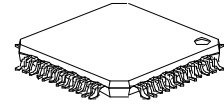


## INTRODUCTION

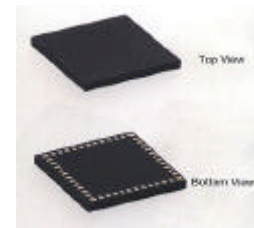
S1M8656A/8657 are CDMA/AMPS Dual Mode IF/ baseband IC which is divided into three main parts - IF frequency processing, baseband processing, and digital interface. The receiver IC (S1M8656A) and transmitter IC (S1M8657) are provided as a KIT.

S1M8656A is a receiver IC, installed with a Rx AGC, Baseband Converter, Baseband analog filter, and A-D Converter. It can send a digital baseband signal to the digital baseband IC. The S1M8657X01 is a transmission-only IC, installed with a Tx AGC, IF frequency converter, analog filter, D-A Converter, PLL, 8-bit A-D Converter for the system monitor, and 3-input analog switch. It connects the digital baseband IC to the RF processing. Designed to operate in direction connection with the MSM, S1M8656A and S1M8657 are fabricated on the Samsung's 0.5um high-speed, high-frequency BICMOS processing and can achieve superior high frequency and low power digital operations. Its operating voltage is 2.7V – 3.6V, and operating temperature -30°C – +85°C.

48-LQFP-0707



48-BCC-7.0x7.0



## FEATURES

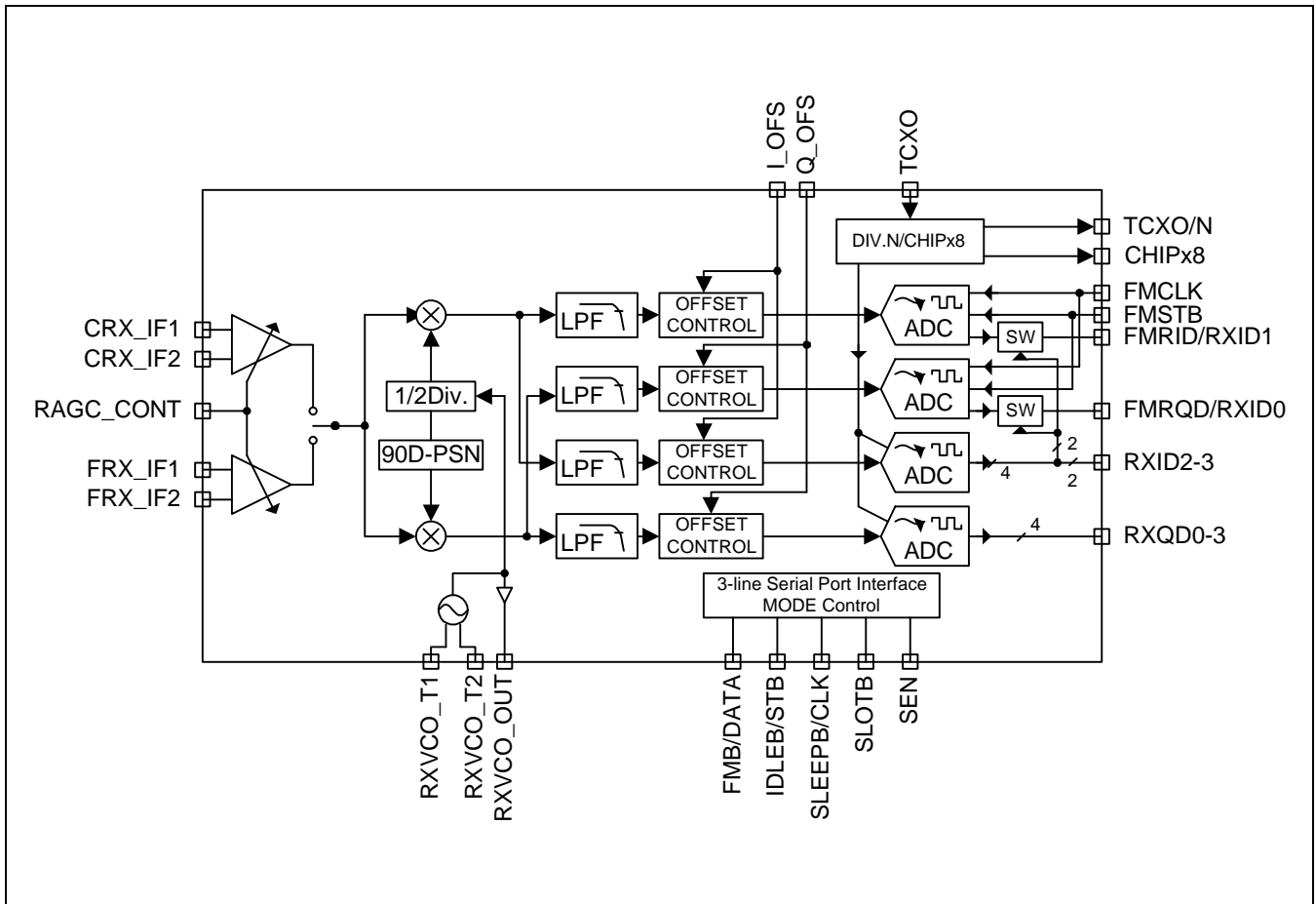
- CDMA/AMPS Dual Mode
- AGC input signal range : 90dB
- QPSK Baseband Converter
- Built-in I, Q Baseband signal extractor LPF
- Built-in 4-bit ADC for converting I and Q CDMA analog baseband signals to digital baseband signals
- Built-in 8-bit ADC for converting I and Q FM analog baseband signals to digital baseband signals
- Adopts the Rx SLOT function to minimize the AMPS Mode consumption power
- Built-in VCO for baseband conversion
- Built-in Modem PDM control circuit to compensate the I and Q offsets
- 3-Line Serial Port Interface (SPI)

## ORDERING INFORMATION

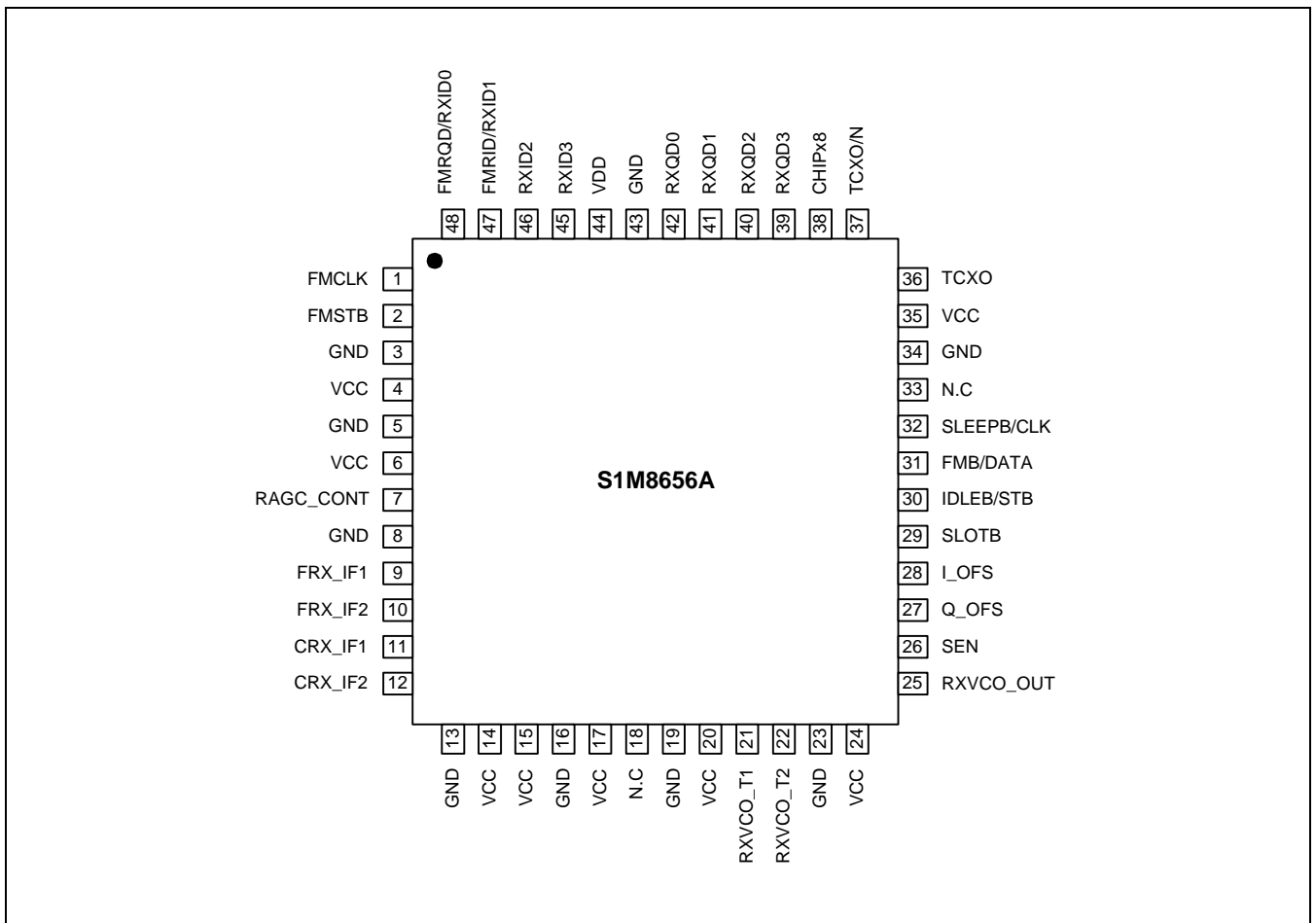
Device	Package	Operating Temperature
+ S1M8656A01-E0T0	48-LQFP-0707	-30 to +85°C
+ S1M8656A01-F0T0	48-BCC-7.0x7.0	

+ : New product

**BLOCK DIAGRAM**



**PIN CONFIGURATION**



## PIN DESCRIPTION

Pin No	Symbol	I/O	Description
1	FMCLK	SEN	FM ADC clock input ,received from the modem. Signal frequency is 360kHz; if unconnected, it becomes LOW.
2	FMSTB	DI	FM STROBE input. Signal that controls the FM ADC initialization and A-D conversion start. CLOCK frequency is 40kHz, which is received from the MODEM; if unconnected, it remains at LOW.
7	RAGC_CONT	AI	AGC gain control input. The input voltage is allowed up to $V_{DD}$ . It remains at High impedance during SLEEP.
9 10	FRX_IF1 FRX_IF2	AI	FM IF input terminals, which have an input impedance of about 865 $\Omega$ ; generally, the FM IF SAW filter is connected to them. Usually, the IF SAW output is single-ended. When these terminals are not used, they remain at High impedance.
11 12	CRX_IF1 CRX_IF2	AI	CDMA IF input terminals, which have an input impedance of about 865 $\Omega$ ; generally, the CDMA IF SAW filter is connected to them. Usually, the IF SAW output is differential. When these terminals are not used, they remain at High impedance.
21 22	RXVCO_T1 RXVCO_T2	AI	Very sensitive terminal, which is connected to the oscillation L-C resonance circuit. Their impedance are about 2k $\Omega$
25	RXVCO_OUT	AO	Output for the PLL, able to output about -12dBm. When this is not used, it remains at high impedance.
26	SEN	D	Input that permits/not permits SPI BUS control. If the input is high, SPI control is allowed, and its related 3-pins, STB, DATA, and CLK, perform their functions; if Low, related 3-pins, IDLEB, FMB, and SLEEPB, are allowed to perform parallel control. When this is not used, it remains at Low.
27 28	Q_OFS I_OFS	AI	Control DC input for removing the DC offset generated in the BBA and system during CDMA and AMPS Mode. The control DC is generated in the modem in PDM form, passes through the R-C filter and is converted to DC, which is sent to this input terminal. No pull up/down should be performed at this terminal.
29	SLOTB	DI	This pin becomes Low during CDMA SLEEP Mode or FM RX Mode, the system is assumed to be in the Rx SLOT mode, and all functions are stopped except for the VCO, VCO buffer and TCXO/N. No external clock inputs are not required in this product with this function.
30	IDLEB/STB	DI	When SEN is high, this pin becomes the STROBE input with the permit of the 3-LINE Serial control input. When SEN is low, parallel control input is allowed and this pin executes the IDLEB function. If this pin is opened, it remains at Low.
31	FMB/DATA	BI	When SEN is high, this pin inputs and outputs data with the permit of the 3-line serial control input. When SEN is low, parallel control input is allowed and this pin performs IDLEB. If this pin is opened, it remains at Low.

**PIN DESCRIPTION (Continued)**

Pin No	Symbol	I/O	Description
32	SLEEPB/CLK	DI	When SEN is high, this pin inputs the clock with the permit of the 3-line serial control input. When SEN is low, parallel control input is allowed and this pin performs SLEEPB. If this pin is opened, it remains at Low.
36	TCXO	AI	Reference frequency input terminal connected to the VCTCXO output. When this pin stops, only DC bias is delivered to maintain the DC charge value of the capacitor connected externally.
37	TCXO/N	DO	Division output of the TCXO Reference frequency input. 3-different division ratio and 2- output drive capacities can be selected through the SPI bus control. Default : 4.92MHz, Weak OUT *division ratio : 1, 1/4, 1/16
38	CHIPx8	BI	CHIPx8 CLOCK output terminal. It has a division ratio of 512/1025 for the TCXO reference frequency. Therefore, it cannot have a perfect 50% duty. When this terminal is not used (CDMA SLEEP, FM IDLE), it remains at Low. This pin can be used exclusively for the externally generated CHIPx8 CLOCK input using the SPI BUS control.
39 40 41 42 45 46 47 48	RXQD3 RXQD2 RXQD1 RXQD0 RXID3 RXID2 RXID1/FMRID RXID0/FMRQD	DO	CDMA A-D Converter's digital outputs, which are connected to the modem data input pins. These data are synchronized at CHIPx8's rising edge and output. Because they are valid at the falling edge, the data are latched at the falling edge in the modem. Because the number of 48-pins are restricted in this product, pins 47 and 48 are shared with the FMDATA pin.
4, 6, 14, 15, 17, 20, 24	VCC	AI	Power input terminal for the analog circuit.
35	VDD	DI	Power for the digital logic.
44	VDD	DI	Power source for a logic circuit ,related to the digital input /output, connected to an external digital logic such as the modem.
3, 5, 8, 13, 16, 18, 19, 23, 43	GNDA	AI	Analog circuit ground. Pin-18 is N.C. in the product.
34	GNDD	DI	Digital logic circuit ground.
33	NC	-	This pin is used for internal testing only and is not connected to anything.

**ABSOLUTE MAXIMUM RATINGS**

Characteristic	Symbol	Value
Power supply	$V_{CC}$	-0.5V to 3.6V
Storage temperature	$T_{STG}$	-55°C to +125°C
Operating temperature	$T_{OPR}$	-30°C to +85°C
Storage temperature	HBM	± 1500V
Electrostatic discharge rating	MM	± 200V

**RECOMMENDED OPERATING CONDITIONS**

Characteristic	Symbol	Value
Power supply	$V_{CC}$	2.7V to 3.6V
Ambient operating temperature	$T_a$	-30°C to +85°C

**ELECTRICAL CHARACTERISTICS****ELECTRICAL CHARACTERISTICS ( $V_{CC} = 3.3V$ ,  $T_a = 25^\circ C$ )**

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Units
Current consumption	CDMA idle mode	$I_{CRX}$	-	23	33	mA
Current consumption	CDMA sleep mode	$I_{CSLP}$	-	300	650	uA
Current consumption	FM idle mode	$I_{FRX}$	-	17	26	mA
Current consumption	FM slot mode	$I_{FSLT}$	-	4.5	5.5	mA
Current consumption	Power down	$I_{DWN}$	-	10	100	uA
Logic high input		$V_{IH}$	$V_{DD}-0.4$	-	-	V
Logic low input		$V_{IL}$	-	-	0.4	V
Logic high output		$V_{OH}$	$V_{DD}-0.4$	-	-	V
Logic low output		$V_{OL}$	-	-	0.4	V
Digital input capacitance		$C_{DI}$	-	-	5	pF
Digital output load capacitance		$C_{DOL}$	-	-	5	pF
TCXO input impedance	Attach C = 2pF	$Z_{TCXO}$	5	-	-	kΩ
CDMA IF input resistance	IF differential	$R_{IFINC}$	-	1	-	kΩ
FM IF input resistance	IF single-ended	$R_{IFINF}$	-	850	-	Ω
IF input capacitance	CDMA, FM IF differential	$C_{IFIN}$	-	-	1	pF
VCO input resistance	RX, TX VCO differential	$R_{VCO}$	1.8	2	2.2	kΩ
VCO input capacitance	RX, TX VCO differential	$C_{VCO}$	-	-	1.5	pF

## AC CHARACTERISTICS

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
<b>CDMA Performance</b>						
Input sensitivity	Maximum AGC gain. Control input signal so that output corresponding to 3LSB is output from ADC. The current source impedance is 500Ω and matched by connecting a 1kΩ resistance to the differential input.	VCSEN	-102	-	-	dBm
Maximum input signal	Minimum AGC gain. Control input signal so that output corresponding to 3LSB is output from ADC. The current source impedance is 500Ω and matched by connecting a 1kΩ resistance to the differential input.	VCMAX	-	-	-12	dBm
AGC gain slope	PDM is controlled to 3.3V and finds the differential gain between the control voltage of 1V and 2V.	GSLOPE	33	45	53	dB/V
AGC gain error over temperature	The difference in gain slope between when the temperature is -30°C and +85°C.	GVAR	-3	-	3	dB
IF input frequency range	The IF frequency is increased to find the frequency where the gain falls below -3dB.	Fin	250	-	-	Mhz
Noise figure	Input power = -102dBm	NFmin	-	7	-	dB
	Input power = -75dBm	NFmid	-	20	-	dB
	Input power = -25dBm	NFmax	-	70	-	dB
IIP3	AGC gain Max.	IIP3max	-55	-	-	dBm
	AGC gain Min.	IIP3min	-10	-	-	dBm
Spurious contents	ADC generated harmonic frequency component. Two signals in the in-band are each mixed with signals which will allow ADC to produce -7dB output signals. The harmonic and non-harmonic components of the ADC output signals between 1kHz – 20MHz are extracted and added. The AGC control voltage is controlled so that ADC output is full scale when the input signal is -80dBm.	TSpur	-	-	-25	dBc
Spurious content related to jammer	In-band spurious peak value produced by IMD based on 2 jammer signals. One in-band signal (@50kHz, 0.5*F/S) and two jammers (@900kHz, 22dB*F/S and @1.7MHz, 21dB*F/S) are simultaneously input. AGC control voltage is controlled so that ADC output is F/S when the input signal is -80dBm.	Jspur	-	-	-18.4	dBc

## AC CHARACTERISTICS (Continued)

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
Single-tone jammer desense	Overall gain reduction due to one jammer. The in-band signal at -97dBm (control the AGC control voltage to 0.5*F/S) and the jammer signal at 900kHz and -57dBm are simultaneously input. The gain reduces if the input/output range is small in the BBA.	Jdsen	-	-	1.0	dB
P1dB IF input level	AGC gain. The input signal level showing 1dB difference from its idealistic linear line when the output signal increase, which results from the input exceeding the output and input range, starts to saturate.	P1dB	-19			dBm
Crosstalk FM to CDMA	leakage ratio between CDMA input and FM input.	CTFC	30	-	-	dB
Offset gain slope	Amount of code change of the voltage ADC output at the I/Q offset control	GOFS	-	250	-	%FS/V
Offset adjust input impedance	-	Zoff	100	-	-	k $\Omega$
Out-band attenuation	$\geq 900\text{kHz}$	ATC9	46	-	-	dB
	$\geq 1.2\text{MHz}$	ATC12	48	-	-	dB
I/Q gain mismatch	Gain mismatch between the I and Q signals between 1kHz to 615kHz.	Gmis	-1	-	1	dB
I/Q Phase mismatch	Phase mismatch between the I and Q signals between 1kHz to 615kHz.	Pmis	-10		10	Deg
Gain flatness	Amount of gain change along I and Q paths between 1kHz to 615kHz	Gft	-1		1	dB
<b>FM Performance</b>						
Input sensitivity	Maximum AGC gain. Control input signal so that ADC outputs 0.5*F/S. The current source impedance is 500 $\Omega$ and matched by connecting a 1.2k $\Omega$ resistance to the differential input.	VSEN	-98.3	-	-	dBm
Maximum input signal	Minimum AGC gain. Control input signal so that ADC outputs 0.5*F/S. The current source impedance is 500 $\Omega$ and matched by connecting a 1.2k $\Omega$ resistance to the differential input.	VMAX	-	-	-8.3	dBm
AGC gain slope	PDM is controlled to 3.3V and finds the differential gain between the control voltage of 1V and 2V.	GSLOPE	33	45	53	dB/V
AGC gain error over temperature	The difference in gain slope between when the temperature is -30 $^{\circ}\text{C}$ and +85 $^{\circ}\text{C}$ .	GVAR	-3	-	3	dB

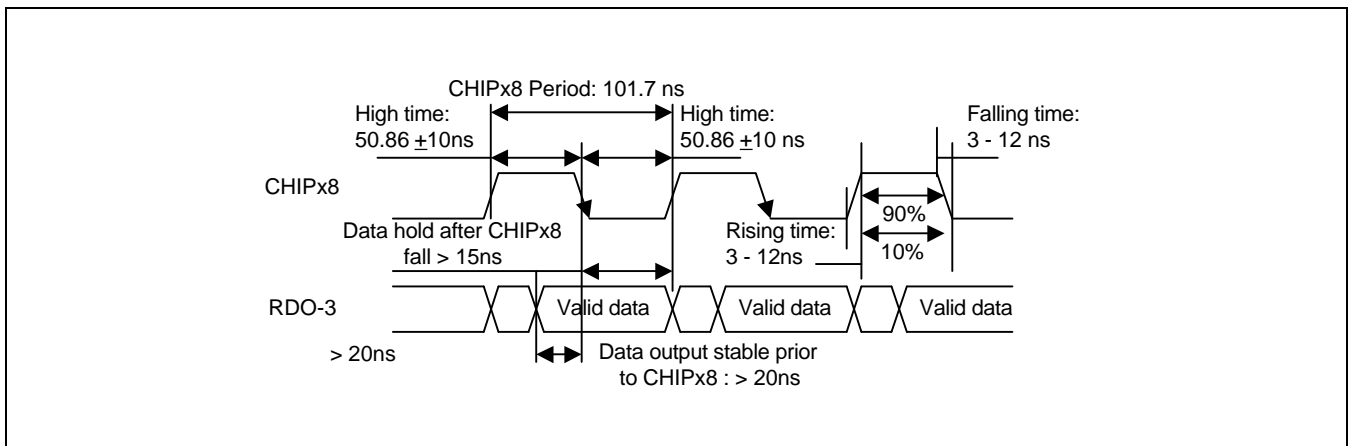
## AC CHARACTERISTICS (Continued)

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
IF input frequency range	The IF frequency is increased to find the frequency where the gain falls below -3dB.	Fin		85.38	150	MHz
Noise figure	Input power = - 98dBm	NFmin	-	7	-	dB
	Input power = - 75dBm	NFmid	-	20	-	dB
	Input power = - 25dBm	NFmax	-	70	-	dB
IIP3	AGC gain Max.	IIP3max	-55	-	-	dBm
	AGC gain Min.	IIP3min	-25	-	-	dBm
Spurious contents	ADC generated harmonic frequency component. ADC generated Two signals in the in-band are each mixed with signals which will allow ADC to produce -7dB output signals. The harmonic and non-harmonic components of the ADC output signals between 1kHz – 20MHz are extracted and added. The AGC control voltage is controlled so that ADC output is full scale when the input signal is - 80dBm.	TSpur	-	-	-42	dBc
Spurious content related to jammer	In-band spurious peak value produced by IMD based on 2 jammer signals. One in-band signal(@1kHz,0.5*F/S) and two jammers(@60kHz, 22dB*F/S and @122kHz, 4dB*F/S)are simultaneously input. AGC control voltage is controlled so that ADC output is F/S when the input signal is -80dBm.	Jspur	-	-	-18.4	dBc
Single-tone jammer desense	Overall gain reduction due to one jammer. The in-band signal at -93dBm (control the AGC control voltage to 0.5*F/S)and the jammer signal at 900kHz and -53dBm are simultaneously input. The gain reduces if the input/output range is small in BBA.	Jdsen	-	-	1.0	dB
Crosstalk CDMA to FM	The leak ratio between the CDMA input and FM input.	CTCF	30	-	-	dB
Offset gain slope	Amount of code change of the voltage ADC output at the I/Q offset control	GOFS		250		%FS/V
Offset adjust input impedance	-	Zoff	100	-	-	kΩ
Out-band attenuation	≥ 45kHz	ATC9	46	-	-	dB
	≥ 60MHz	ATC12	60	-	-	dB
I/Q gain mismatch	Gain mismatch between the I and Q signals between 1kHz to 12kHz.	Gmis	-1		1	dB

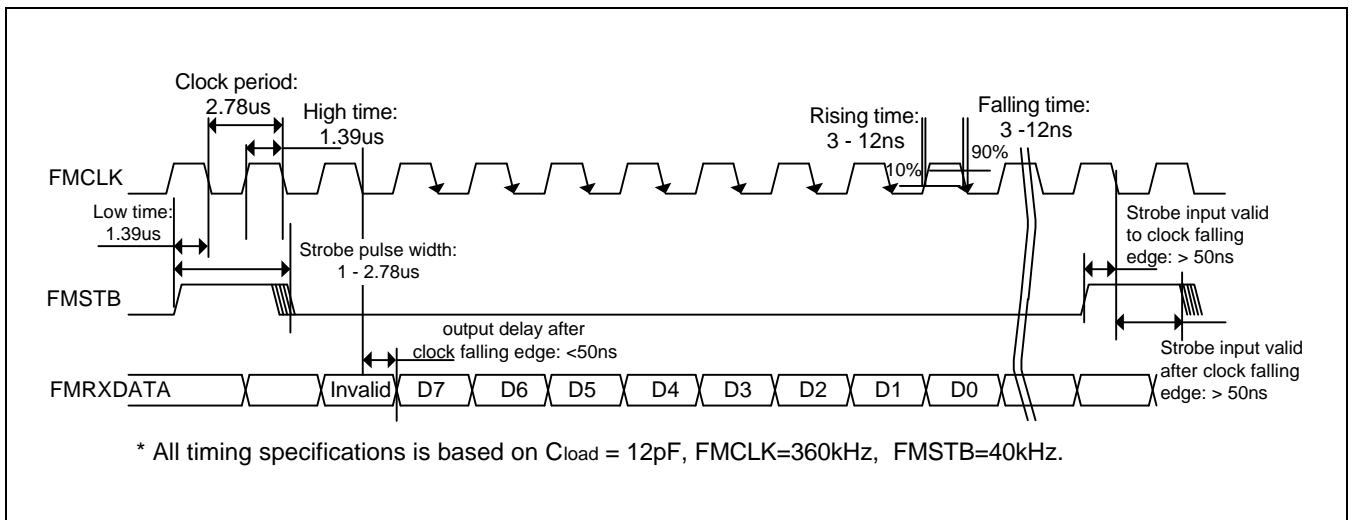
**AC CHARACTERISTICS (Continued)**

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
I/Q Phase mismatch	Phase mismatch between the I and Q signals between 1kHz to 12kHz.	Pmis	-10	-	10	DegGft
Gain flatness	Amount of gain change along I and Q paths between 1kHz to 615kHz	Gft	-1	-	1	db
<b>Receive VCO performance</b>						
VCO and buffered output Frequency range	VCO external time constant and PLL value	Fvco	-	170	500	Mhz
VCO phase noise	Tank LC's Q value should be above 20. Measure @100kHz away from the mid-frequency.	Pvco	-	-	104	dBc/Hz
RXVCO_OUT output power	Select a VCO buffer output value reduced by -2dB. Connect output load to 50Ω.	Ovco	-15	-	-	dBm

**TIMING DIAGRAMS**



**Figure1. CDMA Receive ADC Timing**



**Figure 2. FM Receive ADC Timing**

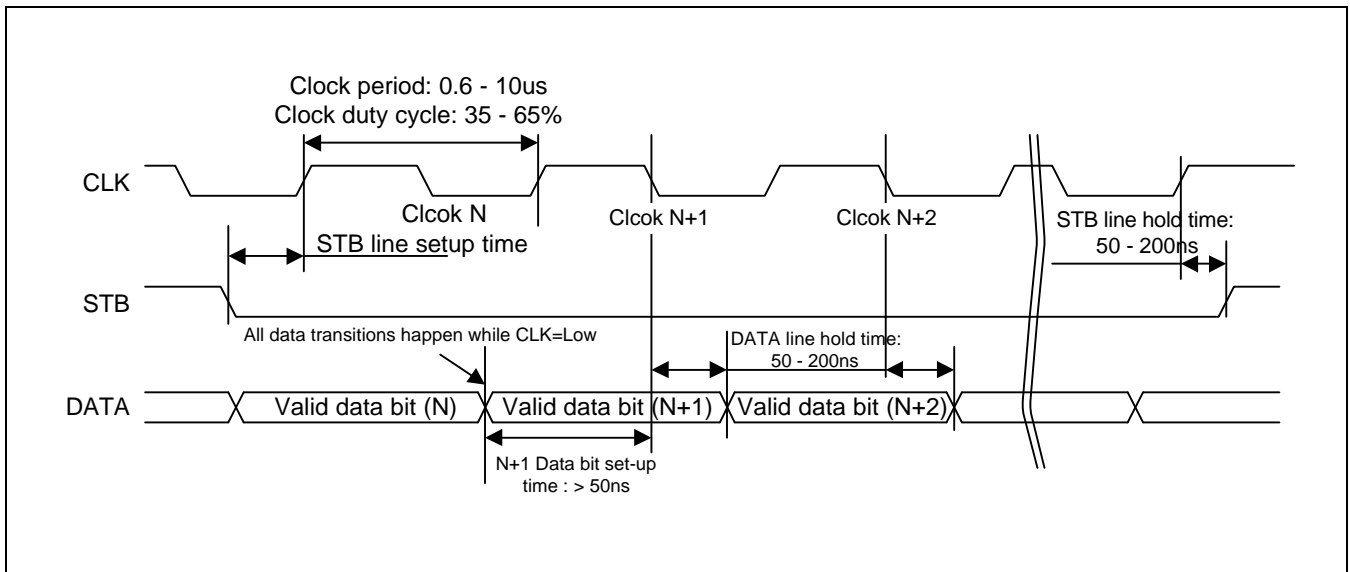


Figure 3. 3-Line Serial Port Interface Timing

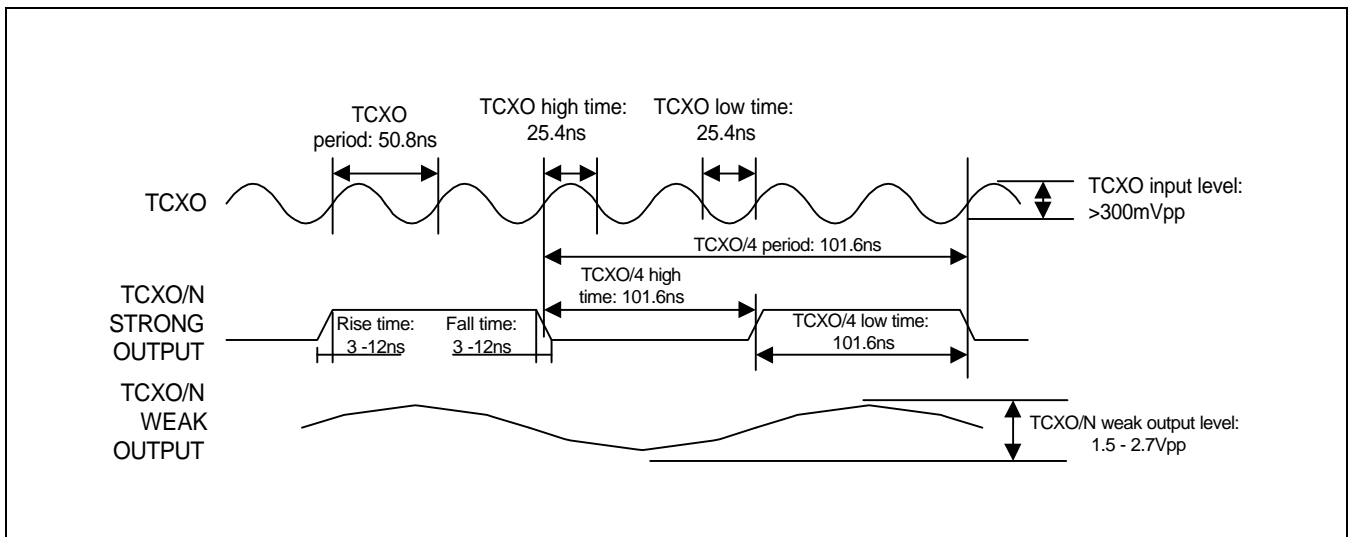


Figure 4. TCXO and TCXO/N Timing

## FUNCTIONAL DESCRIPTION

S1M8656A is a CDMA/AMPS receive-only baseband analog IC, located between the RF mid-frequency processing terminal and baseband processing terminal. The RF analog mid-frequency signal terminal(IF SAW filter output), directly connected to the S1M8656A mid-frequency input pin, converts and processes the baseband signal and sends the corresponding digital signal to the modem IC. Baseband analog processing uses QPSK modulation, LPF, and A-D converter and the modem IC performs digital CDMA/AMPS baseband modulation on the digitalized analog baseband signal it receives.

S1M8656A uses a 0.5um BiCMOS, equipped with high-frequency bipolar and low power standardized CMOS logic, to operate safely in the low power range, consisting of power voltage between 2.7V – 3.6V and operating temperature between -30°C – +85°C.

### CDMA Receive Signal Path

S1M8656A is composed of a receive circuit, installed with TCXO/N, CHIPx8 like clock generator, mode conversion switch and serial I/F apparatus. The receive circuit has the Rx AGC, an automatic gain controller, and baseband LPF and output terminal with the A-D converter, and VCO and mixer etc. The input signal is received as a differential signal, which is modulated to 1.23 MHz spread-spectrum for CDMA. The mid-frequency is 220.38MHz for Korea-PCS, 1.23MHz for US-PCS, and 85.38MHz for cellular; they are set based on the time constants of the components involved with the external VCO and external Rx PLL. Rx AGC, connected to both the IF SAW filter and matching component in the RF-IF converter output located in the RF block, amplifies or reduces according to the signal size. It takes its orders from the modem chip when it sets the appropriate receive level as required by the CDMA system. Gain is controlled by applying a DC voltage to the RAGC\_CONT pin. The applied DC is produced when the PDM signal, generated as a control signal in the modem, passes through the R-C filter. The control band of this AGC is approx. 90dB. The QPSK Baseband modulator separates and modulates the IF signal sent by the AGC using I(In-phase) and Q(Quad-phase) baseband signal. Essentially, two signals, I-LO and Q-LO (Local oscillator), are mixed with AGC's IF output signals, respectively. The LO(local oscillator) signal is generated by the internal oscillating components, externally connected tank coil, and Varactor, and the externally independent PLL device is used to generate its exact oscillation mid-frequency.

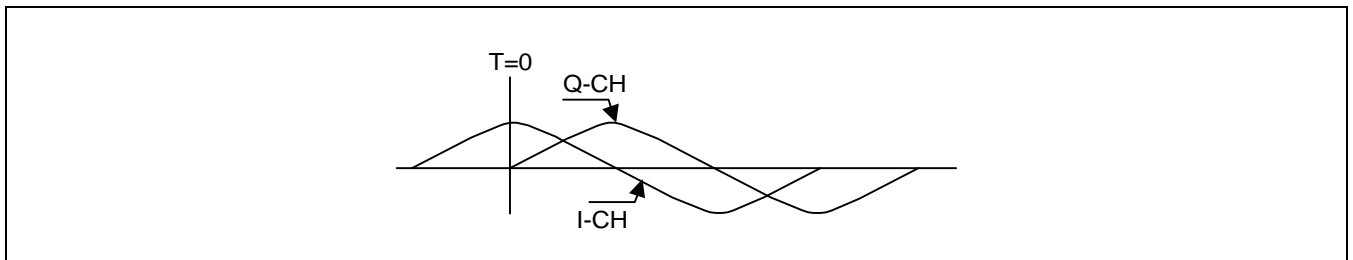


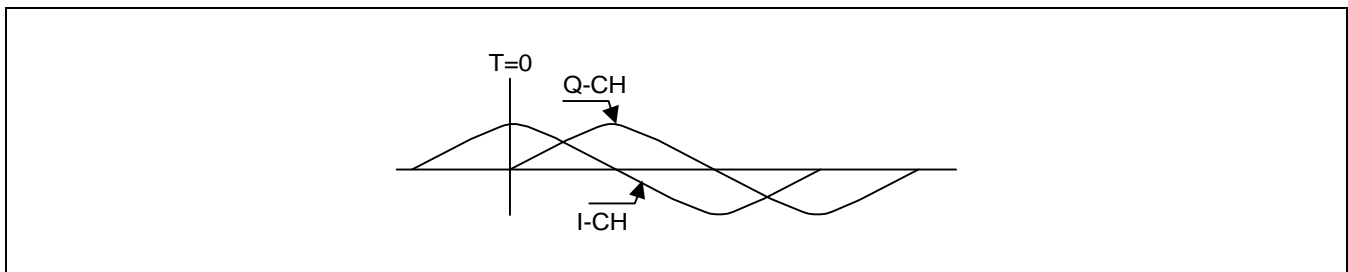
Figure 5. Received I/Q Phase in S1M8656A

Defining of the I-Phase and Q-Phase receive path is very important to its design. The polarities of these paths are also important to digital baseband modulation. Therefore, the output of the QPSK baseband modulation determines the I and Q phases; I-phase is defined as the phase leading the Q-phase by exactly 90°, but it simpler to think of I as Cosin and Q as Sin. The figure related to this is shown in Figure 5. This definition is valid only when the QPSK IF input signal is higher than the IF mid-frequency. The baseband signal, output by the QPSK modulator, includes various other unnecessary surrounding band noises, which are removed by the use of the LPF(Low-Pass-Filter).

Ultimately, I and Q filtered signals are converted to digital signals by the 4-bit A-D converter and sent to the modem. The A-D converter used is a parallel output type and its outputs are synchronized at the CHIPx8 rising edge. The modem chip captures the data on the CHIPx8 falling edge. The CHIPx8 clock used in the A-D converter can change the CHIPx8 output to input so that the clock can be used in systems with different TCXO reference frequency.

### FM Rx Signal Path

S1M8656A FM signal path is the same as that of the CDMA with the exception of a different LPF and A-D converter, which meet the system specification. Basically a FM modulated signal between IF mid-frequency to  $\pm 15\text{kHz}$  is input so that the baseband LPF, unlike CDMA, has the 12kHz cut-off frequency characteristic. A-D Converter has 8-bit resolution, characteristic of AMPS, and processing speed of approx. 40kHz. It does not adopt the power consuming parallel configuration but rather the series configuration to minimize the consumption power. Regular receive path processing is the same as the BBA except for the separation of the CDMA/AMPS signal paths. Rx AGC, connected to both the IF SAW filter and matching component in the RF-IF converter output located in the RF block, amplifies or reduces according to the signal size. It takes its orders from the modem chip when it sets the appropriate receive level as required by the CDMA system. Gain is controlled by applying a DC voltage to the RAGC\_CONT pin. The applied DC is produced when the PDM signal, generated as a control signal in the modem, passes through the R-C filter. The control band of this AGC is approx. 90dB. The QPSK Baseband modulator separates and modulates the IF signal sent by the AGC using I(In-phase) and Q(Quad-phase) baseband signals. Essentially, two signals, I-LO and Q-LO (Local oscillator), are mixed with AGC's IF output signals, respectively. The LO(local oscillator) signal is generated by the internal oscillating component, externally connected tank coil, and Varactor, and the externally independent PLL device is used to generate its exact oscillation mid-frequency. Defining of the I-Phase and Q-Phase receive path is very important to its design. The polarities of these paths are also important to digital baseband modulation. Therefore, the output of the QPSK baseband modulation determines the I and Q phases; I-phase is defined as the phase leading the Q-phase by exactly  $90^\circ$ , but it simpler to think of I as Cosin and Q as Sin.



**Figure 6 Received I/Q Phase in S1M8656A**

The figure related to this is shown in Figure 6. This definition is valid only when the QPSK IF input signal is higher than the IF mid-frequency. The baseband signal, output by the QPSK modulator, includes various other unnecessary surrounding band noises, which are removed by the use of the LPF(Low-Pass-Filter). The filter pole is barely 12kHz, merely in the audible range, for AMPS considering that the CDMA is 630kHz. Ultimately, I and Q filtered signals are converted to digital signals by the 4-bit A-D converter and sent to the modem. The A-D converter used is a parallel output type; its outputs are synchronized at the FMCLK and output in the order that it was synchronized. The modem chip captures the data by matching the FMCLK to the FMCLK clock. The CHIPx8 clock used in the A-D converter can change the CHIPx8 output to input so that the clock can be used in systems with different TCXO reference frequency. The clock used by the A-D converter is provided by the modem chip. It has a 360kHz frequency but can have 40kHz cycle when converting an 8-bit data.

**Rx Low-Pass Filters**

The CDMA baseband signal frequency can range between 1kHz – 630kHz. Normally, the range between 1kHz – 615kHz is called the In-band, between 630kHz – 750kHz Band-edge, and anything outside of these ranges out band. Very precise characteristics are required in the in-band range. The ripple, I/Q gain-phase error are critical factors that lead to noise in the in-band. FM Baseband signal ranges between 100Hz – 15kHz. Normally, the frequency range between 100Hz –12kHz is called the in-band, between 12kHz – 18kHz the band-edge, and anything outside of these ranges the out-band. As for the CDMA, the ripple, I/Q gain-phase error are critical factors that lead to noise in the in-band.

The LPF characteristic required by these two systems are shown in Figures 7 and 8 below.

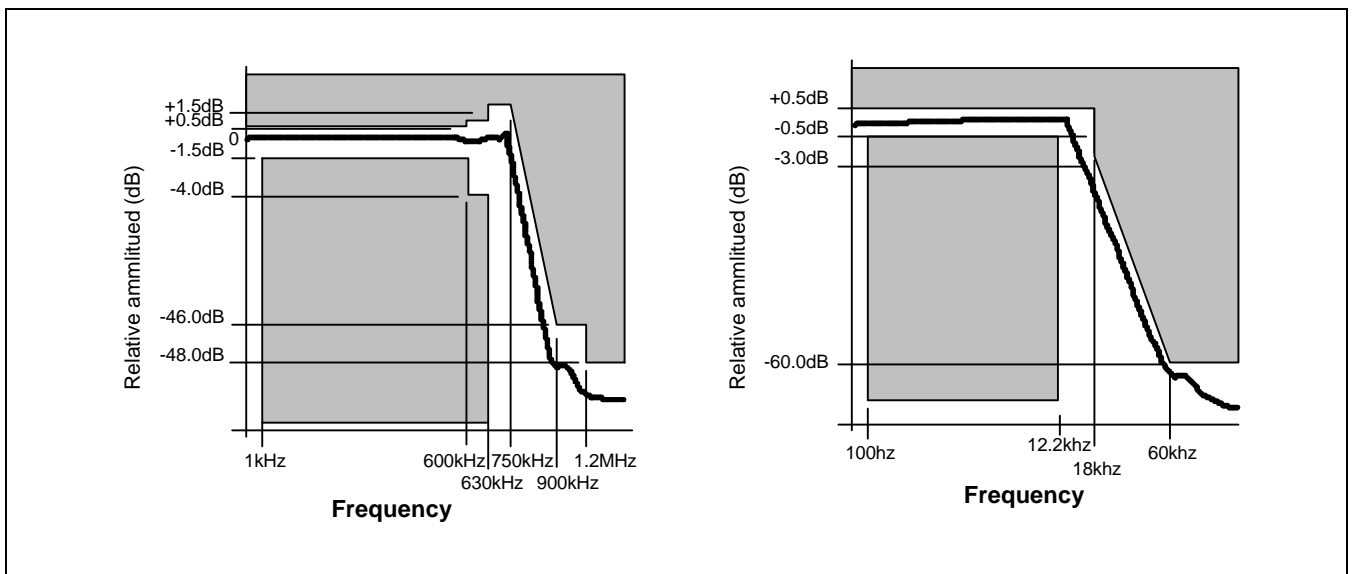


Figure 7. CDMA Rx Low-Pass Filter Masks

Figure 8. FM Rx Low-Pass Filter Masks

**CHIPx8 Clock Generator**

CHIPx8 CLOCK is a digital division that divides the 19.68MHz TCXO by 512/1025. It holds the TCXO clock by half cycle every 512th TCXO cycle and strictly speaking it does not generate 9,8304 MHz precisely. The 9.8304MHz is the mean on the 1025TCXO cycle, where 9.84MHz of 50% duty is obtained from 1 – 512 and 513 – 1024. The timing diagram in Figure 9 explains this. The CHIPx8 CLOCK output is held at low when the CDMA is asleep and FM is idle. Moreover, it can use three division ratios(19.68MHz, 9.84MHz, 9.8304MHz) through the serial I/F. Various external chip clocks can be used by converting them to inputs.

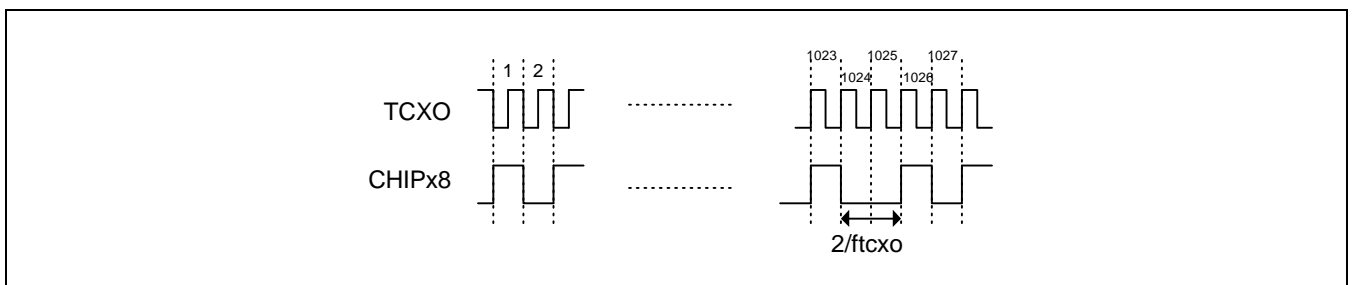


Figure 9. CHIPx8 Clock form

### Rx Voltage Controlled Oscillator(VCO)

S1M8656A includes the Rx LO block having the VCO and quad-phase generator. The quad-phase generator outputs I-phase and Q-phase clocks with 1/2 the VCO frequency and sends them to the QPSK modulator. The VCO buffer is used when the VCO output is sent to the external RX PLL. Although the allowable VCO frequency is determined based on an external time constant, it can only range between approx. 100MHz – 500MHz, suggesting that the maximum input IF frequency is 250MHz.

### Serial Port Interface(SPI)

S1M8656A is equipped with the Serial I/F. All internal functions can be controlled through a common bus using an external controller. The serial I/F can be used by setting pin 26(SEN) high, the pin which permits/ not permit the SPI. If the SEN becomes low, the SPI cannot be used and the BBA must be used in the existing BBA 2.0 mode. (All the internal registers are default, which makes the register have the same characteristic as BBA 2.0) Here, the modem is the master and BBA the slave.

Each pin which uses the SPI bus has the following common functions.

- The STB(STROBE) for the serial bus start signal is used to initialize serial data transmission. This pin is used with the IDLEB function in manual mode and designated the IDLB/STB pin.
- Serial BUS DATA is used for the bidirection data input /output at serial data transmission. This pin is used with the FMB function in parallel mode and designated the FMB/DATA pin. Because it is an open drain type pin, it requires the pull-up resistance of approx. 8k $\Omega$ .
- Serial BUS CLK is used to synchronize the data input/output at serial data transmission. This pin is used with the SLEEPB function in manual mode and designated the SLEEPB/CLK pin.

S1M8656A can be used to power down the TCXO/N block using the SPI bus when the CDMA is asleep (CDMA SLEEP). This mode, installed to minimize the product consumption power, is entered by setting a specific bit (PWRDWN) in the CLK\_GEN\_MODE register to '1'. The current in the sleep mode reduces from 300uA to 10uA. The SEN(PIN26) pins decide on whether the product will use the SPI bus or parallel control inputs; if it is in low, then the pins the parallel control input functions, IDLEB, FMB, and SLEEPB, but if in high then these pins execute the SPI bus functions, STB, DATA, and CLK. This product does not require any external time constants in initializing the internal register because it can use the internal reset function. Figure. 10 shows the serial bus connection.

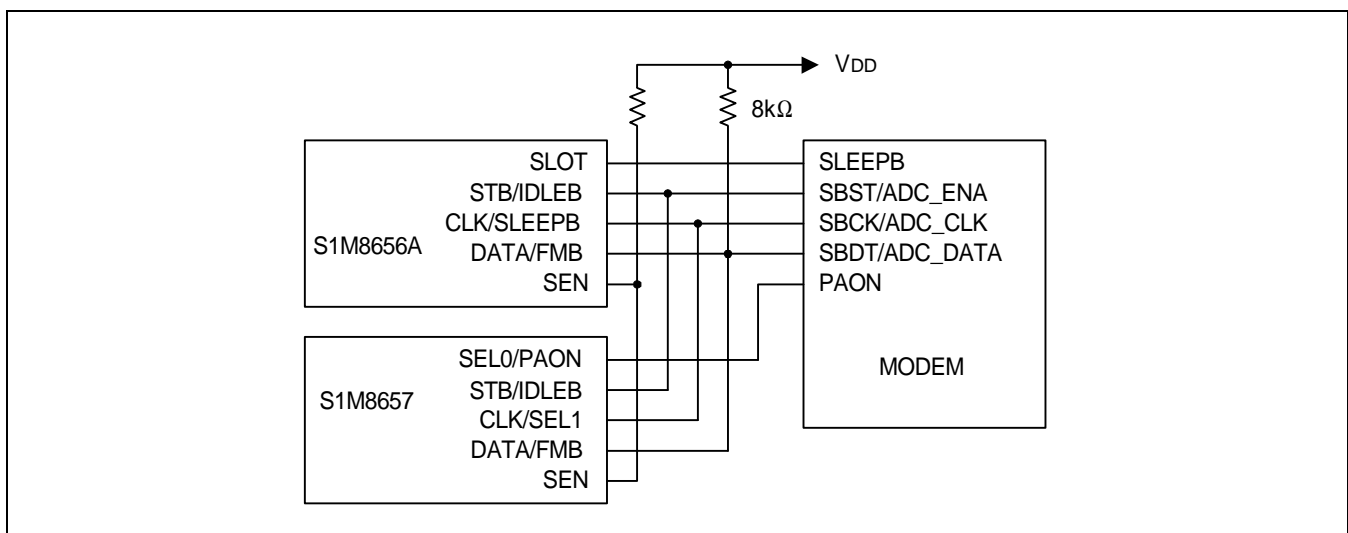


Figure 10. Serial Bus connection

The advantage of using the SPI bus is the opportunity given to use all the various functions in the product, thus allowing more flexibility. Moreover, by tying all the products using a common bus and controlling them together, the PCB application area and the number of control pins for the master can be simultaneously reduced, as compared to controlling the products independently.

### Serial Port Interface Operation

The modem, the master, controls slaves such as S1M8656A using the SPI bus.

The STB falling edge indicates the start of the serial I/F data transmission. The STB becomes high to mark the end of the data transmission.

(Data sent after the STB turns high are not valid.)

Serial line data is captured and stored as soon as the BBA or the MODEM places the clock on the falling edge.

The SPI 3-line must remain high for at least 1-clock cycle in order to send new data.

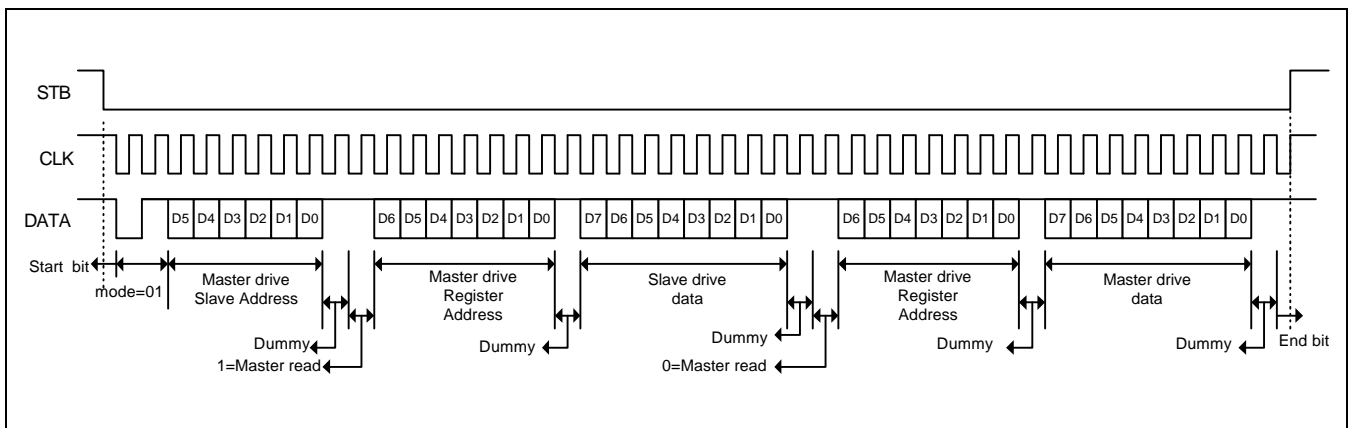
The MSB always outputs the data line data.

After 9-clocks, which is required to send data, the data line driver opens the data line, at which time the data line becomes high because of the external pull-up resistance.

### Serial Data Transfer format

S1M8656A and S1M8657 are all slave devices with the SPI bus. What differentiates them from one another is their different device IDs. Each company has its own characteristic SPI bus configuration, but normally the 3-line bus is most often used and sometimes the 2-line bus such as the IIC bus.

Figure 11. shows the serial data transfer format.



**Figure 11. Serial Data Transfer Format**

- (1) The first 2-BITS are for transmission only and this product must send '01'.(Others are not permitted.)
- (2) The following 6-bit data specifies the slave device, which is connected to the SPI bus and has its own ID.
- (3) The following 1-bit is a dummy bit, which marks the end of the 8-bit data transmission and the beginning of the next data to be sent.
- (4) The following 1-bit decides on whether the master will drive the data line or the slave will. If this bit is '1', the master will drive, but if '0' the slave will drive the data line.
- (5) The following 7-bit data is the register address of the specified slave device; the 7-bits for an address allows 128 register addresses for slaves.
- (6) The following high 1-BIT data is a dummy data.
- (7) The following 8-BIT data is the data in the device to be driven.

- (8) The following 1-BIT data is a dummy data, which marks the end of the 8-bit data transmission and beginning of the next data to be sent.
- (9) The following 1-bit decides on whether the master will drive the data line or the slave will. If this bit is '1', the master will drive , but if '0' the slave will drive the data line.
- (10) The following 7-bit data is the register address of the specified slave device.
- (11) The following high 1-BIT data is a dummy data.
- (12) The following 8-BIT data is the data in the device to be driven.  
(Continuous data transmission such as this can be ended with a 1-byte transmission or can be read/written repeatedly.)
- (13) After the last data is sent, the data line opens and becomes high;
- (14) the CLK continues for half the 1-clock cycle and then becomes high;
- (15) and the STB becomes high as soon as the clock becomes high and this marks the end of data transmission.

### Modes of Operation

S1M8656A can be controlled by existing parallel control inputs such as BBA 2.0 or by the SPI bus. The modes of operation consists of digital state FMB, IDLEB, and SLEEPB modes; Table 2 shows the various modes.

**Table 2. Mode control in the Parallel mode control**

Mode	FMB	IDLEB	SLEEPB	CHIPx8	TCXO/N
CDMA talk	H	H	H	On	On
CDMA idle	H	L	H	On	On
CDMA sleep	H	L	L	Off	On
FM talk	L	H	X	On	On
FM idle	L	L	H	Off	On
Rx slot	L	L	L	Off	On

A Rx slot which is not in the existing BBA is shown in the table above. This function was installed for the new FM Slotted mode. The reason for this new slot is simple. All users are aware of the need to quickly convert from the sleep mode to the idle mode and that PLL related functions are the slowest to set-up. This is because the PLL incorporates many external time constants and the large capacitor that is includes takes a long time to charge and discharge. As one measure, the external time constant could be changed or PLL related blocks could be left on completely. Here, the Rx slot function in the BBA leaves the VCO completely on. The Rx slot function leaves the Rx VCO on only when IDLEB is low, SLEEP is low and FMB is low, but an additional 4.5mA of current is consumed. Even if the RXSLOTB is low in the FM idle mode, remains in the FMSLOT mode.

## CONTROL REGISTERS

S1M8656A has various registers which can be programmed by the SPI bus. These registers have their own function which are described below.

**Table 3. S1M8656A Control Registers**

Register name	Address	R/W	Default vale	Description
RESET	0x00	W	-	Reset. Reset S1M8656A and all the register values are returned to their default value.
SPI_ID	0x01	R	0x1F	SPI_ID. Each slave device has its own, independent code; S1M8656A code is 1Fh.
Not applied	0x02	Not used.		
BLOCK_CTL	0x04	R/W	0x3C	BLOCK_CTL Decides on the S1M8656A operation and performs the same functions as IDLEB, FMB and SLEEPB in the parallel control mode.
Not applied.	0x06	Not used.		
CLK_GEN_MODE	0x09	R/W	0x0C	CLK_GEN_MODE Changes the internal divider(TCXO,CHIPx8) conditions; controls the output drive.
Not applied.	0x0A	Not used.		
AGC_DCONV	0x0C	R/W	0x0B	AGC_DCONV Controls the AGC gain control range and VCO output.
Not applied.	0x0E	Not used		
Reserved	0x10	Absolutely not permitted.		
Reserved	0x11			

W : MODEM is recorded in the S1M8656A register R : When S1M8656A sends data to the modem

**Table 4. Description Of Control Registers**

ADDRESS	NAME	TYPE	BITS	Description
00	RESET	W	-	When the master uses this register, the S1M8656A returns all the programmed register values to their initial value.
01	SPI_ID	R	[5:0]	This read-only register is used to confirm the type of slave connected to the master. It is set to 1Fh and all S1M8656A has the same value. This is the ID absolutely required to differentiate the controller from the data, when there are many slaves connected to the SPI bus.

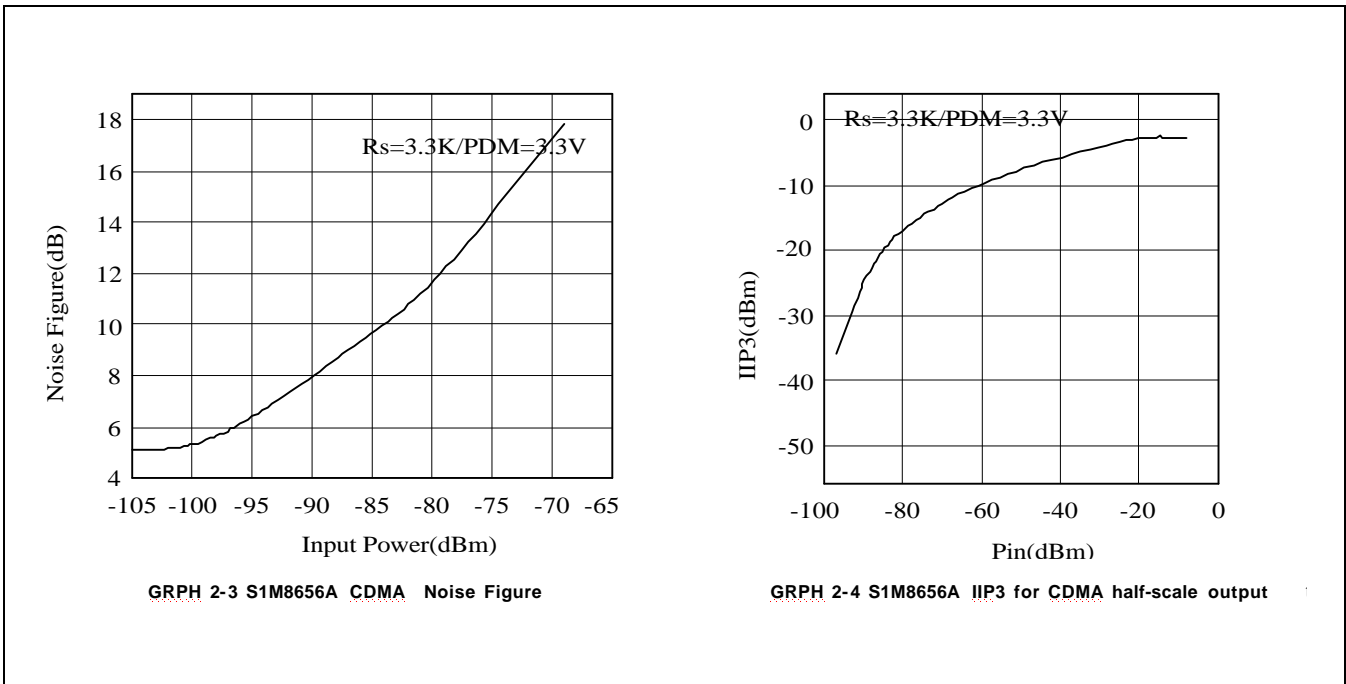
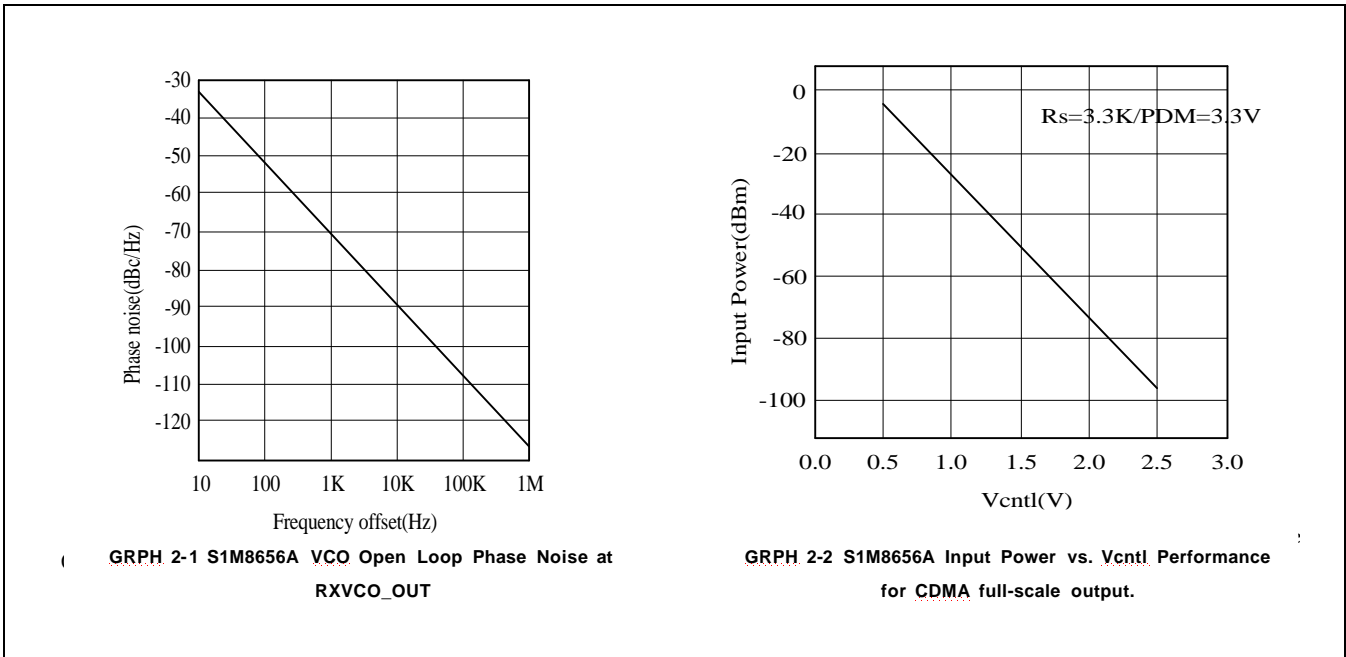
Table 4. Description Of Control Registers(Continued)

ADDRESS	NAME	TYPE	BITS	Description
04	Block_CTL [4:0]	R/W	[7:5]	Reserved. Default = 001
			[4]	Reserved. Default = 1
			[3]	Reserved. Default = 1
			[2]	FMB. Default = 1 1: CDMA Mode, 0: FM Mode CDMA Mode or FM Mode select bit.
			[1]	IDLEB. Default = 0 1: RxTx Mode, 0: Idle Mode Talk Mode or idle Mode select bit.
			[0]	SLEEPB. Default = 0 1: follows the IDLEB state. 0: SLEEP Mode SLEEP or None-SLEEP select bit.
<p>When [2:0] = 001 and RXSLOTB=0, FMSLOT Mode; if RXSLOTB = 1, FM Rx Mode. If [2:0]=000, becomes FMSLOT Mode, regardless of RXSLOTB. Operates in the CDMA Mode, regardless of the RXSLOTB state.</p>				
09	CLK_GEN_MODE [4:0]	R/W	[7:5]	Reserved. Default = 000
			[4]	TCXO_PWR. Default = 0 1: TCXO/N output not allowed 0: TCXO/N output allowed TCXO/N division and output permit/not permit select bit.
			[3]	TCXO_DRV. Default = 1 1: TCXO/N Weak CMOS output 0: TCXO/N is STRONG CMOS output TCXO/N DRIVE select bit according to conditions of use.
			[2]	TCXO_N. Default = 1 1: TXCO/N ; N = 4 0: TCXO/N ; N = 1 TCXO/N output division ratio selection parameter.
			[1:0]	CHIPx8. Default = 00 00: In the Normal Mode, it has the TCXO*512/1025 ratio. 01: CHIPx8 output is converted to external clock input. 10: Half the TCXO is output. 11: CHIPx8 division and output are not allowed. Select bit on whether to use the CHIPx8 division ratio with the input mode or output mode.

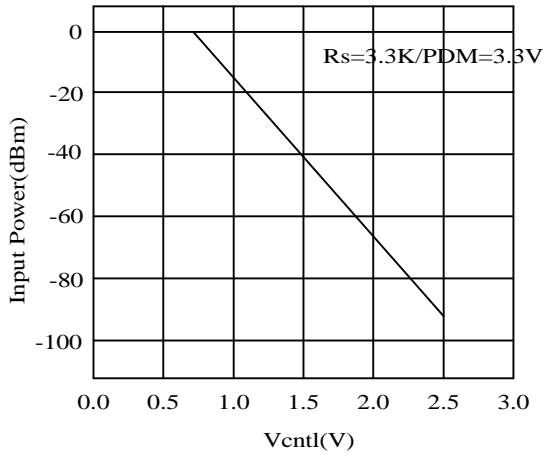
Table 4. Description Of Control Registers (Continued)

ADDRESS	NAME	TYPE	BITS	Description
			[7]	Reserved. Default = 0
			[6:5]	AGCPDM. Default=00. AGC PDM control range 00: PDM 3.3V : Use when VDDM = 3.3V 01: PDM 2.4V : Use when VDDM = 2.4V 10: PDM 2.7V : Use when VDDM = 2.7V 11: Reserved : not allowed. Reserved bit for changes to PDM voltage according to the MODEM power voltage BIT.
			[4]	Reserved. Default = 0
0Ch	AGC_RVCO [5:0]	R/W	[3]	AGCPON. Default=1. RX AGC power control 1: Power on : allows AGC 0: Power down mode : not allow AGC .
			[2]	RVCOLVL. Default=0. RXVCO output level control 1: Outputs RXVCO_OUT normally. 0: Reduces RXVCO_OUT by -2dB. Bit to eliminate the harmonic component that can be caused by RX VCO.
			[1:0]	RVCO. Default = 11. 00: All block Power down, excluding TCXO/N. 01: Mode that forces external VCO in the VCO Tank. 10: Mode that forces external VCO in the VCO Tank. 11: Normal VCO Mode. VCO operating mode defining bit.

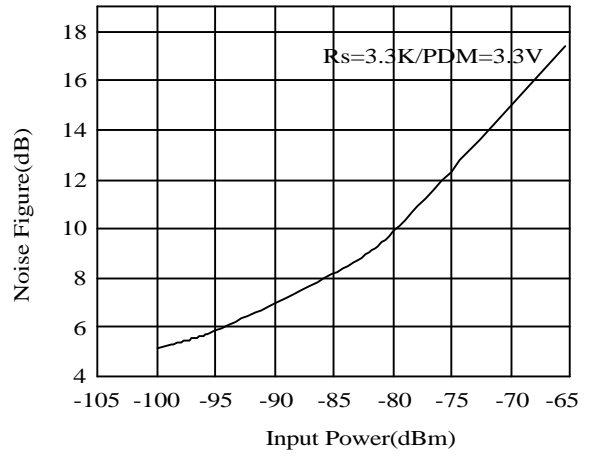
CHARACTERISTIC GRAPH



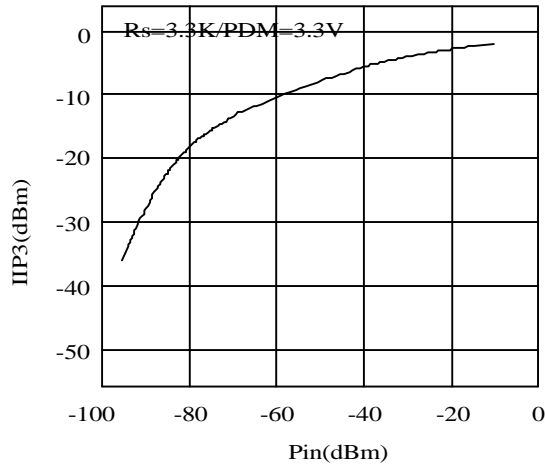
CHARACTERISTIC GRAPH (Continued)



GRPH 2-5 Input Power vs. Vcntl Performance for FM full-scale output.



GRPH 2-6 S1M8656A FM Noise Figure



GRPH 2-7 S1M8656A IIP3 for FM half-scale output

TEST CIRCUIT

