transport Stream Error.**
30	INT / RLK / GPO	O	**Multi Purpose Output Pin.** This pin can be configured to one of the following outputs using the Pin Ctrl 2 (05h) register. INT = Interrupt RLK = Receiver lock indicator GPO = General purpose output
31	VDD_PLL33	I	**Supply Voltage.** Analog PLL power supply. Connect to 3.3 V.
32	XTOUT	O	**No Connect/Crystal oscillator output.** If this device is to be used as the clock master in a multi-channel design, this pin should be connect to the XTAL1 pin of a clock slave device. (Otherwise, this pin should be left unconnected.)
33	VDD_XTAL	I	**Supply Voltage.** Crystal Oscillator power supply. Connect to 3.3 V.
34	XTAL2	O	**Crystal Oscillator.** Connect to 20 MHz crystal unit.
35	XTAL1	I	**Crystal Oscillator.** Connect to 20 MHz crystal unit.
36	VDD_SYNTH	I	**Supply Voltage.** Synth power supply. Connect to 3.3 V.
37	VDD_LO	I	**Supply Voltage.** Local Oscillator power supply. Connect to 3.3 V.
38,41,44	GND	I	**Ground.** Reference ground.
39, 43	RFIP1, RFIP2	I	**RF Input.** These pins must be connected together on the board.
40, 42	RFIN1, RFIN2	I	**RF Input.** These pins must be connected together on the board.
ePad	GND	I	**Ground.** Reference ground.

10. Ordering Guide[1,2]

Ordering Part #	Description	Temperature
Si2110-X-FM	Satellite receiver for DVB-S/DSS with LNB step-up dc-dc controller and on-chip blindscan accelerator, Lead-free and RoHS Compliant	0 to 70 °C
Si2109-X-FM	Satellite receiver for DVB-S/DSS with on-chip blindscan accelerator, Lead-free and RoHS Compliant	0 to 70 °C
Si2108-X-FM	Satellite receiver for DVB-S/DSS with step-up dc-dc controller, Lead-free and RoHS Compliant	0 to 70 °C
Si2107-X-FM	Satellite receiver for DVB-S/DSS, Lead-free and RoHS Compliant	0 to 70 °C

Notes:
1. "X" denotes product revision.
2. Add an "R" at the end of the device to denote tape and reel option; 2500 quantity per reel.

11. Package Outline: 44-pin QFN

Figure 18 illustrates the package details for the Si2110. Table 20 lists the values for the dimensions shown in the illustration.

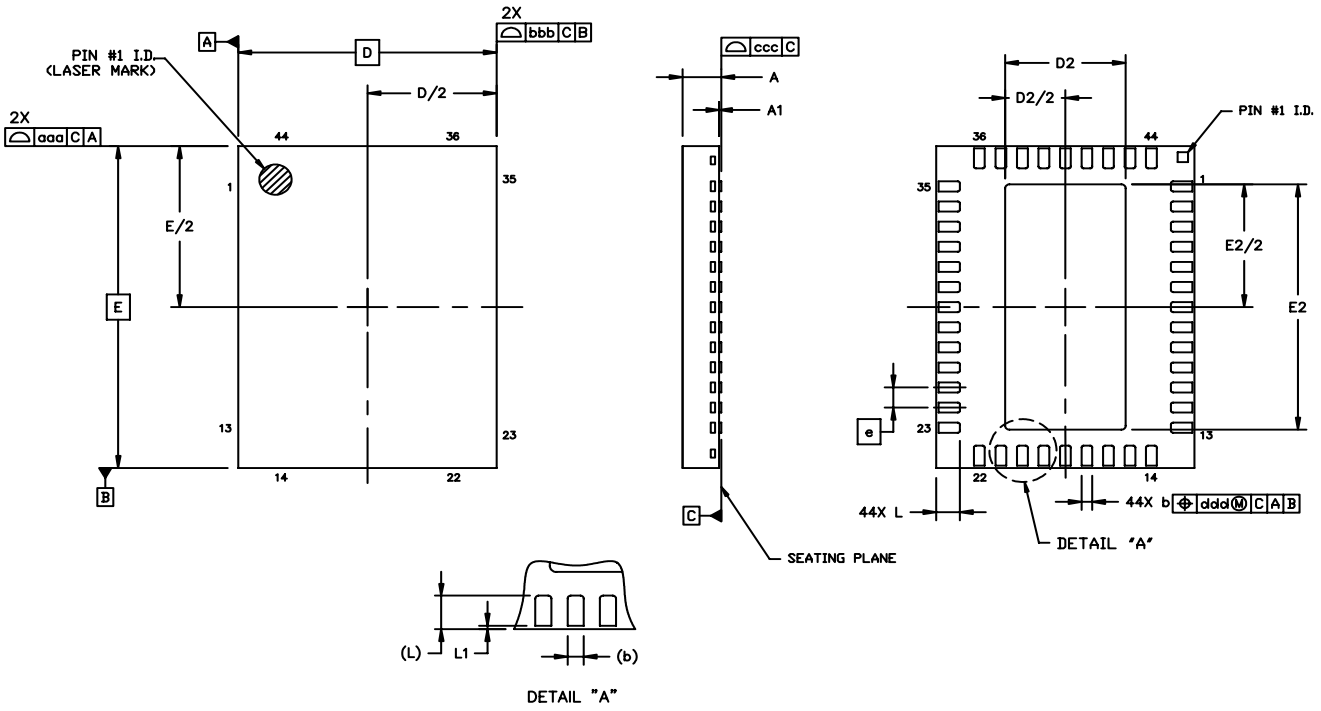


Figure 18. 44-Pin QFN

Table 20. Package Diagram Dimensions

Dimension	Millimeters			Dimension	Millimeters		
	Min	Nom	Max		Min	Nom	Max
A	0.80	0.90	1.00	E2	6.00	6.10	6.20
A1	0.00	0.02	0.05	L	0.45	0.55	0.65
b	0.18	0.25	0.30	L1	0.03	0.05	0.08
D	6.00 BSC.			aaa	0.10		
D2	2.70	2.80	2.90	bbb	0.10		
e	0.50 BSC.			ccc	0.08		
E	8.00 BSC.			ddd	0.10		

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1994.
2. This drawing conforms to the JEDEC Solid State Outline MO-220, Variation VJLD.
3. Recommended card reflow profile is per the JEDEC/IPC J-STD-020C specification for small body Components.
4. The pin 1 I.D. pad is for component orientation only and is not to be soldered to the PCB.

DOCUMENT CHANGE LIST

Revision 0.4 to Revision 0.5

- Package dimensions changed to 6 x 8 mm.
- Updated pin numbering and pin descriptions.
- Schematics updated.
- I2C interface description added.
- MPEG-TS timing specifications added.

Revision 0.5 to revision 0.6

- Data sheet for Si2107/08/09/10.
- Added detailed operational description.
- Register map changed for Rev. C silicon.
  - Various editorial changes and corrections.

Revision 0.6 to revision 0.7

- Updated application diagram and BOM.
- Added table for multi-device I2C address support.

CONTACT INFORMATION

Silicon Laboratories Inc.

4635 Boston Lane
Austin, TX 78735
Tel: 1+(512) 416-8500
Fax: 1+(512) 416-9669
Toll Free: 1+(877) 444-3032

Email: DBSinfo@silabs.com
Internet: www.silabs.com