AKM

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AK1548

8GHz Low Noise Integer-N Frequency Synthesizer

1. Overview

The AK1548 is an Integer-N PLL (Phase Locked Loop) frequency synthesizer, covering a wide range of frequency from 1GHz to 8GHz. Consisting of a highly accurate charge pump, a reference divider, a programmable divider and a dual-modulus prescaler (P/P+1), this product provides high performance, very low Phase Noise and small footprints.

An ideal PLL can be achieved by combining the AK1548 with the external loop filter and VCO (Voltage Controlled Oscillator). Access to the registers is controlled via a 3-wire serial interface. The operating supply voltage is from 2.7V to 3.3V, and the charge pump circuit and the serial interface can be driven by individual supply voltage.

2. Features

☐	Operating frequency :	1GHz to 8GHz
☐	Programmable charge pump current :	650μA to 5200μA typical with 8steps The current range can be controlled by an external resistor.
☐	Fast lock mode for improved lock time :	The programmable timer can switch two charge pump current setting.
☐	Supply Voltage :	2.7 to 3.3 V (PVDD, AVDD pins)
☐	Separate Charge Pump Power Supply :	PVDD to 5.5V (CPVDD pin)
☐	Excellent Phase Noise :	-226dBc/Hz
☐	On-chip lock detection feature of PLL :	Selectable Phase Frequency Detector (PFD) Output or Digital filtered lock detect
☐	Package :	20pin QFN (0.5mm pitch, 4mm × 4mm × 0.75mm)
☐	Operating temperature :	-40°C to 85°C

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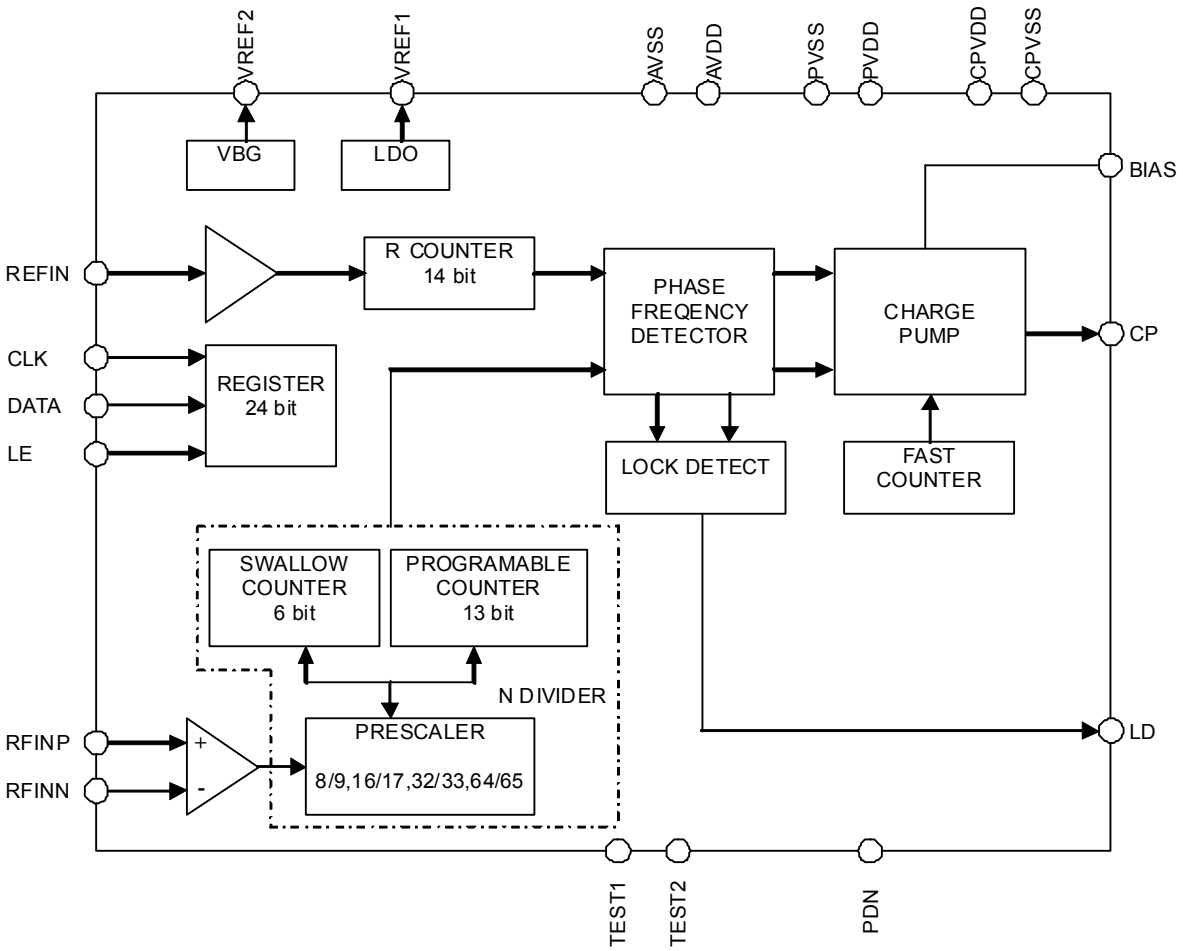
In this specification, the following notations are used for specific signal and register names.

[Name] : Pin name

<Name> : Register group name (Address name)

{Name} : Register bit name

3. Block Diagram



4. Pin Functional Description and Assignments

1. Pin Functions

No.	Name	I/O	Pin Functions	Power down (Note 1)	Remarks
1	CPVSS	G	Charge pump ground		
2	TEST1	DI	Test pin 1		Internal pull-down, Schmidt trigger input
3	AVSS	G	Analog ground		
4	RFINN	AI	Complementary input to the RF Prescaler		
5	RFINP	AI	Input to the RF Prescaler		
6	AVDD	P	Power supply for analog blocks		
7	VREF1	AO	Connect reference voltage capacitor for LDO	“Low”	
8	REFIN	AI	Reference signal input		
9	PVSS	G	Peripherals ground		
10	TEST2	DI	Test pin 2		Internal pull-down, Schmidt trigger input
11	PDN	DI	Power down		
12	CLK	DI	Serial clock input		Schmidt trigger input
13	DATA	DI	Serial data input		Schmidt trigger input
14	LE	DI	Load enable input		Schmidt trigger input
15	LD	DO	Lock detect output	“Low”	
16	PVDD	P	Power supply for peripherals		
17	VREF2	AO	Connect reference voltage capacitor	“Low”	
18	CPVDD	P	Power supply for charge pump		
19	BIAS	AIO	Resistance pin for setting charge pump current		
20	CP	AO	Charge pump output	“Hi-Z”	

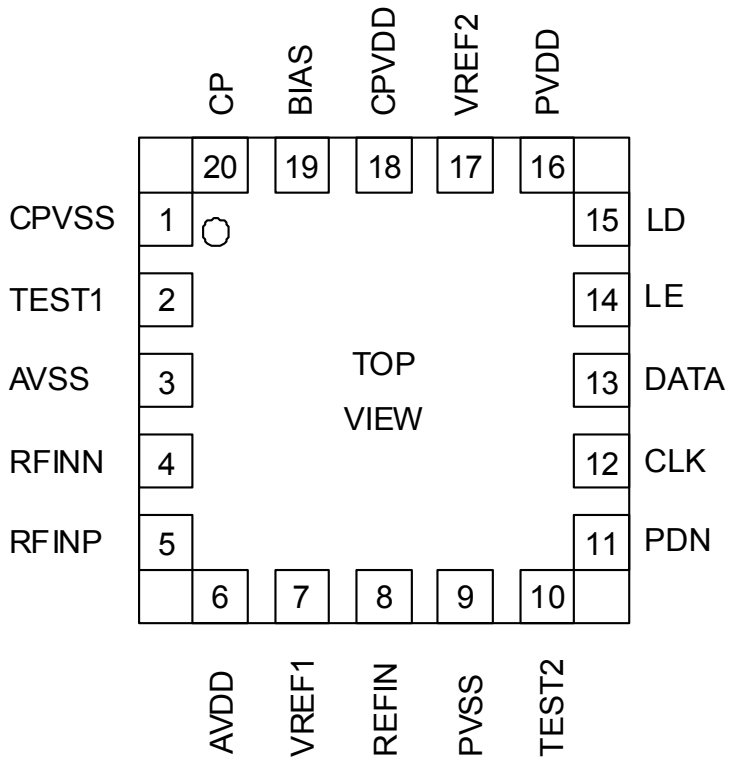
Note 1) “Power Down” means the state of [PDN]=”Low” after power on.

Note 2) The exposed pad at the center of the backside should be connected to ground.

The following table shows the meaning of abbreviations used in the “I/O” column.

AI: Analog input pin	AO: Analog output pin	AIO: Analog I/O pin	DI: Digital input pin
DO: Digital output pin	P: Power supply pin	G: Ground pin	

2. Pin Assignments



20pin QFN (0.5mm pitch, 4mm × 4mm)

5. Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Remarks
Supply Voltage	VDD1	-0.3	3.6	V	[AVDD], [PVDD] (Note 1)
	VDD2	-0.3	6.5	V	[CPVDD] (Note 1)
Ground Level	VSS1	0	0	V	[AVSS], [PVSS]
	VSS2	0	0	V	[CPVSS]
Analog Input Voltage	VAIN	VSS1-0.3	VDD1+0.3	V	[RFINN], [RFINP], [REFIN] (Notes 1 & 2)
Digital Input Voltage	VDIN	VSS1-0.3	VDD1+0.3	V	[CLK], [DATA], [LE], [PDN], [TEST1], [TEST2] (Notes 1 & 2)
Input Current	IIN	-10	10	mA	
Storage Temperature	Tstg	-55	125	°C	

Note 1) 0V reference for all voltages.

Note 2) Maximum must not be over 3.6V.

Exceeding these maximum ratings may result in damage to the AK1548. Normal operation is not guaranteed at these extremes.

6. Recommended Operating Range

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks
Operating Temperature	Ta	-40		85	°C	
Supply Voltage	VDD1	2.7	3.0	3.3	V	Applied to the [AVDD],[PVDD] pins
	VDD2	VDD1	5.0	5.5	V	Applied to the [CPVDD] pin

Note 1) VDD1 and VDD2 can be driven individually within the Recommended Operating Range.

Note 2) All specifications are applicable within the Recommended Operating Range (Operating Temperature / Supply Voltage) .

7. Electrical Characteristics

1. Digital DC Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Remarks
High level input voltage	Vih		0.8×VDD1			V	Note 1)
Low level input voltage	Vil				0.2×VDD1	V	Note 1)
High level input current 1	Iih1	Vih = VDD1=3.3V	-1		1	μA	Note 2)
High level input current 2	Iih2	Vih = VDD1=3.3V	17	33	66	μA	Note 3)
Low level input current	Iil	Vil = 0V, VDD1=3.3V	-1		1	μA	Note 1)
High level output voltage	Voh	Ioh = -500μA	VDD1-0.4			V	Note 4)
Low level output voltage	Vol	Iol = 500μA			0.4	V	Note 4)

Note 1) Applied to the [CLK], [DATA], [LE], [PDN], [TEST1] and [TEST2] pins.

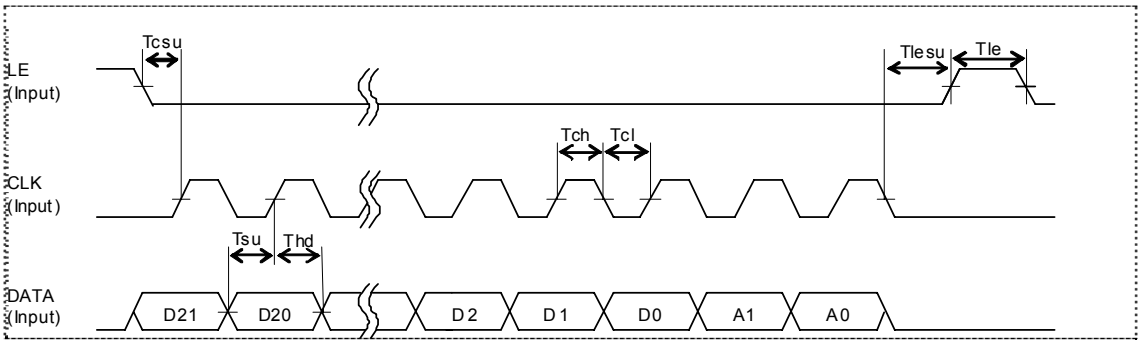
Note 2) Applied to the [CLK], [DATA], [LE] and [PDN] pins.

Note 3) Applied to the [TEST1] and [TEST2] pins.

Note 4) Applied to the [LD] pin.

2. Serial Interface Timing

<Write-In Timing>



Serial Interface Timing Chart

Serial Interface Timing

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks
Clock L level hold time	Tcl	25			ns	
Clock H level hold time	Tch	25			ns	
Clock setup time	Tcsu	10			ns	
Data setup time	Tsu	10			ns	
Data hold time	Thd	10			ns	
LE setup time	Tlesu	10			ns	
LE pulse width	Tle	25			ns	

3. Analog Circuit Characteristics

The resistance of 27kΩ is connected to the [BIAS] pin.

VDD1＝2.7V to 3.3V, VDD2=VDD1 to 5.5V,–40°C≤Ta≤85°C, unless otherwise specified.

Parameter	Min.	Typ.	Max.	Unit	Remarks
RF Characteristics					
Input Sensitivity	-5		5	dBm	
Input Frequency	1000		8000	MHz	
REFIN Characteristics					
Input Sensitivity	0.4		VDD1	Vpp	REFIN≤200MHz
	0.4		2	Vpp	REFIN>200MHz
Input Frequency	10		300	MHz	
Maximum Allowable Prescaler Output Frequency			300	MHz	
Phase Detector					
Phase Detector Frequency			104	MHz	
Charge Pump					
Charge Pump Maximum Value		5200		μA	
Charge Pump Minimum Value		650		μA	
Icp TRI-STATE Leak Current		1		nA	0.7≤Vcpo≤VDD2-0.7, Ta=25°C Vcpo : CP terminal voltage
Mismatch between Source and Sink Currents (Note 1)			10	%	Vcpo=VDD2/2, Ta=25°C
Icp vs. Vcpo (Note 2)			15	%	0.5≤Vcpo≤VDD2-0.5, Ta=25°C
Regulator					
VREF1 Rise Time			10	ms	Connect 470nF Capacitance at VREF2 Pin
VREF2 Rise Time			10	ms	Connect 470 nF Capacitance at VREF2 Pin
Current Consumption					
IDD1			10	μA	[PDN]="0"
IDD2		16	26	mA	[PDN]"1", {PD}=0, IDD for VDD1
IDD3 (Note 4)		0.8	1.6	mA	[PDN]"1", {PD}=0, IDD for VDD2
IDD4		0.55	0.9	mA	[PDN]"1", {PD}=1, IDD for VDD1

Note 1) Mismatch between Source and Sink Currents : [(|Isink|-|Isource|)/{(|Isink|+|Isource|)/2}] × 100 [%]

Note 2) See "Charge Pump Characteristics - Voltage vs. Current". Vcpo is the output voltage at [CP].

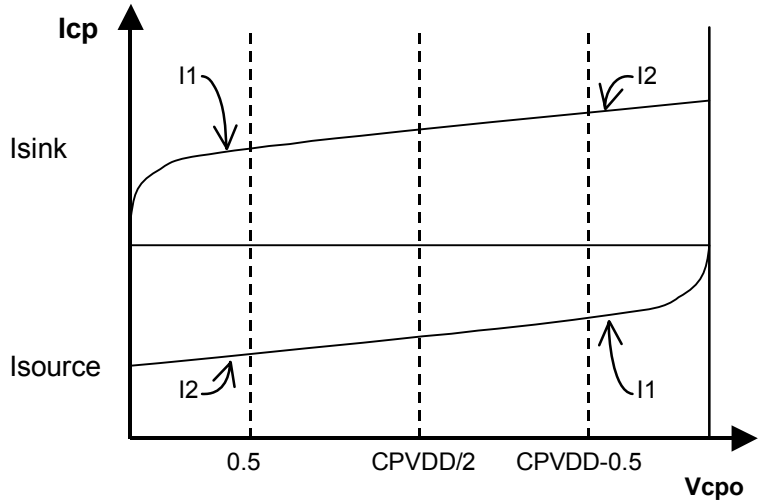
Icp vs. Vcpo : [{1/2×(|I1|-|I2|)}/{1/2×(|I1|+|I2|)}]×100 [%]

Note 3) When [PDN] is ”1”, the total power supply current of the AK1548 is “IDD2+IDD3+ Charge pump current”.

Note 4) The current depending on Phase Detector Frequency isn’t included. IDD3 is the stationary current that charge pump circuit consumes.

Resistance Connected to the BIAS Pin for Setting Charge Pump Output Current

Parameter	Min.	Typ.	Max.	Unit	Remarks
BIAS resistance	22	27	33	kΩ	



Charge Pump Characteristics - Voltage (Vcpo) vs. Current (Icp)

8. Block Functional Descriptions

1. Frequency Setup

The following formula is used to calculate the frequency setting for the AK1548.

Frequency setting (external VCO output frequency) = F_{PFD} x N

Where :

N	: Dividing number N = [(P x B) + A]
F_{PFD}	: Phase detector frequency F_{PFD} = [REFIN] pin input frequency / R counter dividing number
P	: Prescaler Value (See < Address2>:{Pre[1:0]})
B	: B (Programmable) counter value (See <Address1>:{B[12:0]})
A	: A (Swallow) counter value (See <Address1>:{A[5:0]})

Calculation example

The output frequency of external reference frequency oscillator is 10MHz, and F_{PFD} is 1MHz and VCO frequency is 7400MHz.

AK1548 setting :

R (Reference counter)=10000000/1000000 = 10 (<Address0>:{R[13:0]}= “10”)

P=32 (<Address2>:{PRE[1:0]}=”10Bin”)

B=231 (<Address1>:{B[12:0]}=”231”)

A=8 (<Address1>:{A[5:0]}=”8”)

Frequency setting = 1M × [(32×231) + 8] = 7400MHz

Lower limit for setting consecutive dividing numbers

In the AK1548, it is not possible to set consecutive dividing numbers below the lower limit.

(The lower limit is determined by a dividing number set for the prescaler.)

The following table shows an example where consecutive dividing numbers below the lower limit cannot be set. The consecutive dividing numbers can be set when B ≥ P-1.

P=8 (Dual modulus prescaler 8/9)

P	B[12:0]	A[5:0]	N [(P×B) + A]	Remarks
8	6	6	54	55 cannot be set as an N divider.
8	7	0	56	This is the lower limit. 56 or over can consecutively be set as an N divider.
8	7	1	57	
.	.	.	.	
8	100	9	809	
.	.	.	.	
8	8191	62	65590	
8	8191	63	65591	

P=16 (Dual modulus prescaler 16/17)

P	B[12:0]	A[5:0]	N [(P×B) + A]	Remarks
16	14	14	238	239 cannot be set as an N divider.
16	15	0	240	This is the lower limit. 240 or over can consecutively be set as an N divider.
16	15	1	241	
.	.	.	.	
16	4099	7	65591	
.	.	.	.	
16	8191	62	131118	
16	8191	63	131119	

P=32 (Dual modulus prescaler 32/33)

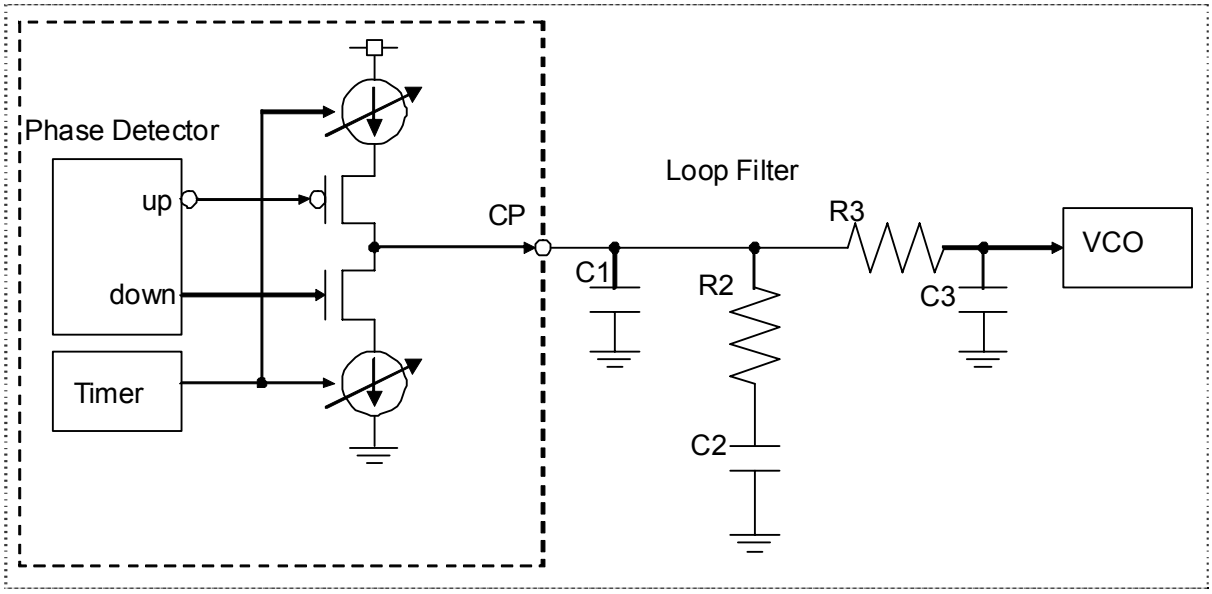
P	B[12:0]	A[5:0]	N [(P×B) + A]	Remarks
32	30	30	990	991 cannot be set as an N divider.
32	31	0	992	This is the lower limit. 992 or over can consecutively be set as an N divider.
32	31	1	993	
.	.	.	.	
32	4097	15	131119	
.	.	.	.	
32	8191	62	262174	
32	8191	63	262175	

P=64 (Dual modulus prescaler 64/65)

P	B[12:0]	A[5:0]	N [(P×B) + A]	Remarks
64	62	62	4030	4031 cannot be set as an N divider.
64	63	0	4032	This is the lower limit. 4032 or over can consecutively be set as an N divider.
64	63	1	4033	
.	.	.	.	
64	4096	31	262175	
.	.	.	.	
64	8191	62	524286	
64	8191	63	524287	

2. Charge Pump, Loop Filter

The current setting of charge pump and loop filter can switch with the built-in timer for Fast Lock.



Loop Filter Schematic

The charge pump current for normal operation (CP1) is determined by the setting in {CP1[2:0]}, which is a 3-bit address of {D[15:13]} in <Address2> and a value of the resistance connected to the [BIAS] pin. The charge pump current for the Fast Lock Up mode operation (CP2) is determined by the setting in {CP2[2:0]}, which is a 3-bit address of D[18:16] in <Address2> and a value of the resistance connected to the [BIAS] pin.

The following formula shows the relationship among the resistance value, the register setting and the electric current value.

charge pump minimum current (Icp_min) [A] =17.46 / Resistance connected to the BIAS pin [Ω]

charge pump current (Icp) [A] = Icp_min [A] × ({CP1} or {CP2} setting +1)

The allowed value range for the resistance connected to the [BIAS] pin is from 22 to 33kΩ for both normal and Fast Lock Up mode operations.

3. Fast Lock Up Mode

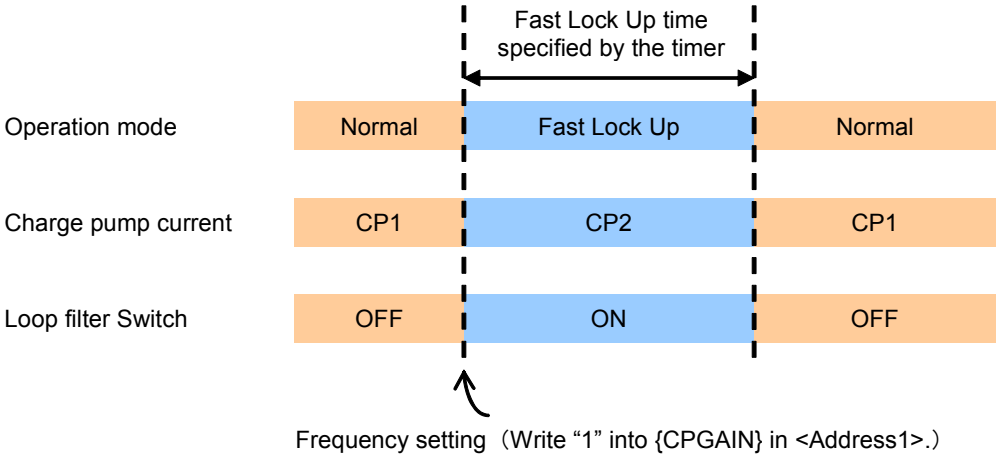
Setting {FAST[1:0]} in <Address2> to “11Bin” and {CPGAIN} in <Address1> to “1” enables the Fast Lock Up mode for the AK1548.

The Fast Lock Up mode is enabled only during the time period set by the timer according to the counter value in {TIMER[3:0]} in <Address2>. The charge pump current is set to the value specified by {CP2}. When the specified time period elapses, the Fast Lock Up mode operation is switched to the normal operation, and {CPGAIN} in <Address1> is reset to “0”.

{TIMER[3:0]} in <Address2> is used to set the time period for this mode. The following formula is used to calculate the time period :

Switchover time = 1 /F_{PFD} × Counter Value

Counter Value = 3 + (Timer[3:0] setting × 4)



Fast Lock Up Mode Timing Chart

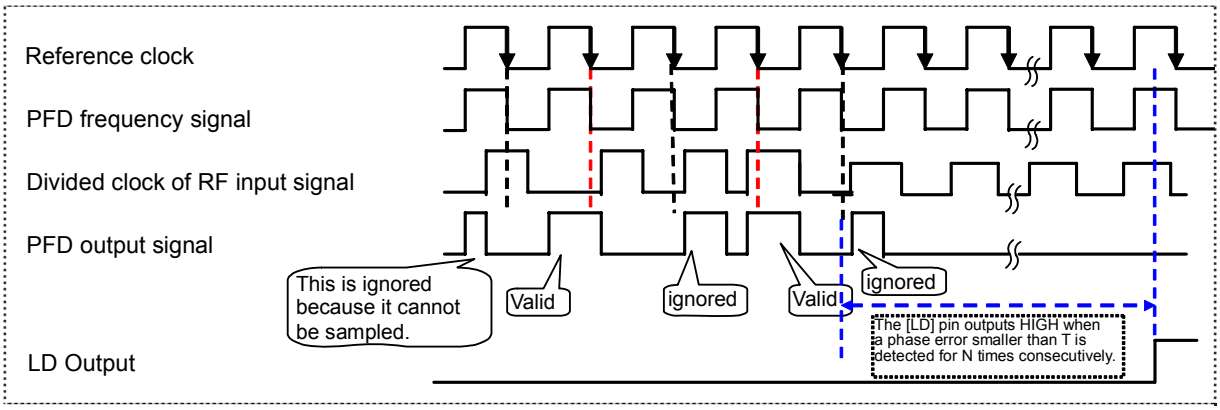
4. Lock Detect

Lock detect output can be selected by {LD[2:0]} in <Address2>. When {LD} is set to “101Bin", the phase detector outputs an unmanipulated phase detection (comparison) result. (This is called “analog lock detect”.) When {LD} is set to “001Bin”, the lock detect signal is output according to the on-chip logic. (This is called “digital lock detect”.)

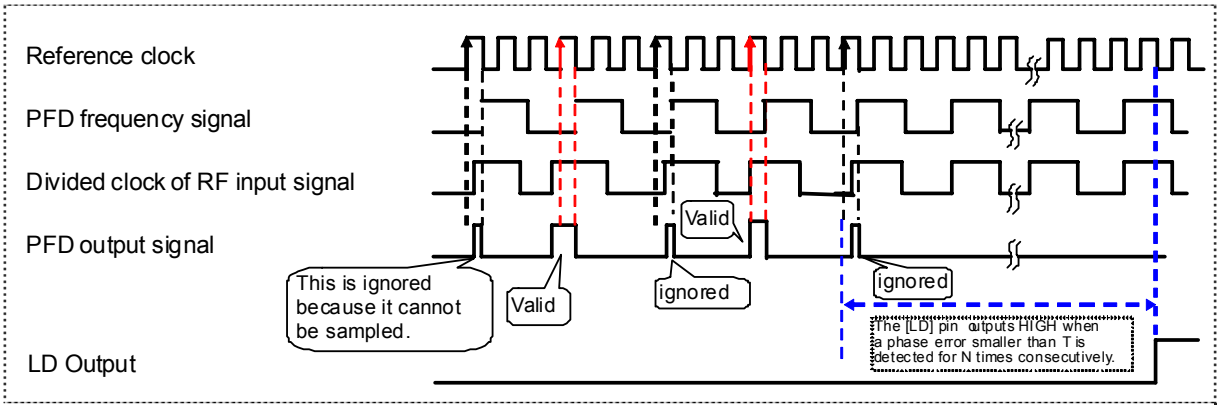
The lock detect can be done as following:
The [LD] pin is in unlocked state (which outputs “LOW”) when a frequency setup is made.
In the digital lock detect, the [LD] pin outputs “HIGH” (which means the locked state) when a phase error smaller than a cycle of [REFIN] clock (T) is detected for N times consecutively. When a phase error larger than T is detected for N times consecutively while the [LD] pin outputs “HIGH”, then the [LD] pin outputs “LOW” (which means the unlocked state). The counter value N can be set by {LDP} in <Address0>. The N is different between “unlocked to locked” and “locked to unlocked”.

{LDP}	unlocked to locked	locked to unlocked
0	N=15	N=3
1	N=31	N=7

The lock detect signal is shown below:

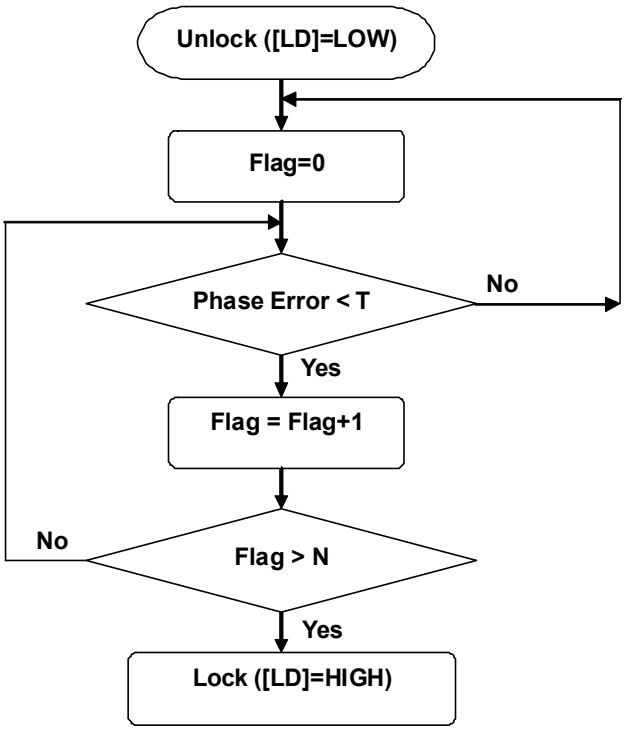


Case of “R = 1”

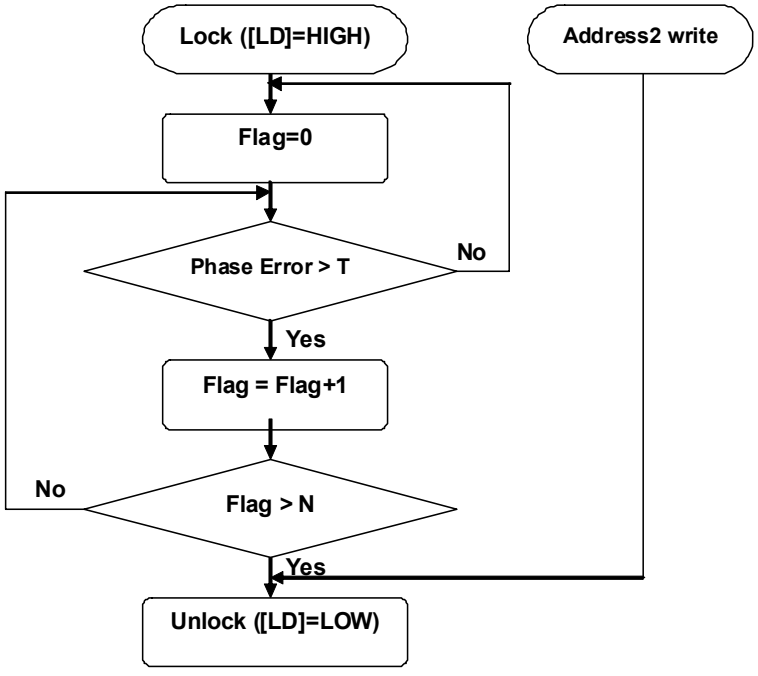


Case of “R > 1”

Digital Lock Detect Operations



Unlock to Lock Operation Flow



Lock to Unlock Operation Flow

5. Reference counter

The reference input can be set with a dividing number in the range of 1 to 16383 using {R[13:0]}, which is an 14-bit address of {D[13:0]} in <Address0>. 0 cannot be set as a dividing number.

6. Prescaler

The dual modulus prescaler (P/P+1) and the swallow counter are used to provide a large dividing ratio.
The prescaler is set by {PRE[1:0]}, which is a 2-bit latch of {D[21:20]} in <Address2>.

{PRE[1:0]}="00Bin", P=8, Dual modulus prescaler 8/9

{PRE[1:0]}="01Bin", P=16, Dual modulus prescaler 16/17

{PRE[1:0]}="10Bin", P=32, Dual modulus prescaler 32/33

{PRE[1:0]}="11Bin", P=64, Dual modulus prescaler 64/65

The maximum prescaler output frequency is 300MHz. P should be set as "RF Input Frequency /P ≤ 300MHz".

7. Power-down and Power-save mode

It is possible to operate in the power-down or power-save mode if necessary by using the external control pin.

Power On

Follow the power-up sequence.

Normal Operation

[PDN]	<Address2>		Function
	{PD2}	{PD1}	
"Low"	X	X	Power Down
"High"	X	0	Normal Operation
"High"	0	1	VBG & LDO : Power UP Synthesizer Circuits : Asynchronous Power Down
"High"	1	1	VBG & LDO : Power UP Synthesizer Circuits : Synchronous Power Down

X : Don't care

9. Register Map

Name	Data	Address	
R Counter	D21 - D0	0	0
N Counter (A and B)		0	1
Function		1	0
Initialization		1	1

Name	D21	D20	D19	D18	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	Address
R Count	0	0	0	LDP	0	0	Low Noise	0	R [13]	R [12]	R [11]	R [10]	R [9]	R [8]	R [7]	R [6]	R [5]	R [4]	R [3]	R [2]	R [1]	R [0]	0x0
N Count	0	0	CP GAIN	B [12]	B [11]	B [10]	B [9]	B [8]	B [7]	B [6]	B [5]	B [4]	B [3]	B [2]	B [1]	B [0]	A [5]	A [4]	A [3]	A [2]	A [1]	A [0]	0x1
Func.	PRE [1]	PRE [0]	PD2	CP2 [2]	CP2 [1]	CP2 [0]	CP1 [2]	CP1 [1]	CP1 [0]	TIMER [3]	TIMER [2]	TIMER [1]	TIMER [0]	FAST [1]	FAST [0]	CP HiZ	CP POLA	LD [2]	LD [1]	LD [0]	PD1	CNTR RST	0x2
Initial.	PRE [1]	PRE [0]	PD2	CP2 [2]	CP2 [1]	CP2 [0]	CP1 [2]	CP1 [1]	CP1 [0]	TIMER [3]	TIMER [2]	TIMER [1]	TIMER [0]	FAST [1]	FAST [0]	CP HiZ	CP POLA	LD [2]	LD [1]	LD [0]	PD1	CNTR RST	0x3

Notes for writing into registers

After powers on AK1548, the initial register value is not defined. It is required to write the data in all addresses in order to commit it.

[Examples of writing into registers]

(Ex. 1) Power-On

- Bring [PDN] to ”0 (Low)”
- Apply VDD
- Program Address0, Address1 and Address2
- Bring [PDN] to ”1 (High)”
- Program {PD1} in Address 2 to “0”

(Ex. 2) Changing frequency settings : Initialization

- Program Address3
- Program Address1

(Ex. 3) Changing frequency settings : Counter reset

- Program Address2. As part of this, load “1” to both {PD1} and {CNTR_RST}.
- Program Address1
- Program Address2. As part of this, load “0” to both {PD1} and {CNTR_RST}.

(Ex. 4) Changing frequency settings : PDN pin method

- Bring [PDN] to ”0 (Low)”
- Program Address1
- Bring [PDN] to ”1 (High)”

10. Function Description - Registers

< Address0 : R Counter >

D[21:19]	D18	D[17:14]	D[13:0]	Address
0	LDP	0	R[13:0]	00

D[21:19], D[17:14] : These bits are set to the following for normal operation

D21	D20	D19		D17	D16	D15	D14
0	0	0		0	0	0	0

LDP : Lock Detect Precision

The counter value for digital lock detect can be set.

D18	Function	Remarks
0	15 times Count	unlocked to locked
	3 times Count	locked to unlocked
1	31 times Count	unlocked to locked
	7 times Count	locked to unlocked

R[13:0] : Reference clock division number

The following settings can be selected for the reference clock division.

The allowed range is 1 (1/1 division) to 16383 (1/16383 division). 0 cannot be set.

The maximum frequency for F_{PFD} is 104MHz.

D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	Function	Remarks
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Prohibited
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1/1 division	
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1/2 division	
0	0	0	0	0	0	0	0	0	0	0	0	1	1	1/3 division	
0	0	0	0	0	0	0	0	0	0	0	1	0	0	1/4 division	
DATA															
1	1	1	1	1	1	1	1	1	1	1	1	0	1	1/16381 division	
1	1	1	1	1	1	1	1	1	1	1	1	1	0	1/16382 division	
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1/16383 division	

< Address1 : N Counter >

D[21:20]	D19	D[18:6]	D[5:0]	Address
0	CPGAIN	B[12:0]	A[5:0]	01

D21, D20 : These bits are set to the following for normal operation

D21	D20
0	0

CPGAIN : Sets the charge pump current

When {FAST[1:0]} is NOT ”11Bin” :

D19	Function	Remarks
0	CP1 is enabled	
1	CP2 is enabled	

When {FAST[1:0]} is ”11Bin” :

D19	Function	Remarks
0	CP1 is enabled	
1	CP2 is enabled, also Timer is enabled	

B[12:0] : B (Programmable) counter value

D18	D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	Function	Remarks
0	0	0	0	0	0	0	0	0	0	0	0	0	0	Prohibited
0	0	0	0	0	0	0	0	0	0	0	0	1	1 Dec	Prohibited
0	0	0	0	0	0	0	0	0	0	0	1	0	2 Dec	Prohibited
0	0	0	0	0	0	0	0	0	0	0	1	1	3 Dec	
DATA														
1	1	1	1	1	1	1	1	1	1	1	0	1	8189 Dec	
1	1	1	1	1	1	1	1	1	1	1	1	0	8190 Dec	
1	1	1	1	1	1	1	1	1	1	1	1	1	8191 Dec	

A[5:0] : A (Swallow) counter value

D5	D4	D3	D2	D1	D0	Function	Remarks
0	0	0	0	0	0	0	
0	0	0	0	0	1	1 Dec	
0	0	0	0	1	0	2 Dec	
0	0	0	0	1	1	3 Dec	
DATA							
1	1	1	1	0	1	61 Dec	
1	1	1	1	1	0	62 Dec	
1	1	1	1	1	1	63 Dec	

*** Requirements for A[5:0] and B[12:0]**

The data at A[5:0] and B[12:0] must meet the following requirements:

$A[5:0] \geq 0,\ B[12:0] \geq 3,\ B[12:0] \geq A[5:0]$

See “Frequency Setup” in section “Block Functional Descriptions” for details of the relationship between a frequency division number N and the data at A[5:0] and B[12:0].

< Address2 : Function >

D[21:20]	D19	D[18:16]	D[15:13]	D[12:9]	D[8:7]
PRE[1:0]	PD2	CP2[2:0]	CP1[2:0]	TIMER[3:0]	FAST[1:0]

D6	D5	D[4:2]	D1	D0	Address
CPHIZ	CPPOLA	LD[2:0]	PD1	CNTR_RST	02

PRE[1:0] : Selects a dividing ratio for the prescaler

The prescaler value should be chosen so that the prescaler output frequency is always less than or equal to 300MHz.

D21	D20	Function	Remarks
0	0	P=8, Dual modulus prescaler 8/9	
0	1	P=16, Dual modulus prescaler 16/17	
1	0	P=32, Dual modulus prescaler 32/33	
1	1	P=64, Dual modulus prescaler 64/65	

PD2, PD1 : Power Down Select

[PDN]	<Address2>		Function
	{PD2}	{PD1}	
“Low”	X	X	Power Down
“High”	X	0	Normal Operation
“High”	0	1	VBG & LDO : Power UP Synthesizer Circuits : Asynchronous Power Down
“High”	1	1	VBG & LDO : Power UP Synthesizer Circuits : Synchronous Power Down

X : Don’t care (recommended “0”)

{PD2}=1 and {PD1}=1 : Synthesizer circuits powers down at the timing when the Phase detector frequency signal reverses.

{PD2}=0 and {PD1}=1 : Synthesizer circuits goes into Power Down during the rise up of LE signal that latches 1 into {PD1}.

CP2[2:0] : Charge pump current setting 2

CP1[2:0] : Charge pump current setting 1

AK1548 provides two setting for charge pump current. They can be set by {CP1} and {CP2}.

The following formula shows the relationship among the resistance value, the register setting and the electric current that is used for LPF band calculation (tran_Icp).

tran_Icp [A] = Icp_min [A] × ({CP1} or {CP2} setting +1)

Charge pump minimum current (Icp_min)[A]

= (0.85×1.164×15) / Resistance connected to the BIAS pin [ohm]

The following table shows the typical tran_Icp for each status.

t ran_Icp (typical) [Unit : μA]

D18	D17	D16	Bias Resistance			Remarks
D15	D14	D13	33 kΩ	27 kΩ	22 kΩ	
0	0	0	450	550	675	
0	0	1	900	1100	1350	
0	1	0	1350	1650	2025	
0	1	1	1800	2200	2700	
1	0	0	2250	2750	3375	
1	0	1	2700	3300	4050	
1	1	0	3150	3850	4725	
1	1	1	3600	4400	5400	

The following formula shows the relationship among the resistance value, the register setting and the electric current that can be measured (Icp).

Icp [A] = Icp_min [A] × ({CP1} or {CP2} setting +1)

Charge pump minimum current (Icp_min)[A]

= (1.164×15) / Resistance connected to the BIAS pin [ohm]

The following table shows the typical tran_Icp for each status.

Icp (typical) [Unit : μA]

D18	D17	D16	Bias Resistance			Remarks
D15	D14	D13	33 kΩ	27 kΩ	22 kΩ	
0	0	0	529	647	794	
0	0	1	1058	1293	1587	
0	1	0	1587	1940	2381	
0	1	1	2116	2587	3175	
1	0	0	2645	3233	3968	
1	0	1	3175	3880	4762	
1	1	0	3704	4527	5555	
1	1	1	4233	5173	6349	

TIMER[3:0] : Sets the switchover time for CP2-to-CP1

This is enabled when {FAST[1:0]} is ”11Bin” and {[CPGAIN}=”1”.

The charge pump current is set into value {CP2[2:0]} designate during switchover time. It goes to be {CP1[2:0]} setting value after the time out.

The following formula shows the relationship between the switchover time and the counter value.

Switchover time = 1/ F_{PFD} × Counter Value

Counter Value = 3 + Timer[3:0] × 4

The following table shows the relationship between counter value and {TIMER[3:0]}.

D12	D11	D10	D9	Function	Remarks
0	0	0	0	3 Counts	
0	0	0	1	7 Counts	
0	0	1	0	11 Counts	
0	0	1	1	15 Counts	
0	1	0	0	19 Counts	
0	1	0	1	23 Counts	
0	1	1	0	27 Counts	
0	1	1	1	31 Counts	
1	0	0	0	35 Counts	
1	0	0	1	39 Counts	
1	0	1	0	43 Counts	
1	0	1	1	47 Counts	
1	1	0	0	51 Counts	
1	1	0	1	55 Counts	
1	1	1	0	59 Counts	
1	1	1	1	63 Counts	

FAST[1:0] : Enables or disables the Fast Lock mode

When {FAST[1:0]} is ”11Bin”, {CPGAIN} of function latch is the Fast Lock mode bit. When Fast Lock is enabled, charge pump current is set to the value of {CP2} setting during the switchover time under the control of the timer counter. After the timeout, {CPGAIN} is reset into “0” and charge pump current goes to be {CP1} setting value.

D8	D7	{CPGAIN}	Function	Remarks
X	0	0	{CP1} is enabled	
		1	{CP2} is enabled	
0	1	0	{CP1} is enabled	
		1	{CP2} is enabled	
1	1	0	{CP1} is enabled	
		1	{CP2} is enabled, and switchover operates.	{CPGAIN} is reset to “0” after timeout.

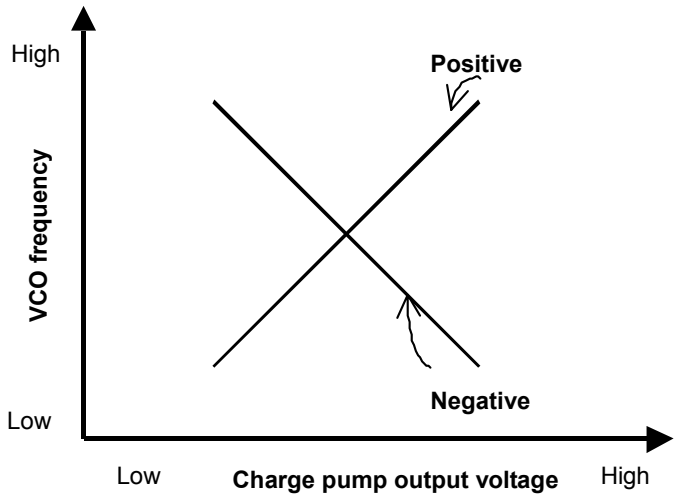
CPHIZ : TRI-STATE output setting for charge pump

D6	Function	Remarks
0	Charge pumps are activated.	Use this setting for normal operation.
1	TRI-STATE	Note 1)

Note 1) The charge pump output is turned OFF and put in the high-impedance (Hi-Z) state.

CPPOLA : Selects positive or negative output polarity for CP1 and CP2

D5	Function	Remarks
0	Negative	
1	Positive	



LD : Selects output from [LD] pin

D4	D3	D2	Function	Remarks
0	0	1	Digital lock detect	
1	0	1	Analog lock detect	

CNTR_RST : Counter Reset

D0	Function	Remarks
0	Normal operation	
1	R and N counters are reset.	

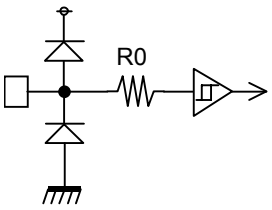
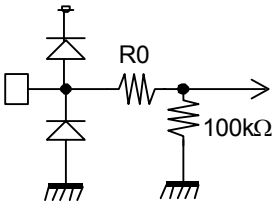
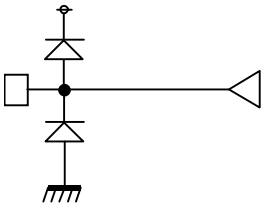
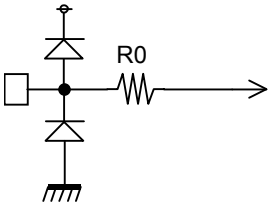
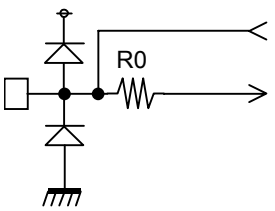
< Address3 : Initialization >

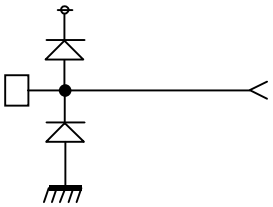
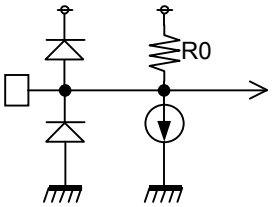
This function is same as <Address2>.

When this register is accessed, the following occurs :

- Address2 is loaded.
- An internal pulse resets the R counter, N counter and {TIMER} settings to load-state conditions, and also charge pump to Tri-state.
- Writing Address1 activates the R and N counter, {TIMER} and charge pump. {TIMER} is enabled when {FAST}="11Bin" and {CPGAIN}="1".

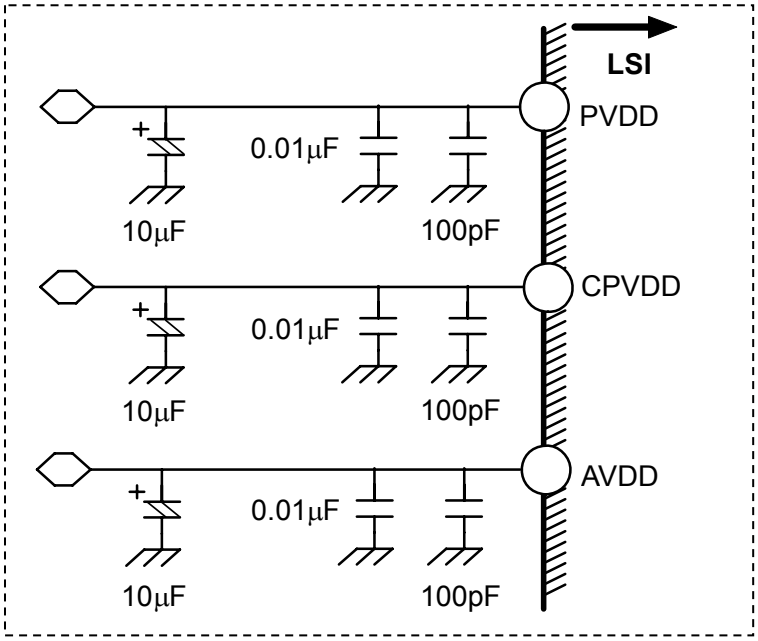
11. IC Interface Schematic

No.	Pin name	I/O	R0(Ω)	Cur(μA)	Function
11	PDN	I	300		**Digital input pin** 
12	CLK	I	300		
13	DATA	I	300		
14	LE	I	300		
2	TEST1	I	300		**Digital input pin (Pull-Down)** 
10	TEST2	I	300		
15	LD	O			**Digital output pin** 
8	REFIN	I	300		**Analog input pin** 
19	BIAS	IO	300		**Analog input/output pin** 
7	VREF1	IO	300		
17	VREF2	IO	300		

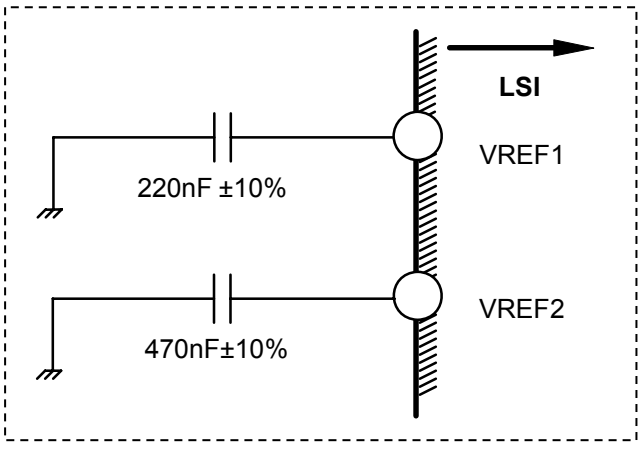
No.	Pin name	I/O	R0(Ω)	Cur(μA)	Function
20	CP	O			**Analog output pin** 
4	RFINN	I	12k	20	**Analog input pin (RF input pin)**
5	RFINP	I	12k	20	

12. Recommended Connection Schematic of Off-Chip Component

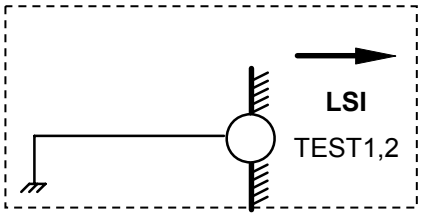
1. Power Supply Pins



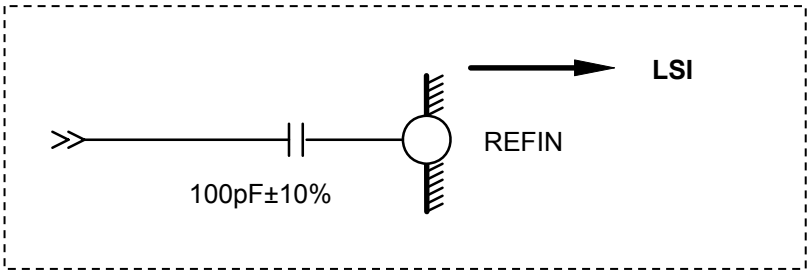
2. VREF1, VREF2



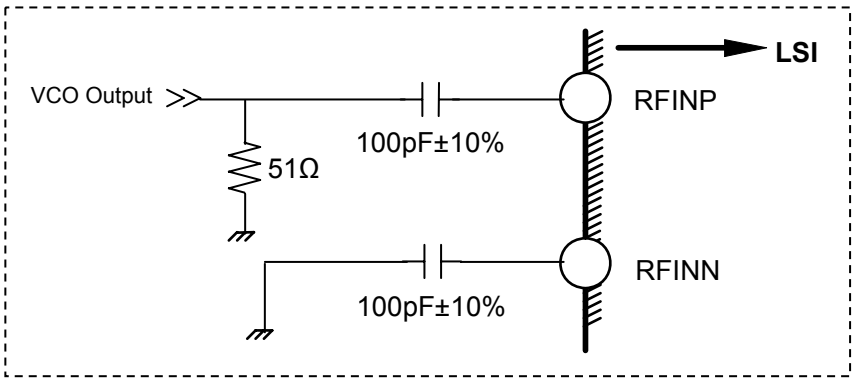
3. TEST1, TEST2



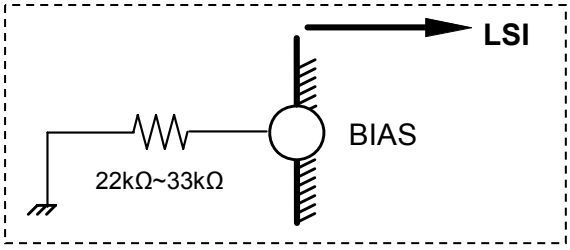
4. REFIN



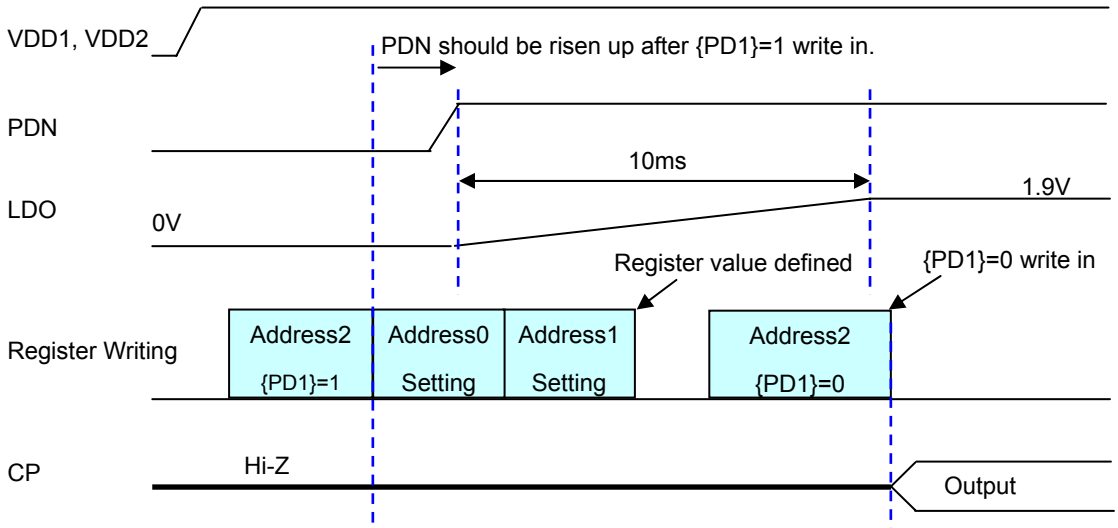
5. RFINP、RFINN



6. BIAS

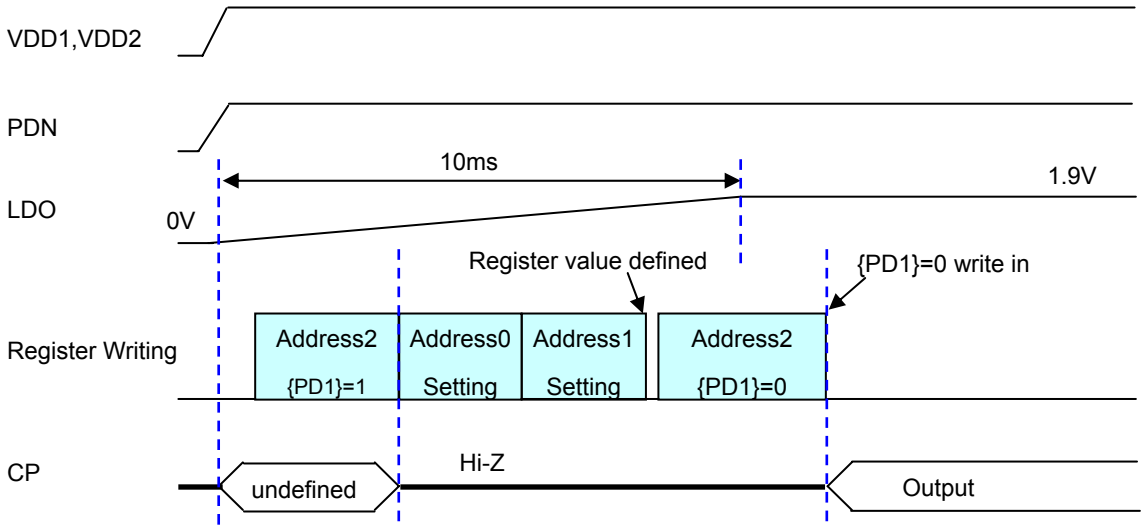

LSI
BIAS
22kΩ~33kΩ

13. Block Power-Up Timing Chart (Recommended Flow)



Power-Up Sequence (PDN control case)

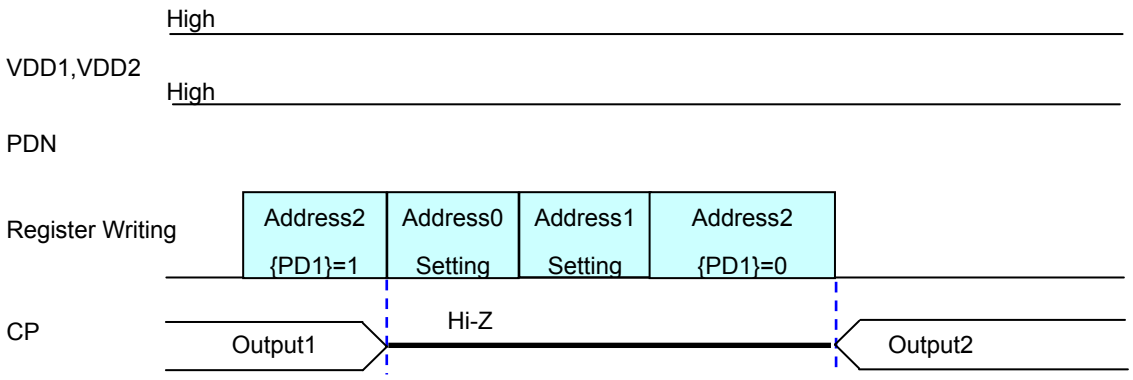
Note) After powers on, the initial setting of registers is undefined. It is required to write in Address0, 1 and 2 to settle them. It is recommended that [PDN] pin is risen up after Address2 {PD1}=1 write in. It takes about 10ms from PDN rise-up to LDO rise-up. The power-up by register ({PD1}=0 write in) should be done after LDO rise-up.



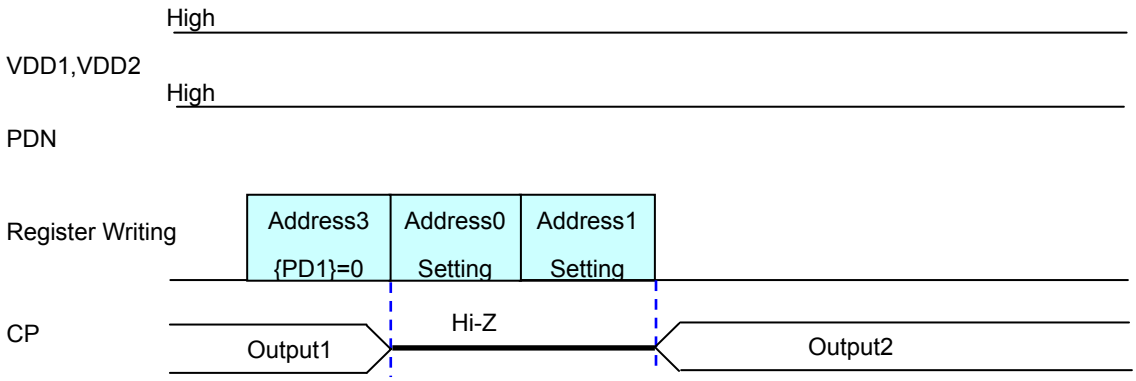
Power-Up Sequence (VDD1/VDD2/PDN simultaneous power-up)

Note) After powers on, the initial setting of registers is undefined. It is required to write in Address0, 1 and 2 to settle them. It takes about10ms from PDN rise-up to LDO rise-up. The power-up by register ({PD1}=0 write in) should be done after LDO rise-up.

14. Frequency Change Timing Chart (Recommended Flow)



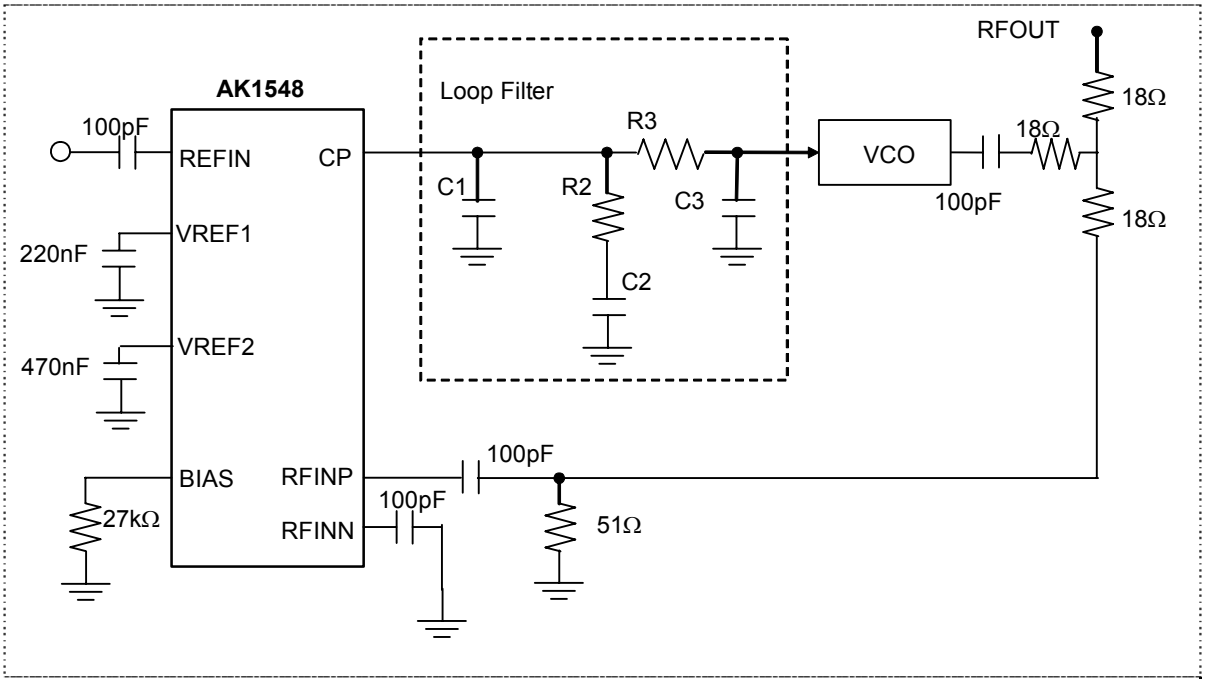
Frequency Change Sequence ({PD1} control)



Frequency Change Sequence (Initialization Register control)

Note) The data on Address3 is same as Address2, but {PD1} should be set “0”. Writing in Address3 puts CP output to Hi-Z. The rise-up of LE signal at writing in Address1, which is subsequent frequency setting up sequence, is trigger for CP Output.

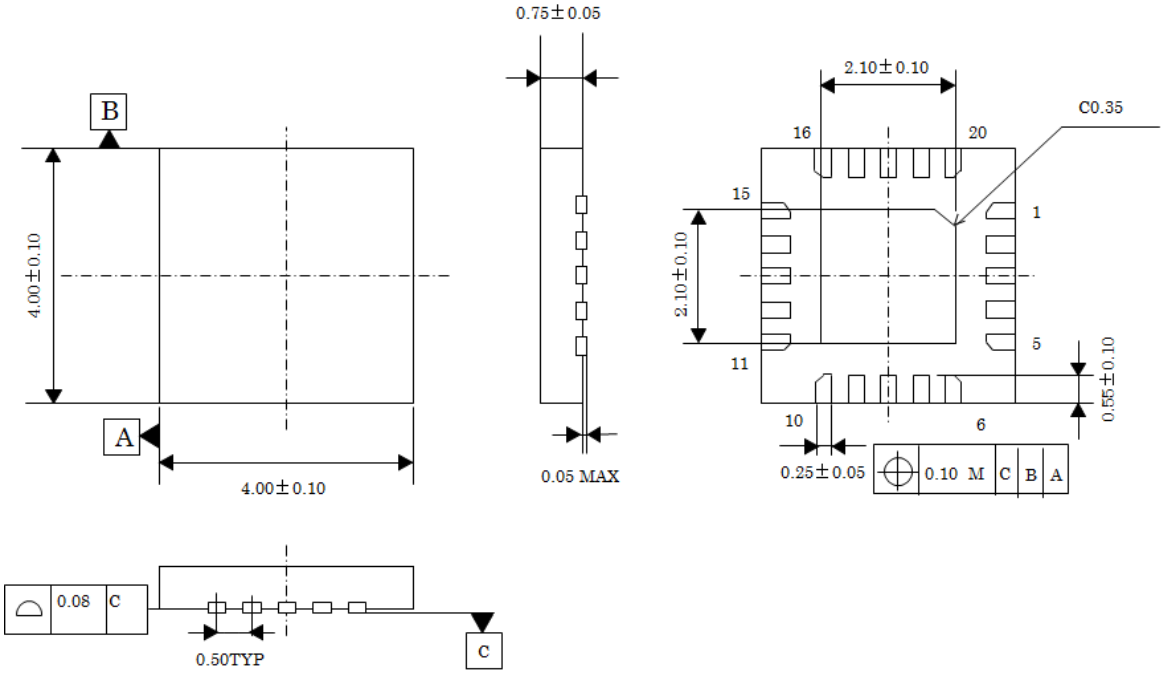
Typical Evaluation Board Schematic



Note1) Although it is no problem that both of [TEST1] and [TEST2] are open, it is recommended that they should be connected to ground.

Note2) Although it is no problem that Exposed Pad at the center of the backside is open, it is recommended that it should be connected to ground.

15. Outer Dimensions



Note) The exposed pad at the center of the backside should be connected to ground.

16. Marking

a. S tyle : QFN

b. Number of pins : 20

c. A1 pin marking : ●

d. Product number : 154 8

e. Da te code : YWWL (4 digits)

Y : Lower 1 digit of calendar year

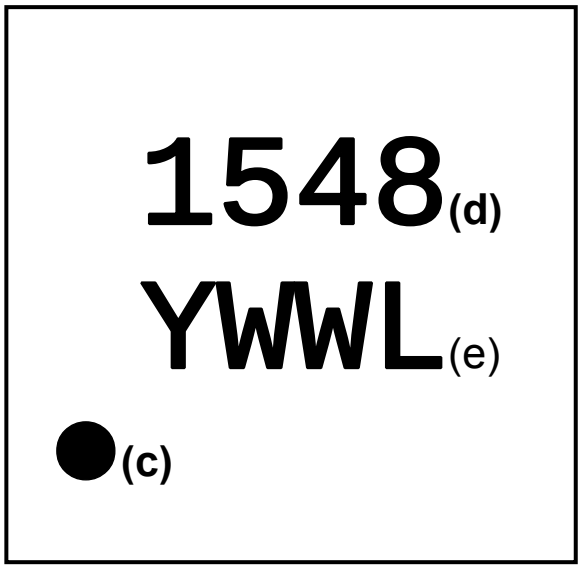
(Year 2012-> 2, 2013-> 3 ...)

WW : Week

L : Lot identification, given to each product lot which is made in a week

(A, B, C…)

→ LOT ID is given in alphabetical order



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