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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



# ADC1415S series

Single 14-bit ADC; 65 Msps, 80 Msps, 105 Msps or 125 Msps with input buffer; CMOS or LVDS DDR digital outputs

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Product data sheet

## 1. General description

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The ADC1415S is a single channel 14-bit Analog-to-Digital Converter (ADC) optimized for high dynamic performance and low power consumption at sample rates up to 125 Msps. Pipelined architecture and output error correction ensure the ADC1415S is accurate enough to guarantee zero missing codes over the entire operating range. Supplied from a single 3 V source, it can handle output logic levels from 1.8 V to 3.3 V in CMOS mode, thanks to a separate digital output supply.

The ADC1415S supports the Low Voltage Differential Signalling (LVDS) Double Data Rate (DDR) output standard. An integrated Serial Peripheral Interface (SPI) allows the user to easily configure the ADC.

The device also includes a SPI programmable full-scale to allow flexible input voltage range from 1 V to 2 V (peak-to-peak). With excellent dynamic performance from the baseband to input frequencies of 170 MHz or more, the ADC1415S is ideal for use in communications, imaging and medical applications - especially in high Intermediate Frequency (IF) applications thanks to the integrated input buffer. The input buffer ensures that the input impedance remains constant and low and the performance consistent over a wide frequency range.

## 2. Features and benefits

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- SNR, 72 dBFS; SFDR, 86 dBc
- Sample rate up to 125 Msps
- 14-bit pipelined ADC core
- Clock input divided by 2 for less jitter contribution
- Integrated input buffer
- Flexible input voltage range: 1 V (p-p) to 2 V (p-p)
- CMOS or LVDS DDR digital outputs
- Pin compatible with ADC1215S series, ADC1015S series and the ADC1115S125
- Input bandwidth, 600 MHz
- Power dissipation, 635 mW at 80 Msps, including analog input buffer
- Serial Peripheral Interface (SPI)
- Duty cycle stabilizer
- Fast Out-of-Range (OTR) detection
- Offset binary, two's complement, gray code
- Power-down mode and Sleep mode
- HVQFN40 package



### 3. Applications

- Wireless and wired broadband communications
- Portable instrumentation
- Imaging systems
- Digital predistortion loop, power amplifier linearization
- Spectral analysis
- Ultrasound equipment
- Software defined radio

### 4. Ordering information

Table 1. Ordering information

Type number	f <sub>s</sub> (Msp/s)	Package		Version
		Name	Description	
ADC1415S125HN/C1	125	HVQFN40	plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; body 6 × 6 × 0.85 mm	SOT618-6
ADC1415S105HN/C1	105	HVQFN40	plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; body 6 × 6 × 0.85 mm	SOT618-6
ADC1415S080HN/C1	80	HVQFN40	plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; body 6 × 6 × 0.85 mm	SOT618-6
ADC1415S065HN/C1	65	HVQFN40	plastic thermal enhanced very thin quad flat package; no leads; 40 terminals; body 6 × 6 × 0.85 mm	SOT618-6

## 5. Block diagram

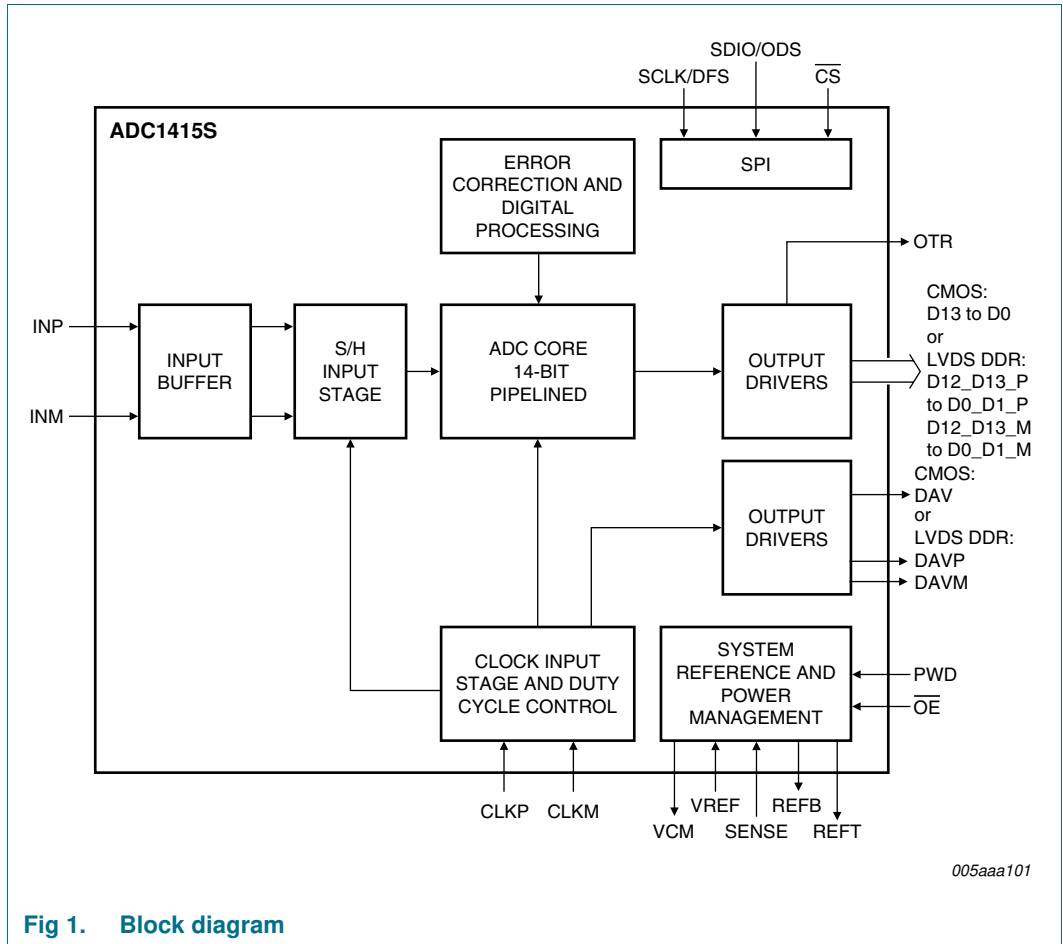


Fig 1. Block diagram

## 6. Pinning information

### 6.1 Pinning

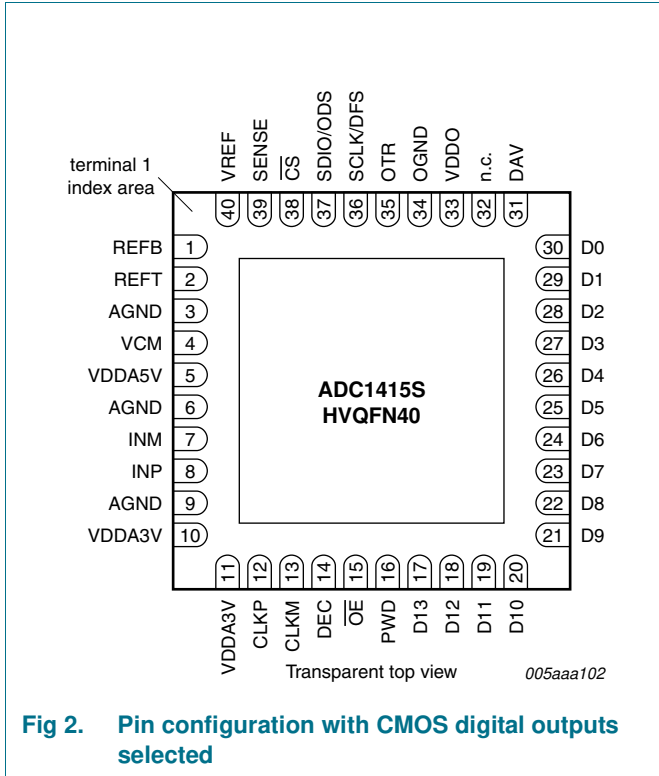


Fig 2. Pin configuration with CMOS digital outputs selected

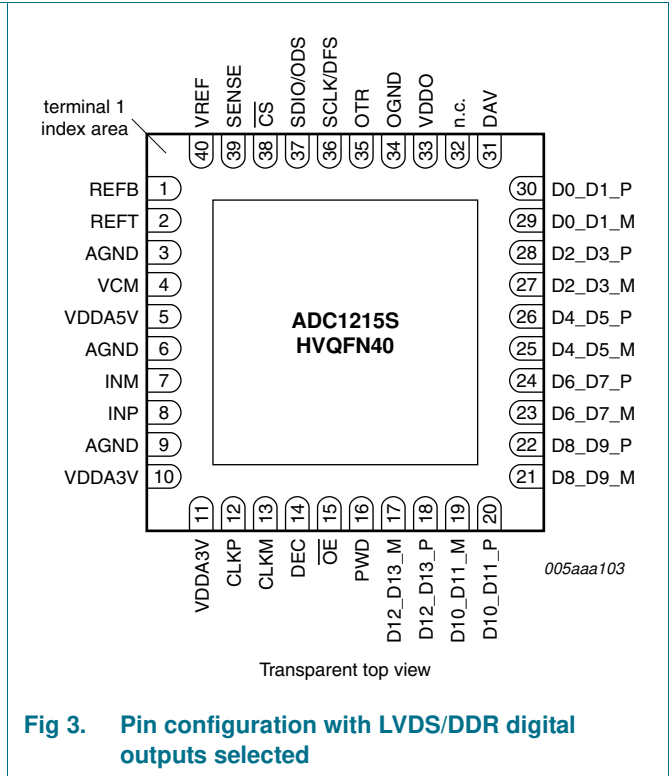


Fig 3. Pin configuration with LVDS/DDR digital outputs selected

### 6.2 Pin description

Table 2. Pin description (CMOS digital outputs)

Symbol	Pin	Type <sup>[1]</sup>	Description
REFB	1	O	bottom reference
REFT	2	O	top reference
AGND	3	G	analog ground
VCM	4	O	common-mode output voltage
VDDA5V	5	P	5 V analog power supply
AGND	6	G	analog ground
INM	7	I	complementary analog input
INP	8	I	analog input
AGND	9	G	analog ground
VDDA3V	10	P	3 V analog power supply
VDDA3V	11	P	3 V analog power supply
CLKP	12	I	clock input
CLKM	13	I	complementary clock input
DEC	14	O	regulator decoupling node
$\overline{OE}$	15	I	output enable, active LOW
PWD	16	I	power down, active HIGH

Table 2. Pin description (CMOS digital outputs) ...continued

Symbol	Pin	Type <sup>[1]</sup>	Description
D13	17	O	data output bit 13 (Most Significant Bit (MSB))
D12	18	O	data output bit 12
D11	19	O	data output bit 11
D10	20	O	data output bit 10
D9	21	O	data output bit 9
D8	22	O	data output bit 8
D7	23	O	data output bit 7
D6	24	O	data output bit 6
D5	25	O	data output bit 5
D4	26	O	data output bit 4
D3	27	O	data output bit 3
D2	28	O	data output bit 2
D1	29	O	data output bit 1
D0	30	O	data output bit 0 (Least Significant Bit (LSB))
DAV	31	O	data valid output clock
n.c.	32	-	not connected
VDDO	33	P	output power supply
OGND	34	G	output ground
OTR	35	O	out of range
SCLK/DFS	36	I	SPI clock / data format select
SDIO/ODS	37	I/O	SPI data IO / output data standard
$\overline{\text{CS}}$	38	I	SPI chip select
SENSE	39	I	reference programming pin
VREF	40	I/O	voltage reference input/output

[1] P: power supply; G: ground; I: input; O: output; I/O: input/output.

Table 3. Pin description (LVDS DDR) digital outputs

Symbol	Pin <sup>[1]</sup>	Type <sup>[2]</sup>	Description
D12_D13_M	17	O	differential output data D12 and D13 multiplexed, complement
D12_D13_P	18	O	differential output data D12 and D13 multiplexed, true
D10_D11_M	19	O	differential output data D10 and D11 multiplexed, complement
D10_D11_P	20	O	differential output data D10 and D11 multiplexed, true
D8_D9_M	21	O	differential output data D8 and D9 multiplexed, complement
D8_D9_P	22	O	differential output data D8 and D9 multiplexed, true
D6_D7_M	23	O	differential output data D6 and D7 multiplexed, complement
D6_D7_P	24	O	differential output data D6 and D7 multiplexed, true
D4_D5_M	25	O	differential output data D4 and D5 multiplexed, complement
D4_D5_P	26	O	differential output data D4 and D5 multiplexed, true
D2_D3_M	27	O	differential output data D2 and D3 multiplexed, complement
D2_D3_P	28	O	differential output data D2 and D3 multiplexed, true
D0_D1_M	29	O	differential output data D0 and D1 multiplexed, complement

**Table 3. Pin description ...continued (LVDS DDR) digital outputs)**

Symbol	Pin <sup>[1]</sup>	Type <sup>[2]</sup>	Description
D0_D1_P	30	O	differential output data D0 and D1 multiplexed, true
DAVM	31	O	data valid output clock, complement
DAVP	32	O	data valid output clock, true

[1] Pins 1 to 16 and pins 33 to 40 are the same for both CMOS and LVDS DDR outputs (see [Table 2](#))

[2] P: power supply; G: ground; I: input; O: output; I/O: input/output.

## 7. Limiting values

**Table 4. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>O</sub>	output voltage	pins D13 to D0 or pins D12_D13_P to D0_D1_P and D12_D13_M to D0_D1_M	-0.4	+3.9	V
V <sub>DDA(3V)</sub>	analog supply voltage 3 V	on pin VDDA3V	-0.4	+4.6	V
V <sub>DDA(5V)</sub>	analog supply voltage 5 V	on pin VDDA5V	-0.5	+6.0	V
V <sub>DDO</sub>	output supply voltage		-0.4	+4.6	V
T <sub>stg</sub>	storage temperature		-55	+125	°C
T <sub>amb</sub>	ambient temperature		-40	+85	°C
T <sub>j</sub>	junction temperature		-	125	°C

## 8. Thermal characteristics

**Table 5. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient		<a href="#">[1]</a> 30.5	K/W
R <sub>th(j-c)</sub>	thermal resistance from junction to case		<a href="#">[1]</a> 13.3	K/W

[1] Value for six layers board in still air with a minimum of 25 thermal vias.

## 9. Static characteristics

Table 6. Static characteristics<sup>[1]</sup>

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supplies</b>						
$V_{DDA(5V)}$	analog supply voltage 5 V		4.75	5.0	5.25	V
$V_{DDA(3V)}$	analog supply voltage 3 V		2.85	3.0	3.4	V
$V_{DDO}$	output supply voltage	CMOS mode	1.65	1.8	3.6	V
		LVDS DDR mode	2.85	3.0	3.6	V
$I_{DDA(5V)}$	analog supply current 5 V	$f_{clk} = 125$ Msps; $f_i = 70$ MHz	-	46	-	mA
$I_{DDA(3V)}$	analog supply current 3 V	$f_{clk} = 125$ Msps; $f_i = 70$ MHz	-	205	-	mA
$I_{DDO}$	output supply current	CMOS mode; $f_{clk} = 125$ Msps; $f_i = 70$ MHz	-	14	-	mA
		LVDS DDR mode: $f_{clk} = 125$ Msps; $f_i = 70$ MHz	-	43	-	mA
P	power dissipation	ADC1415S125; analog supply only	-	840	-	mW
		ADC1415S105; analog supply only	-	770	-	mW
		ADC1415S080; analog supply only	-	635	-	mW
		ADC1415S065; analog supply only	-	580	-	mW
		Power-down mode	-	2	-	mW
		Standby mode	-	40	-	mW
<b>Clock inputs: pins CLKP and CLKM</b>						
<b>LVPECL</b>						
$V_{i(clk)dif}$	differential clock input voltage	peak-to-peak		1.6	-	V
<b>SINE wave</b>						
$V_{i(clk)dif}$	differential clock input voltage	peak	-	$\pm 3.0$	-	V
<b>LVC MOS</b>						
$V_{IL}$	LOW-level input voltage		-	-	$0.3V_{DDA(3V)}$	V
$V_{IH}$	HIGH-level input voltage		$0.7V_{DDA(3V)}$	-	-	V
<b>Logic inputs: pins PWD and <math>\overline{OE}</math></b>						
$V_{IL}$	LOW-level input voltage		0	-	0.8	V
$V_{IH}$	HIGH-level input voltage		2	-	$V_{DDA(3V)}$	V
$I_{IL}$	LOW-level input current		-	55	-	$\mu A$
$I_{IH}$	HIGH-level input current		-	65	-	$\mu A$
<b>Serial peripheral interface: pins <math>\overline{CS}</math>, SDIO/ODS, SCLK/DFS</b>						
$V_{IL}$	LOW-level input voltage		0	-	$0.3V_{DDA(3V)}$	V
$V_{IH}$	HIGH-level input voltage		$0.7V_{DDA(3V)}$	-	$V_{DDA(3V)}$	V



Table 6. Static characteristics<sup>[1]</sup> ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$I_{IL}$	LOW-level input current		-10	-	+10	$\mu\text{A}$
$I_{IH}$	HIGH-level input current		-50	-	+50	$\mu\text{A}$
$C_I$	input capacitance		-	4	-	pF
<b>Digital outputs, CMOS mode: pins D13 to D0, OTR, DAV</b>						
Output levels, $V_{DDO} = 3\text{ V}$						
$V_{OL}$	LOW-level output voltage		OGND	-	$0.2V_{DDO}$	V
$V_{OH}$	HIGH-level output voltage		$0.8V_{DDO}$	-	$V_{DDO}$	V
$C_O$	output capacitance	high impedance; OE = HIGH	-	3	-	pF
Output levels, $V_{DDO} = 1.8\text{ V}$						
$V_{OL}$	LOW-level output voltage		OGND	-	$0.2V_{DDO}$	V
$V_{OH}$	HIGH-level output voltage		$0.8V_{DDO}$	-	$V_{DDO}$	V
<b>Digital outputs, LVDS mode: pins D12_D13_P to D0_D1_P, D12_D13_M to D0_D1_M, DAVP and DAVM</b>						
Output levels, $V_{DDO} = 3\text{ V}$ only, $R_{load} = 100\ \Omega$						
$V_{O(\text{offset})}$	output offset voltage	output buffer current set to 3.5 mA	-	1.2	-	V
$V_{O(\text{dif})}$	differential output voltage	output buffer current set to 3.5 mA	-	350	-	mV
$C_O$	output capacitance		-	3	-	pF
<b>Analog inputs: pins INP and INM</b>						
$I_I$	input current		-5	-	+5	$\mu\text{A}$
$R_I$	input resistance		-	550	-	$\Omega$
$C_I$	input capacitance		-	1.3	-	pF
$V_{I(\text{cm})}$	common-mode input voltage	$V_{INP} = V_{INM}$	0.9	1.5	2	V
$B_i$	input bandwidth		-	600	-	MHz
$V_{I(\text{dif})}$	differential input voltage	peak-to-peak	1	-	2	V
<b>Common mode output voltage: pin VCM</b>						
$V_{O(\text{cm})}$	common-mode output voltage		-	$0.5V_{DDA(3V)}$	-	V
$I_{O(\text{cm})}$	common-mode output current		-	4	-	mA
<b>I/O reference voltage: pin VREF</b>						
$V_{VREF}$	voltage on pin VREF	output	-	0.5 to 1	-	V
		input	0.5	-	1	V

**Table 6. Static characteristics**<sup>[1]</sup> ...continued

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Accuracy</b>						
INL	integral non-linearity		-5	-	+5	LSB
DNL	differential non-linearity	guaranteed no missing codes	-0.95	±0.5	+0.95	LSB
E <sub>offset</sub>	offset error		-	±2	-	mV
E <sub>G</sub>	gain error		-	±0.5	-	%FS
<b>Supply</b>						
PSRR	power supply rejection ratio	200 mV (p-p) on V <sub>DDA(3V)</sub>	-	-54	-	dBc

[1] Typical values measured at V<sub>DDA(3V)</sub> = 3 V, V<sub>DDO</sub> = 1.8 V, V<sub>DDA(5V)</sub> = 5 V; T<sub>amb</sub> = 25 °C and C<sub>L</sub> = 5 pF; minimum and maximum values are across the full temperature range T<sub>amb</sub> = -40 °C to +85 °C at V<sub>DDA(3V)</sub> = 3 V, V<sub>DDO</sub> = 1.8 V, V<sub>DDA(5V)</sub> = 5 V, V<sub>INP</sub> - V<sub>INM</sub> = -1 dBFS; internal reference mode; applied to CMOS and LVDS interface; unless otherwise specified.

## 10. Dynamic characteristics

### 10.1 Dynamic characteristics

Table 7. Dynamic characteristics<sup>[1]</sup>

Symbol	Parameter	Conditions	ADC1415S065			ADC1415S080			ADC1415S105			ADC1415S125			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>Analog signal processing</b>															
$\alpha_{2H}$	second harmonic level	$f_i = 3$ MHz	-	87	-	-	87	-	-	86	-	-	88	-	dBc
		$f_i = 30$ MHz	-	86	-	-	86	-	-	86	-	-	87	-	dBc
		$f_i = 70$ MHz	-	85	-	-	85	-	-	84	-	-	85	-	dBc
		$f_i = 170$ MHz	-	82	-	-	82	-	-	81	-	-	83	-	dBc
$\alpha_{3H}$	third harmonic level	$f_i = 3$ MHz	-	86	-	-	86	-	-	85	-	-	87	-	dBc
		$f_i = 30$ MHz	-	85	-	-	85	-	-	85	-	-	86	-	dBc
		$f_i = 70$ MHz	-	84	-	-	84	-	-	83	-	-	84	-	dBc
		$f_i = 170$ MHz	-	81	-	-	81	-	-	80	-	-	82	-	dBc
THD	total harmonic distortion	$f_i = 3$ MHz	-	83	-	-	83	-	-	82	-	-	84	-	dBc
		$f_i = 30$ MHz	-	82	-	-	82	-	-	82	-	-	83	-	dBc
		$f_i = 70$ MHz	-	81	-	-	81	-	-	80	-	-	81	-	dBc
		$f_i = 170$ MHz	-	78	-	-	78	-	-	77	-	-	79	-	dBc
ENOB	effective number of bits	$f_i = 3$ MHz	-	11.7	-	-	11.7	-	-	11.6	-	-	11.6	-	bits
		$f_i = 30$ MHz	-	11.6	-	-	11.5	-	-	11.5	-	-	11.5	-	bits
		$f_i = 70$ MHz	-	11.5	-	-	11.5	-	-	11.4	-	-	11.4	-	bits
		$f_i = 170$ MHz	-	11.4	-	-	11.4	-	-	11.3	-	-	11.3	-	bits
SNR	signal-to-noise ratio	$f_i = 3$ MHz	-	72.1	-	-	72.0	-	-	71.8	-	-	71.4	-	dBFS
		$f_i = 30$ MHz	-	71.3	-	-	71.2	-	-	71.2	-	-	71.1	-	dBFS
		$f_i = 70$ MHz	-	70.7	-	-	70.7	-	-	70.6	-	-	70.5	-	dBFS
		$f_i = 170$ MHz	-	70.2	-	-	70.1	-	-	70.0	-	-	69.9	-	dBFS
SFDR	spurious-free dynamic range	$f_i = 3$ MHz	-	86	-	-	86	-	-	85	-	-	87	-	dBc
		$f_i = 30$ MHz	-	85	-	-	85	-	-	85	-	-	86	-	dBc
		$f_i = 70$ MHz	-	84	-	-	84	-	-	83	-	-	84	-	dBc
		$f_i = 170$ MHz	-	81	-	-	81	-	-	80	-	-	82	-	dBc

Table 7. Dynamic characteristics<sup>[1]</sup> ...continued

Symbol	Parameter	Conditions	ADC1415S065			ADC1415S080			ADC1415S105			ADC1415S125			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
IMD	Intermodulation distortion	$f_i = 3 \text{ MHz}$	-	89	-	-	89	-	-	88	-	-	89	-	dBc
		$f_i = 30 \text{ MHz}$	-	88	-	-	88	-	-	88	-	-	88	-	dBc
		$f_i = 70 \text{ MHz}$	-	87	-	-	87	-	-	86	-	-	86	-	dBc
		$f_i = 170 \text{ MHz}$	-	84	-	-	85	-	-	83	-	-	84	-	dBc

[1] Typical values measured at  $V_{DDA(3V)} = 3 \text{ V}$ ,  $V_{DDO} = 1.8 \text{ V}$ ,  $V_{DDA(5V)} = 5 \text{ V}$ ;  $T_{\text{amb}} = 25 \text{ }^\circ\text{C}$  and  $C_L = 5 \text{ pF}$ ; minimum and maximum values are across the full temperature range  $T_{\text{amb}} = -40 \text{ }^\circ\text{C}$  to  $+85 \text{ }^\circ\text{C}$  at  $V_{DDA(3V)} = 3 \text{ V}$ ,  $V_{DDO} = 1.8 \text{ V}$ ,  $V_{DDA(5V)} = 5 \text{ V}$ ,  $V_{\text{INP}} - V_{\text{INM}} = -1 \text{ dBFS}$ ; internal reference mode; applied to CMOS and LVDS interface; unless otherwise specified.

## 10.2 Clock and digital output timing

**Table 8. Clock and digital output timing characteristics<sup>[1]</sup>**

Symbol	Parameter	Conditions	ADC1410S065			ADC1410S080			ADC1410S105			ADC1410S125			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
<b>Clock timing input: pins CLKP and CLKM</b>															
f <sub>clk</sub>	clock frequency		40	-	65	60	-	80	75	-	105	100	-	125	MHz
t <sub>lat(data)</sub>	data latency time		-	13.5	-	-	13.5	-	-	13.5	-	-	13.5	-	clock cycles
δ <sub>clk</sub>	clock duty cycle	DCS_EN = 1	30	50	70	30	50	70	30	50	70	30	50	70	%
		DCS_EN = 0	45	50	55	45	50	55	45	50	55	45	50	55	%
t <sub>d(s)</sub>	sampling delay time		-	0.8	-	-	0.8	-	-	0.8	-	-	0.8	-	ns
t <sub>wake</sub>	wake-up time		-	76	-	-	76	-	-	76	-	-	76	-	μs
<b>CMOS Mode timing output: pins D13 to D0 and DAV</b>															
t <sub>PD</sub>	propagation delay	DATA	13.6	14.9	16.4	11.9	12.9	14.4	8.0	10.8	12.4	8.2	9.7	11.3	ns
		DAV	-	4.2	-	-	3.6	-	-	3.3	-	-	3.4	-	ns
t <sub>su</sub>	set-up time		-	12.5	-	-	9.8	-	-	6.8	-	-	5.6	-	ns
t <sub>h</sub>	hold time		-	3.4	-	-	3.3	-	-	3.1	-	-	2.8	-	ns
t <sub>r</sub>	rise time	DATA	<a href="#">[2]</a> 0.39	-	2.4	0.39	-	2.4	0.39	-	2.4	0.39	-	2.4	ns
		DAV	0.26	-	2.4	0.26	-	2.4	0.26	-	2.4	0.26	-	2.4	ns
t <sub>f</sub>	fall time	DATA	<a href="#">[2]</a> 0.19	-	2.4	0.19	-	2.4	0.19	-	2.4	0.19	-	2.4	ns

Table 8. Clock and digital output timing characteristics<sup>[1]</sup> ...continued

Symbol	Parameter	Conditions	ADC1410S065			ADC1410S080			ADC1410S105			ADC1410S125			Unit
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
LVDS DDR mode timing output: pins D12_D13_P to D0_D1_P, D12_D13_M to D0_D1_M, DAVP and DAVM															
t <sub>PD</sub>	propagation delay	DATA	3.3	5.1	7.6	2.9	4.6	7.1	2.5	4.2	6.8	2.2	4.0	6.6	ns
		DAV	-	2.8	-	-	2.5	-	-	2.3	-	-	2.2	-	ns
t <sub>SU</sub>	set-up time		-	5.4	-	-	4.1	-	-	2.6	-	-	1.9	-	ns
t <sub>H</sub>	hold time		-	2.2	-	-	2.0	-	-	1.8	-	-	1.7	-	ns
t <sub>r</sub>	rise time	DATA	<sup>[3]</sup> 0.5	-	5	0.5	-	5	0.5	-	5	0.5	-	5	ns
		DAV	0.18	-	2.4	0.18	-	2.4	0.18	-	2.4	0.18	-	2.4	ns
t <sub>f</sub>	fall time	DATA	<sup>[3]</sup> 0.15	-	1.6	0.15	-	1.6	0.15	-	1.6	0.15	-	1.6	ns

[1] Typical values measured at V<sub>DDA(3V)</sub> = 3 V, V<sub>DDO</sub> = 1.8 V, V<sub>DDA(5V)</sub> = 5 V; T<sub>amb</sub> = 25 °C and C<sub>L</sub> = 5 pF; minimum and maximum values are across the full temperature range T<sub>amb</sub> = -40 °C to +85 °C at V<sub>DDA(3V)</sub> = 3 V, V<sub>DDO</sub> = 1.8 V, V<sub>DDA(5V)</sub> = 5 V, V<sub>INP</sub> - V<sub>INM</sub> = -1 dBFS; internal reference mode; applied to CMOS and LVDS interface; unless otherwise specified.

[2] Measured between 20 % to 80 % of V<sub>DDO</sub>.

[3] Rise time measured from -50 mV to +50 mV; fall time measured from +50 mV to -50 mV.

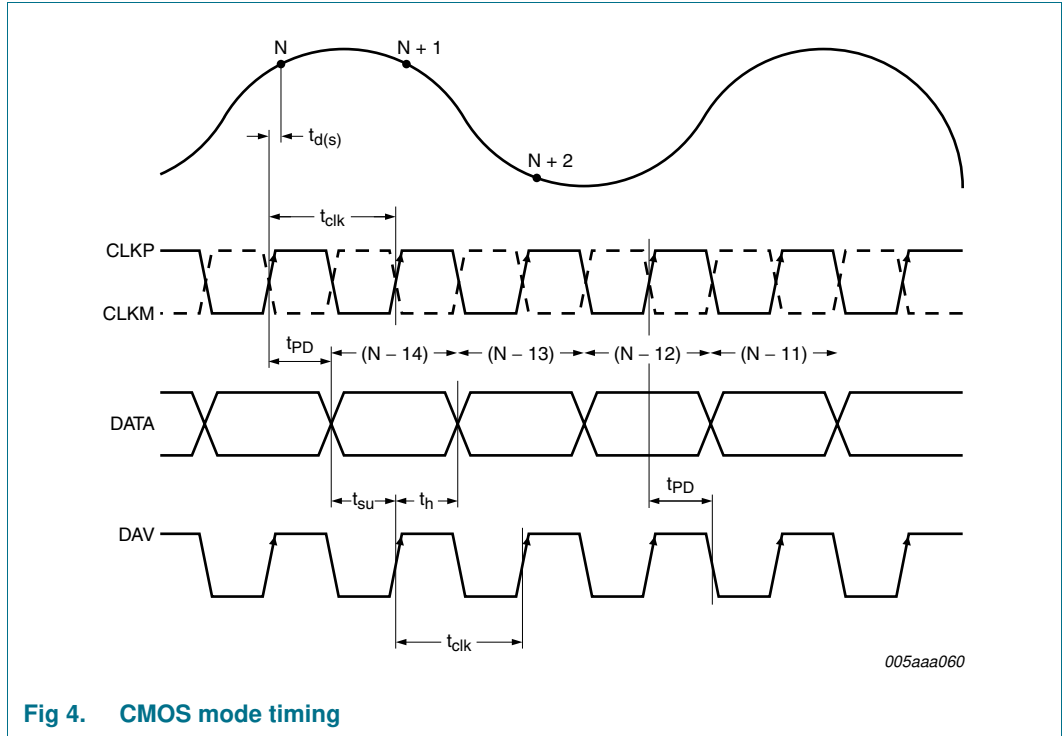


Fig 4. CMOS mode timing

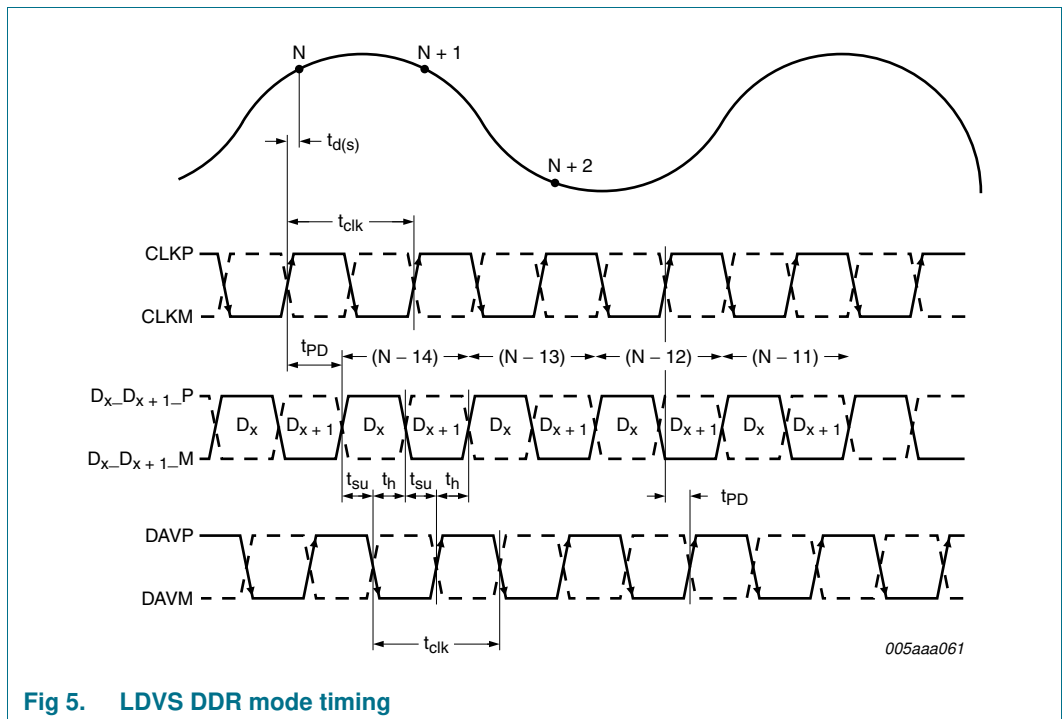


Fig 5. LVDS DDR mode timing

10.3 SPI timings

Table 9. SPI timings characteristics<sup>[1]</sup>

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$t_{w(SCLK)}$	SCLK pulse width		-	40	-	ns
$t_{w(SCLKH)}$	SCLK HIGH pulse width		-	16	-	ns
$t_{w(SCLKL)}$	SCLK LOW pulse width		-	16	-	ns
$t_{su}$	set-up time	data to SCLK HIGH	-	5	-	ns
		$\overline{CS}$ to SCLK HIGH	-	5	-	ns
$t_h$	hold time	data to SCLK HIGH	-	2	-	ns
		$\overline{CS}$ to SCLK HIGH	-	2	-	ns
$f_{clk(max)}$	maximum clock frequency		-	25	-	MHz

[1] Typical values measured at  $V_{DDA(3V)} = 3\text{ V}$ ,  $V_{DDO} = 1.8\text{ V}$ ,  $V_{DDA(5V)} = 5\text{ V}$ ,  $T_{amb} = 25\text{ }^\circ\text{C}$  and  $C_L = 5\text{ pF}$ ; minimum and maximum values are across the full temperature range  $T_{amb} = -40\text{ }^\circ\text{C}$  to  $+85\text{ }^\circ\text{C}$  at  $V_{DDA} = 3\text{ V}$ ,  $V_{DDO} = 1.8\text{ V}$

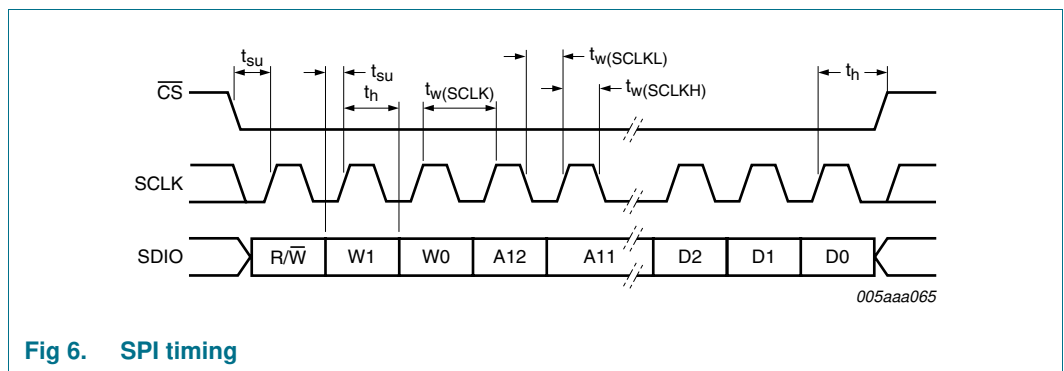
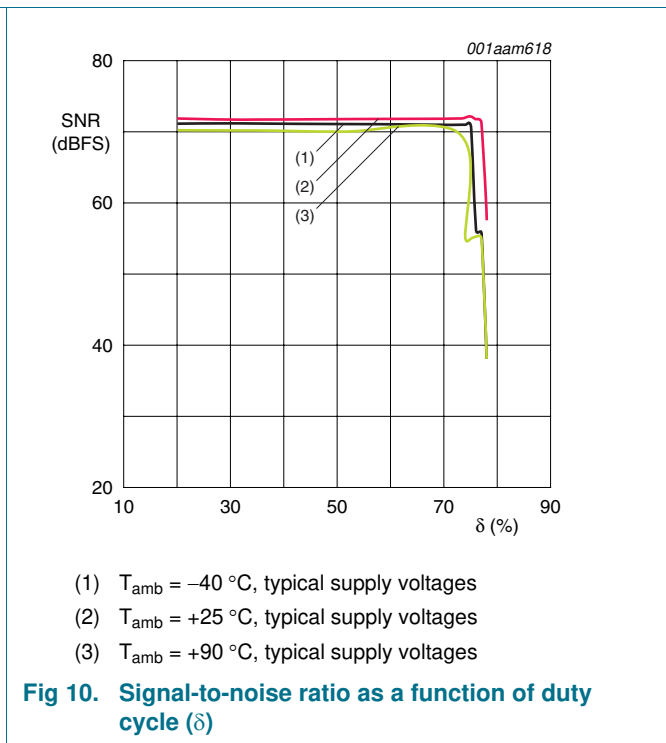
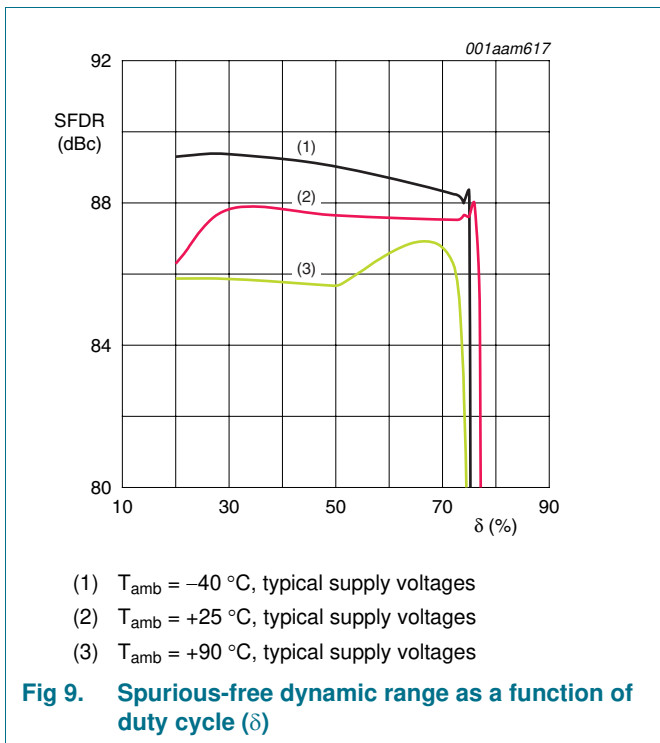
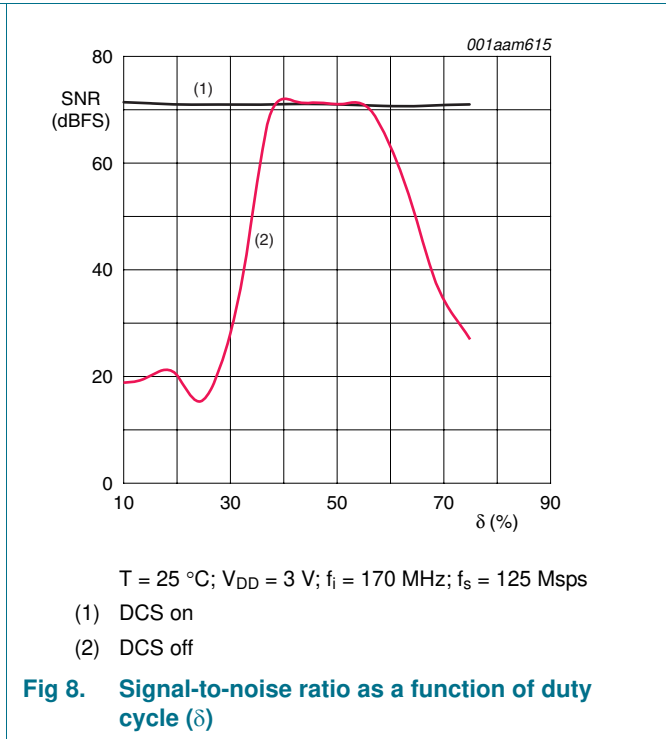
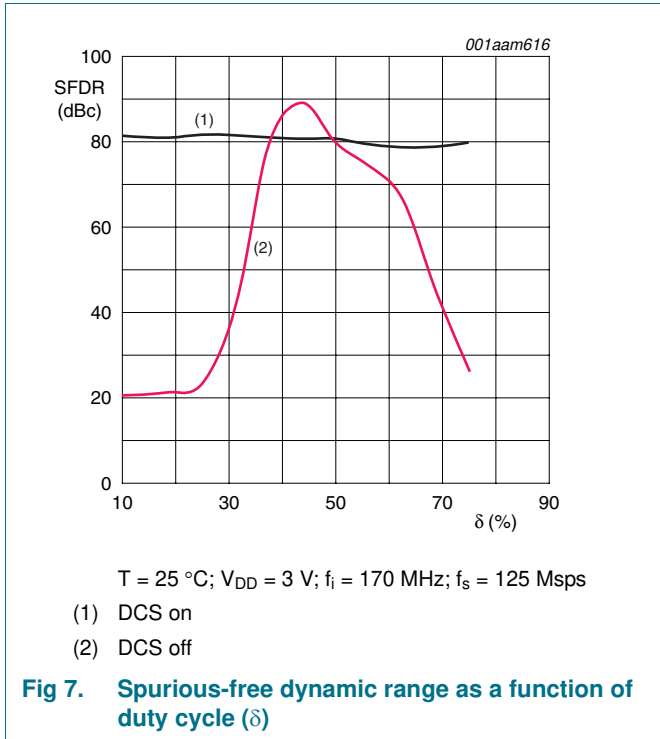


Fig 6. SPI timing



10.4 Typical characteristics



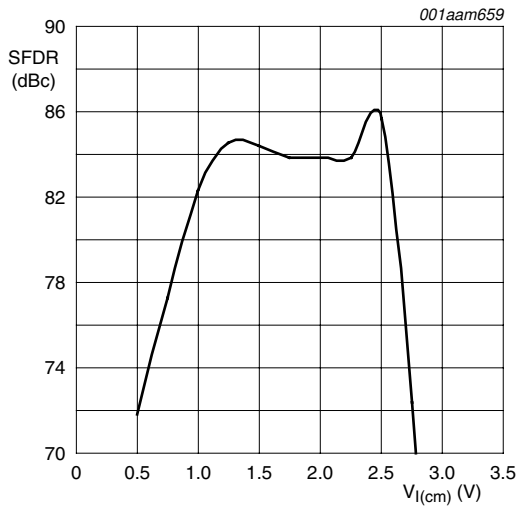


Fig 11. Spurious-free dynamic range as a function of common-mode input voltage ( $V_{i(cm)}$ )

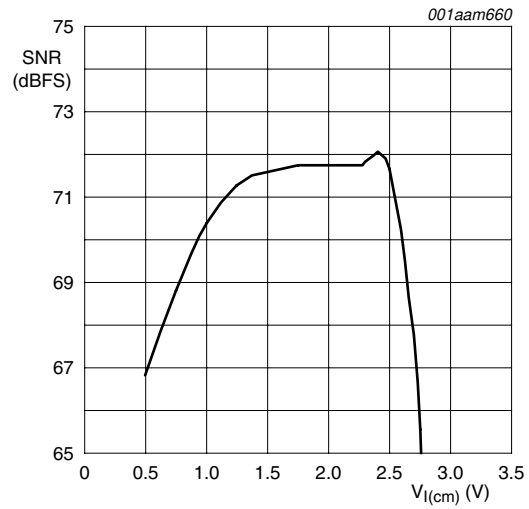


Fig 12. Signal-to-noise ratio as a function of common-mode input voltage ( $V_{i(cm)}$ )

## 11. Application information

### 11.1 Device control

The ADC1415S can be controlled via the Serial Peripheral Interface (SPI control mode) or directly via the I/O pins (Pin control mode).

#### 11.1.1 SPI and Pin control modes

The device enters Pin control mode at power-up, and remains in this mode as long as pin  $\overline{CS}$  is held HIGH. In Pin control mode, the SPI pins SDIO,  $\overline{CS}$  and SCLK are used as static control pins.

SPI control mode is enabled by forcing pin  $\overline{CS}$  LOW. Once SPI control mode has been enabled, the device remains in this mode. The transition from Pin control mode to SPI control mode is illustrated in [Figure 13](#).

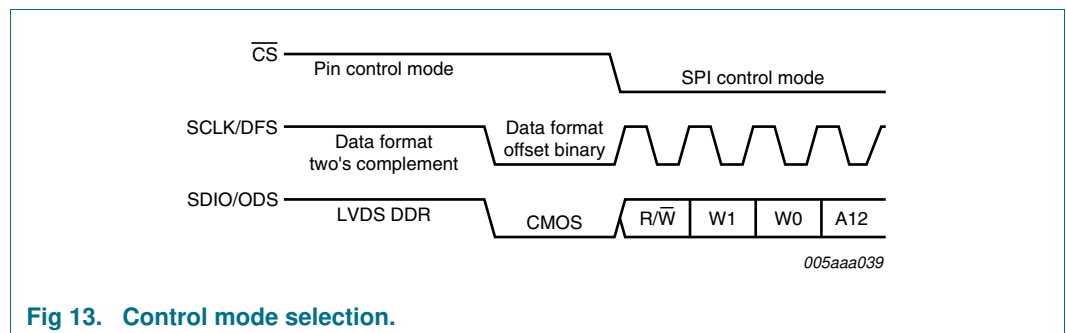


Fig 13. Control mode selection.

When the device enters SPI control mode, the output data standard and data format are determined by the level on pin SDIO as soon as a transition is triggered by a falling edge on  $\overline{CS}$ .

### 11.1.2 Operating mode selection

The active ADC1415S operating mode (Power-up, Power-down or Sleep) can be selected via the SPI interface (see [Table 19](#)) or using pins PWD and  $\overline{OE}$  in Pin control mode, as described in [Table 10](#).

**Table 10. Operating mode selection via pin PWD and  $\overline{OE}$**

Pin PWD	Pin $\overline{OE}$	Operating mode	Output high-Z
0	0	Power-up	no
0	1	Power-up	yes
1	0	Sleep	yes
1	1	Power-down	yes

### 11.1.3 Selecting the output data standard

The output data standard (CMOS or LVDS DDR) can be selected via the SPI interface (see [Table 23](#)) or using pin ODS in Pin control mode. LVDS DDR is selected when ODS is HIGH, otherwise CMOS is selected.

### 11.1.4 Selecting the output data format

The output data format can be selected via the SPI interface (offset binary, two's complement or gray code; see [Table 23](#)) or using pin DFS in Pin control mode (offset binary or two's complement). Offset binary is selected when DFS is LOW. When DFS is HIGH, two's complement is selected.

## 11.2 Analog inputs

### 11.2.1 Input stage

The analog input of the ADC1415S supports a differential or a single-ended input drive. Optimal performance is achieved using differential inputs. The ADC inputs are internally biased and need to be decoupled.

The full-scale analog input voltage range is configurable between 1 V (p-p) and 2 V (p-p) via a programmable internal reference (see [Section 11.3](#) and [Table 21](#)).

The equivalent circuit of the input buffer followed by the Sample and Hold (S/H) input stage, including ElectroStatic Discharge (ESD) protection and circuit and package parasitics, is shown in [Figure 14](#).

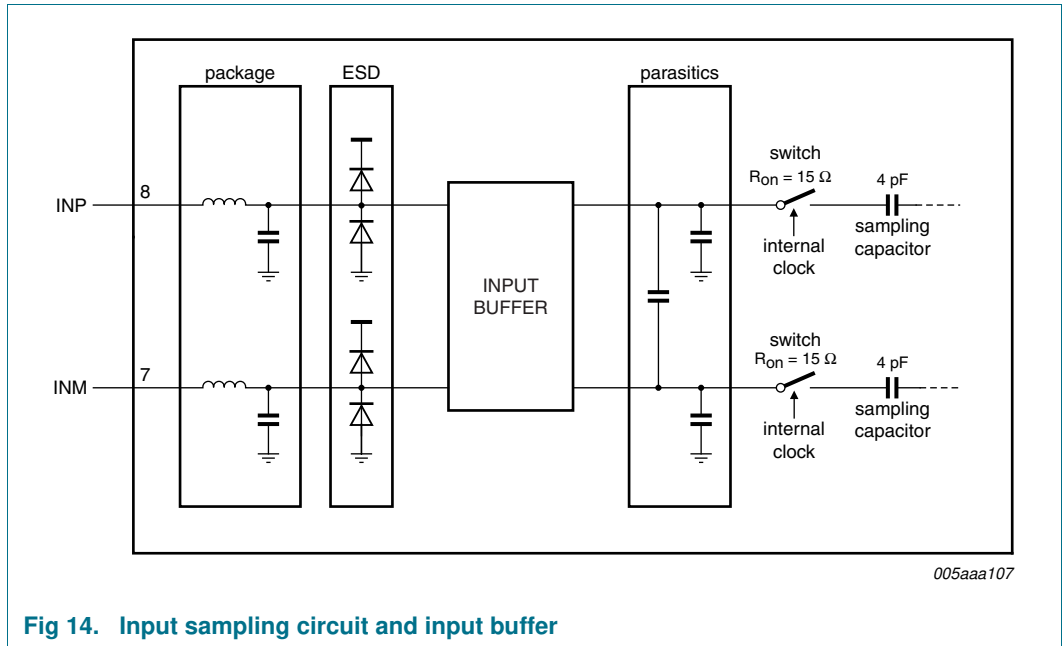


Fig 14. Input sampling circuit and input buffer

The integrated input buffer offers the following advantages:

- The kickback effect is avoided - the charge injection and glitches generated by the S/H input stage are isolated from the input circuitry. So there's no need for additional filtering.
- The input capacitance is very low and constant over a wide frequency range, which makes the ADC1415S easy to drive.

The sample phase occurs when the internal clock (derived from the clock signal on pin CLKP/CLKM) is HIGH. The voltage is then held on the sampling capacitors. When the clock signal goes LOW, the stage enters the hold phase and the voltage information is transmitted to the ADC core.

11.2.2 Transformer

The configuration of the transformer circuit is determined by the input frequency. The configuration shown in [Figure 15](#) would be suitable for a baseband application.

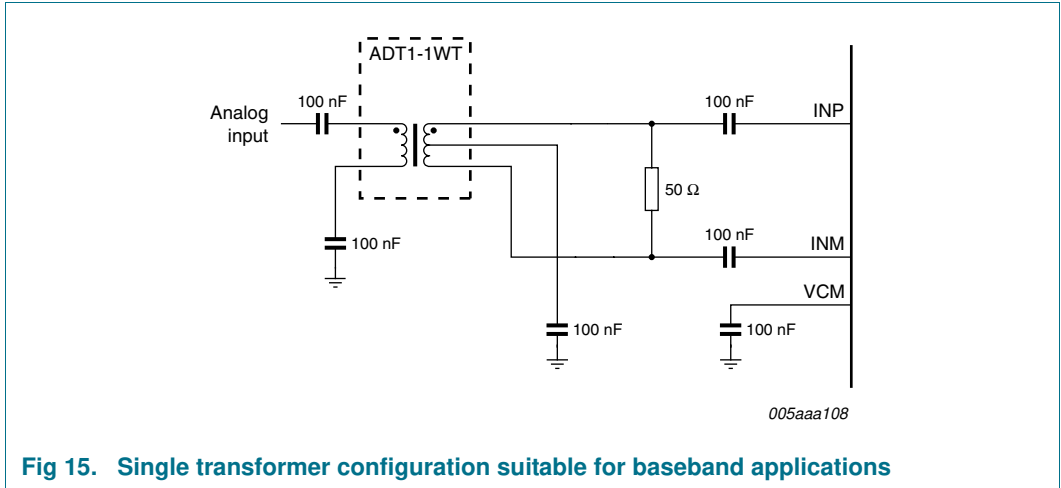


Fig 15. Single transformer configuration suitable for baseband applications

The configuration shown in [Figure 16](#) is recommended for high frequency applications. In both cases, the choice of transformer is a compromise between cost and performance.

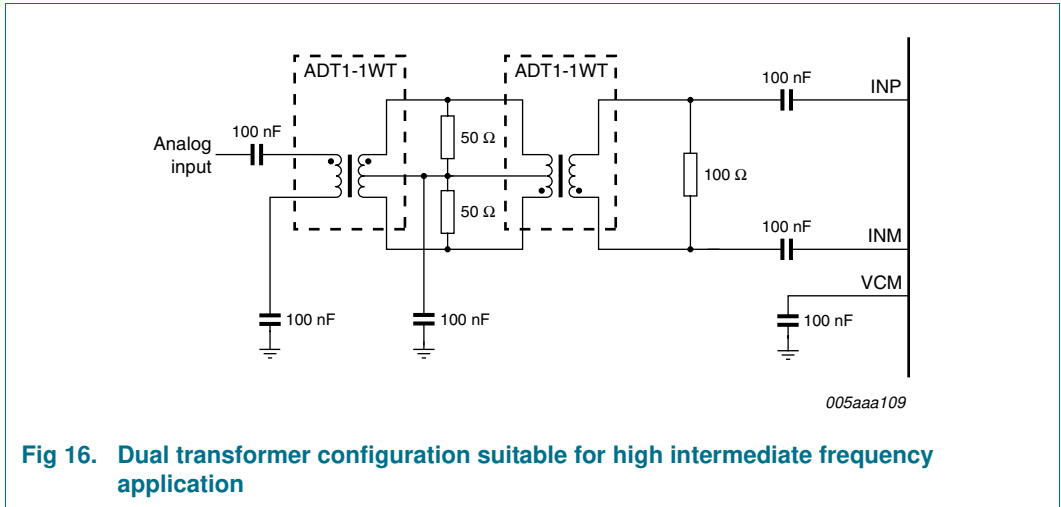


Fig 16. Dual transformer configuration suitable for high intermediate frequency application

### 11.3 System reference and power management

#### 11.3.1 Internal/external references

The ADC1415S has a stable and accurate built-in internal reference voltage to adjust the ADC full-scale. This reference voltage can be set internally via SPI or with pins VREF and SENSE (programmable in 1 dB steps between 0 dB and -6 dB via control bits INTREF[2:0] when bit INTREF\_EN = logic 1; see Table 21) See Figure 18 to Figure 21. The equivalent reference circuit is shown in Figure 17. External reference is also possible by providing a voltage on pin VREF as described in Figure 20.

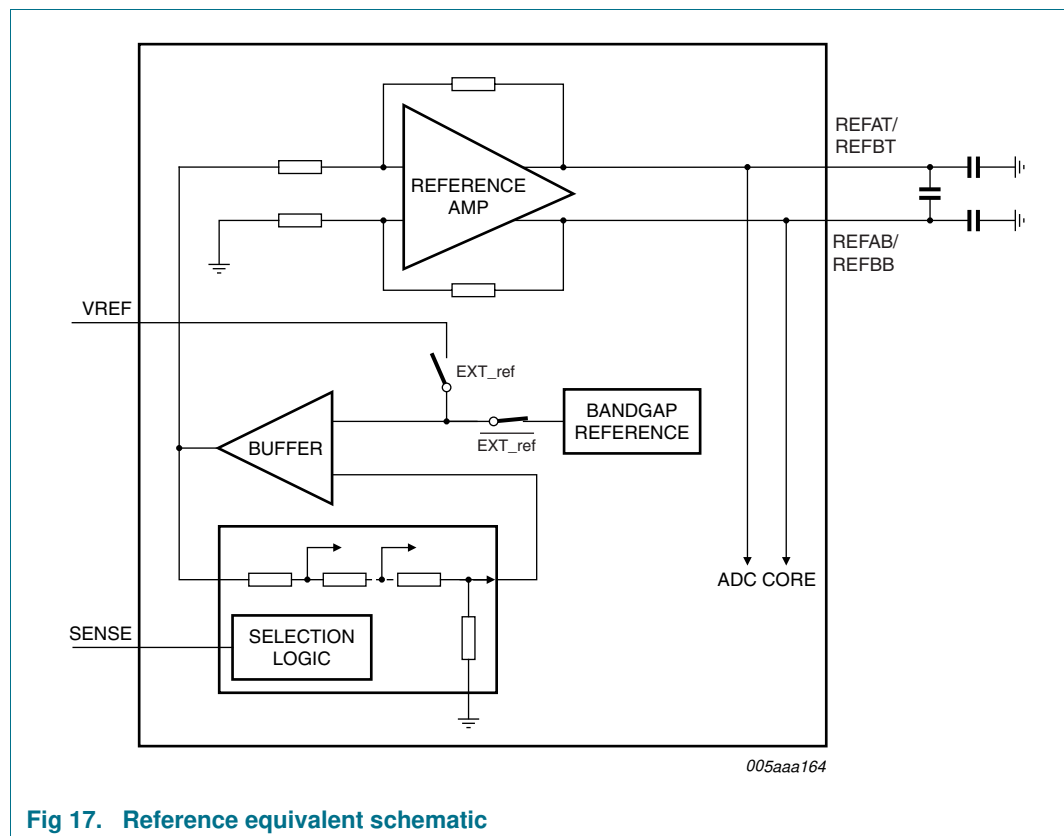


Fig 17. Reference equivalent schematic

If bit INTREF\_EN is set to logic 0, the reference voltage is determined either internally or externally as detailed in Table 11.

Table 11. Reference selection

Selection	SPI bit INTREF_EN	SENSE pin	VREF pin	Full-scale (p-p)
internal (Figure 18)	0	AGND	330 pF capacitor to AGND	2 V
internal (Figure 19)	0	pin VREF connected to pin SENSE and via a 330 pF capacitor to AGND		1 V
external (Figure 20)	0	V <sub>DDA(3V)</sub>	external voltage between 0.5 V and 1 V <sup>[1]</sup>	1 V to 2 V
internal via SPI (Figure 21)	1	pin VREF connected to pin SENSE and via 330 pF capacitor to AGND		1 V to 2 V

[1] The voltage on pin VREF is doubled internally to generate the internal reference voltage.

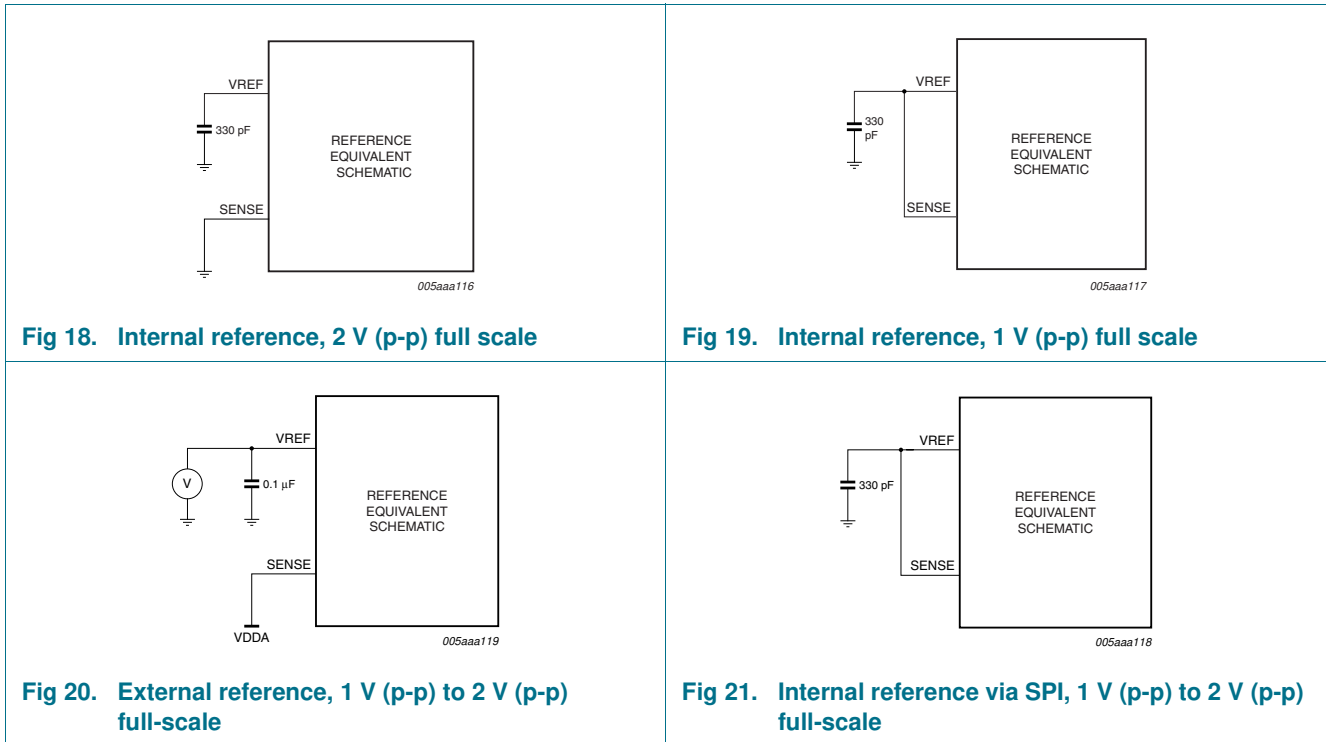


Figure 18 to Figure 21 illustrate how to connect the SENSE and VREF pins to select the required reference voltage source.

**11.3.2 Programmable full-scale**

The full-scale is programmable between 1 V (peak-to-peak) to 2 V (peak-to-peak) (see Table 12).

**Table 12. Reference SPI Gain Control**

INTREF	Gain	Full-scale (p-p)
000	0 dB	2 V
001	-1 dB	1.78 V
010	-2 dB	1.59 V
011	-3 dB	1.42 V
100	-4 dB	1.26 V
101	-5 dB	1.12 V
110	-6 dB	1 V
111	reserved	x

**11.3.3 Common-mode output voltage (V<sub>O(cm)</sub>)**

A 0.1 μF filter capacitor should be connected between pin VCM and ground.

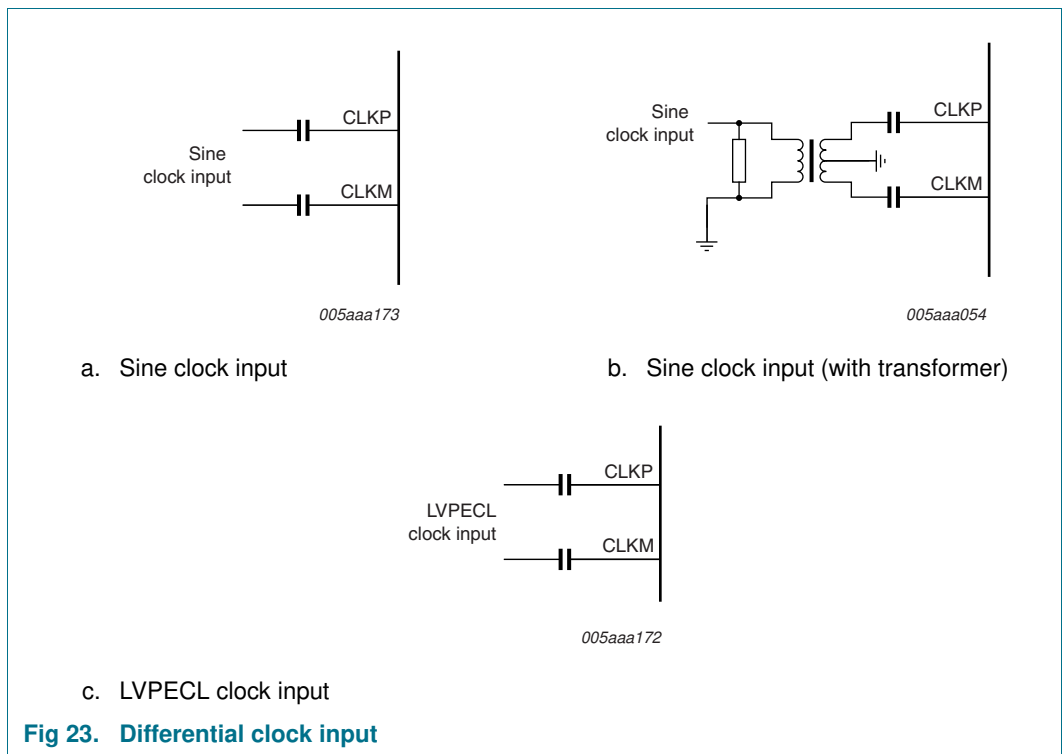
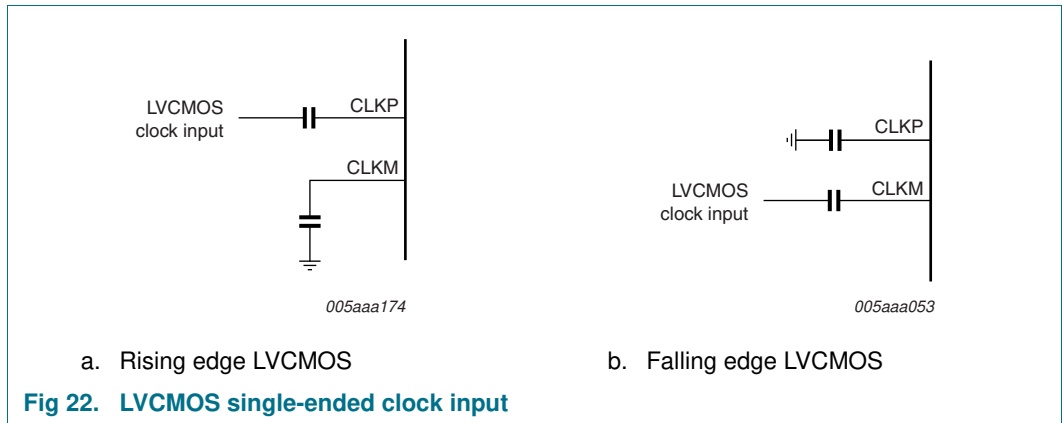
**11.3.4 Biasing**

The common-mode input voltage (V<sub>I(cm)</sub>) on pins INP and INM is set internally. The input buffer bias current can be set to one of three levels (high, medium or low) via the SPI (see Table 22).

11.4 Clock input

11.4.1 Drive modes

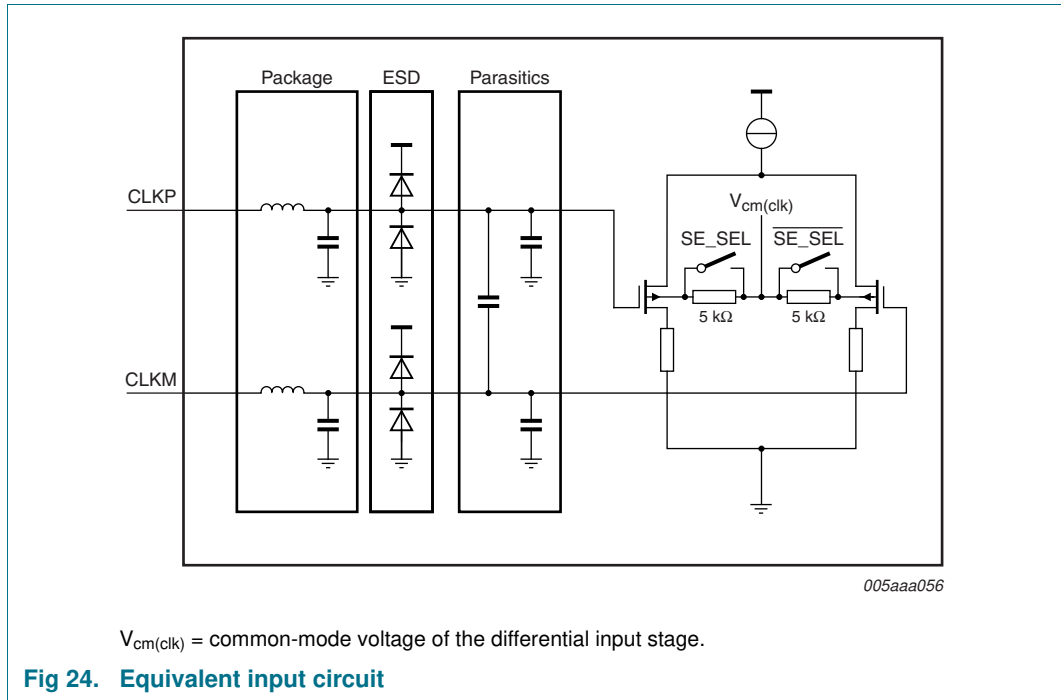
The ADC1415S can be driven differentially (LVPECL). It can also be driven by a single-ended Low Voltage Complementary Metal Oxide Semiconductor (LVCMOS) signal connected to pin CLKP (pin CLKM should be connected to ground via a capacitor) or CLKM (pin CLKP should be connected to ground via a capacitor).





11.4.2 Equivalent input circuit

The equivalent circuit of the input clock buffer is shown in Figure 24. The common-mode voltage of the differential input stage is set via internal 5 kΩ resistors.



Single-ended or differential clock inputs can be selected via the SPI interface (see Table 20). If single-ended is enabled, the input pin (CLKM or CLKP) is selected via control bit SE\_SEL.

If single-ended is implemented without setting bit SE\_SEL to the appropriate value, the unused pin should be connected to ground via a capacitor.

11.4.3 Duty cycle stabilizer

The duty cycle stabilizer can improve the overall performance of the ADC by compensating the duty cycle of the input clock signal. When the duty cycle stabilizer is active (bit DCS\_EN = logic 1; see Table 20), the circuit can handle signals with duty cycles of between 30 % and 70 % (typical). When the duty cycle stabilizer is disabled (DCS\_EN = logic 0), the input clock signal should have a duty cycle of between 45 % and 55 %.

11.4.4 Clock input divider

The ADC1415S contains an input clock divider that divides the incoming clock by a factor of 2 (when bit CLKDIV = logic 1; see Table 20). This feature allows the user to deliver a higher clock frequency with better jitter performance, leading to a better SNR result once acquisition has been performed.

11.5 Digital outputs

11.5.1 Digital output buffers: CMOS mode

The digital output buffers can be configured as CMOS by setting bit LVDS\_CMOS to logic\_0 (see Table 23).

Each digital output has a dedicated output buffer. The equivalent circuit of the CMOS digital output buffer is shown in Figure 25. The buffer is powered by a separate OGND/V<sub>DDO</sub> to ensure 1.8 V to 3.3 V compatibility and is isolated from the ADC core. Each buffer can be loaded by a maximum of 10 pF.

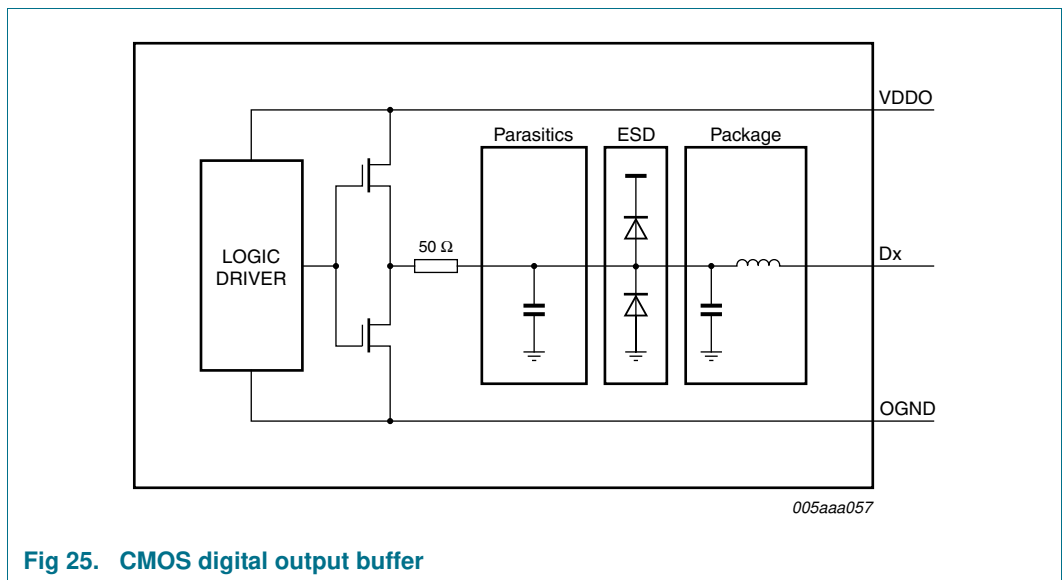


Fig 25. CMOS digital output buffer

The output resistance is 50 Ω and is the combination of the an internal resistor and the equivalent output resistance of the buffer. There is no need for an external damping resistor. The drive strength of both data and DAV buffers can be programmed via the SPI in order to adjust the rise and fall times of the output digital signals (see Table 30):