

## CHANGE NOTIFICATION



Linear Technology Corporation  
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June 05, 2015

Dear Sir/Madam:

PCN# 060515

**Subject: Notification of Change to LTC2410 LTC2411/LTC2411-1, LTC2412, LTC2413, LTC2414/LTC2418, LTC2415/LTC2415-1 Datasheet**

Please be advised that Linear Technology Corporation has made a change to the datasheet specifications of subject devices in order to improve device manufacturability.

The Maximum External Oscillator Frequency ( $f_{EOSC}$ ) in the Timing Characteristics is being reduced from 2000 kHz to 500 kHz. There are many applications that are using the parts at 2000 kHz and the performance is perfectly adequate. But at 2000 kHz, performance is significantly reduced from the limits guaranteed in the specification table, as shown in the graphs at the end of the datasheet.

This change is intended to apply to future customer designs. No changes are being made to the circuit or the test methodology, so customers that are using these devices with FO frequencies between 500 kHz and 2000 kHz and are satisfied with performance will continue to receive the same product.

Should you have any further questions or concerns please contact your local Linear Technology Sales person or you may contact me at 408-432-1900 ext. 2077, or by e-mail at [JASON.HU@LINEAR.COM](mailto:JASON.HU@LINEAR.COM). If I do not hear from you by August 05, 2015, we will consider this change to be approved by your company.

Sincerely,

Jason Hu  
Quality Assurance Engineer

## TIMING CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$f_{\text{EOSC}}$	External Oscillator Frequency Range	●	2.56	<del>500</del> <del>2000</del>		kHz	
$t_{\text{HEO}}$	External Oscillator High Period	●	0.25		390	$\mu\text{s}$	
$t_{\text{LEO}}$	External Oscillator Low Period	●	0.25		390	$\mu\text{s}$	
$t_{\text{CONV}}$	Conversion Time	$F_0 = 0\text{V}$	●	130.86	133.53	136.20	ms
		$F_0 = V_{\text{CC}}$	●	157.03	160.23	163.44	ms
		External Oscillator (Note 11)	●	20510/ $f_{\text{EOSC}}$ (in kHz)			ms
$f_{\text{ISCK}}$	Internal SCK Frequency	Internal Oscillator (Note 10)		19.2		kHz	
		External Oscillator (Notes 10, 11)		$f_{\text{EOSC}}/8$		kHz	
$D_{\text{ISCK}}$	Internal SCK Duty Cycle	(Note 10)	●	45	55	%	
$f_{\text{ESCK}}$	External SCK Frequency Range	(Note 9)	●		2000	kHz	
$t_{\text{LESCK}}$	External SCK Low Period	(Note 9)	●	250		ns	
$t_{\text{HESCK}}$	External SCK High Period	(Note 9)	●	250		ns	
$t_{\text{DOUT\_ISCK}}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (Notes 10, 12)	●	1.64	1.67	1.70	ms
		External Oscillator (Notes 10, 11)	●	256/ $f_{\text{EOSC}}$ (in kHz)			ms
$t_{\text{DOUT\_ESCK}}$	External SCK 32-Bit Data Output Time	(Note 9)	●	32/ $f_{\text{ESCK}}$ (in kHz)			ms
$t_1$	$\overline{\text{CS}} \downarrow$ to SDO Low Z		●	0	200	ns	
$t_2$	$\overline{\text{CS}} \uparrow$ to SDO High Z		●	0	200	ns	
$t_3$	$\overline{\text{CS}} \downarrow$ to SCK $\downarrow$	(Note 10)	●	0	200	ns	
$t_4$	$\overline{\text{CS}} \downarrow$ to SCK $\uparrow$	(Note 9)	●	50		ns	
$t_{\text{QDMAX}}$	SCK $\downarrow$ to SDO Valid		●		220	ns	
$t_{\text{QDMIN}}$	SDO Hold After SCK $\downarrow$	(Note 5)	●	15		ns	
$t_5$	SCK Set-Up Before $\overline{\text{CS}} \downarrow$		●	50		ns	
$t_6$	SCK Hold After $\overline{\text{CS}} \downarrow$		●		50	ns	

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

**Note 2:** All voltage values are with respect to GND.

**Note 3:**  $V_{\text{CC}} = 2.7$  to  $5.5\text{V}$  unless otherwise specified.

$V_{\text{REF}} = \text{REF}^+ - \text{REF}^-$ ,  $V_{\text{REFCM}} = (\text{REF}^+ + \text{REF}^-)/2$ ;

$V_{\text{IN}} = \text{IN}^+ - \text{IN}^-$ ,  $V_{\text{INCM}} = (\text{IN}^+ + \text{IN}^-)/2$ .

**Note 4:**  $F_0$  pin tied to GND or to  $V_{\text{CC}}$  or to external conversion clock source with  $f_{\text{EOSC}} = 153600\text{Hz}$  unless otherwise specified.

**Note 5:** Guaranteed by design, not subject to test.

**Note 6:** Integral nonlinearity is defined as the deviation of a code from a straight line passing through the actual endpoints of the transfer curve. The deviation is measured from the center of the quantization band.

**Note 7:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 153600\text{Hz} \pm 2\%$  (external oscillator).

**Note 8:**  $F_0 = V_{\text{CC}}$  (internal oscillator) or  $f_{\text{EOSC}} = 128000\text{Hz} \pm 2\%$  (external oscillator).

**Note 9:** The converter is in external SCK mode of operation such that the SCK pin is used as digital input. The frequency of the clock signal driving SCK during the data output is  $f_{\text{ESCK}}$  and is expressed in kHz.

**Note 10:** The converter is in internal SCK mode of operation such that the SCK pin is used as digital output. In this mode of operation the SCK pin has a total equivalent load capacitance  $C_{\text{LOAD}} = 20\text{pF}$ .

**Note 11:** The external oscillator is connected to the  $F_0$  pin. The external oscillator frequency,  $f_{\text{EOSC}}$ , is expressed in kHz.

**Note 12:** The converter uses the internal oscillator.

$F_0 = 0\text{V}$  or  $F_0 = V_{\text{CC}}$ .

**Note 13:** The output noise includes the contribution of the internal calibration operations.

**Note 14:** Guaranteed by design and test correlation.

**TIMING CHARACTERISTICS**

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$f_{\text{EOSC}}$	External Oscillator Frequency Range		● 2.56	500 <del>2000</del>		kHz	
$t_{\text{HEO}}$	External Oscillator High Period		● 0.25		390	$\mu\text{s}$	
$t_{\text{LEO}}$	External Oscillator Low Period		● 0.25		390	$\mu\text{s}$	
$t_{\text{CONV}}$	Conversion Time	$F_0 = 0\text{V}$ (LTC2411)	●	130.86	133.53	136.20	ms
		$F_0 = V_{\text{CC}}$ (LTC2411)	●	157.03	160.23	163.44	ms
		$F_0 = 0\text{V}$ (LTC2411-1)	●	143.78	146.71	149.64	ms
		External Oscillator (Note 11)	●	20510/ $f_{\text{EOSC}}$ (in kHz)			ms
$f_{\text{ISCK}}$	Internal SCK Frequency	Internal Oscillator (LTC2411) (Note 10)		19.2		kHz	
		Internal Oscillator (LTC2411-1) (Note 10)		17.5		kHz	
		External Oscillator (Notes 10, 11)		$f_{\text{EOSC}}/8$		kHz	
$D_{\text{ISCK}}$	Internal SCK Duty Cycle	(Note 10)	● 45		55	%	
$f_{\text{ESCK}}$	External SCK Frequency Range	(Note 9)	●		2000	kHz	
$t_{\text{LESCK}}$	External SCK Low Period	(Note 9)	● 250			ns	
$t_{\text{HESCK}}$	External SCK High Period	(Note 9)	● 250			ns	
$t_{\text{DOUT\_ISCK}}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (LTC2411) (Notes 10, 12)	●	1.64	1.67	1.70	ms
		Internal Oscillator (LTC2411-1) (Notes 10, 12)	●	1.80	1.83	1.86	ms
		External Oscillator (Notes 10, 11)	●	256/ $f_{\text{EOSC}}$ (in kHz)			ms
$t_{\text{DOUT\_ESCK}}$	External SCK 32-Bit Data Output Time	(Note 9)	●	32/ $f_{\text{ESCK}}$ (in kHz)		ms	
$t_1$	$\overline{\text{CS}} \downarrow$ to SDO Low Z		● 0		200	ns	
$t_2$	$\overline{\text{CS}} \uparrow$ to SDO High Z		● 0		200	ns	
$t_3$	$\overline{\text{CS}} \downarrow$ to SCK $\downarrow$	(Note 10)	● 0		200	ns	
$t_4$	$\overline{\text{CS}} \downarrow$ to SCK $\uparrow$	(Note 9)	● 50			ns	
$t_{\text{KOMAX}}$	SCK $\downarrow$ to SDO Valid		●		220	ns	
$t_{\text{KOMIN}}$	SDO Hold After SCK $\downarrow$	(Note 5)	● 15			ns	
$t_5$	SCK Set-Up Before $\overline{\text{CS}} \downarrow$		● 50			ns	
$t_6$	SCK Hold After $\overline{\text{CS}} \downarrow$		●		50	ns	

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

**Note 2:** All voltage values are with respect to GND.

**Note 3:**  $V_{\text{CC}} = 2.7$  to  $5.5\text{V}$  unless otherwise specified.

$V_{\text{REF}} = \text{REF}^+ - \text{REF}^-$ ,  $V_{\text{REFCM}} = (\text{REF}^+ + \text{REF}^-)/2$ ;

$V_{\text{IN}} = \text{IN}^+ - \text{IN}^-$ ,  $V_{\text{INCM}} = (\text{IN}^+ + \text{IN}^-)/2$ .

**Note 4:**  $F_0$  pin tied to GND or to  $V_{\text{CC}}$  or to external conversion clock source with  $f_{\text{EOSC}} = 153600\text{Hz}$  unless otherwise specified.

**Note 5:** Guaranteed by design, not subject to test.

**Note 6:** Integral nonlinearity is defined as the deviation of a code from a straight line passing through the actual endpoints of the transfer curve. The deviation is measured from the center of the quantization band.

**Note 7:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 153600\text{Hz} \pm 2\%$  (external oscillator).

**Note 8:**  $F_0 = V_{\text{CC}}$  (internal oscillator) or  $f_{\text{EOSC}} = 128000\text{Hz} \pm 2\%$  (external oscillator).

**Note 9:** The converter is in external SCK mode of operation such that the SCK pin is used as digital input. The frequency of the clock signal driving SCK during the data output is  $f_{\text{ESCK}}$  and is expressed in kHz.

**Note 10:** The converter is in internal SCK mode of operation such that the SCK pin is used as digital output. In this mode of operation the SCK pin has a total equivalent load capacitance  $C_{\text{LOAD}} = 20\text{pF}$ .

**Note 11:** The external oscillator is connected to the  $F_0$  pin. The external oscillator frequency,  $f_{\text{EOSC}}$ , is expressed in kHz.

**Note 12:** The converter uses the internal oscillator.

$F_0 = 0\text{V}$  or  $F_0 = V_{\text{CC}}$ .

**Note 13:** The output noise includes the contribution of the internal calibration operations.

**Note 14:** Guaranteed by design and test correlation.

**Note 15:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 139800\text{Hz} \pm 2\%$  (external oscillator).

**TIMING CHARACTERISTICS**

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$f_{\text{EOSC}}$	External Oscillator Frequency Range	●	2.56	500 <del>2000</del>		kHz	
$t_{\text{HEO}}$	External Oscillator High Period	●	0.25		390	$\mu\text{s}$	
$t_{\text{LEO}}$	External Oscillator Low Period	●	0.25		390	$\mu\text{s}$	
$t_{\text{CONV}}$	Conversion Time	$F_0 = 0\text{V}$	●	130.86	133.53	136.20	ms
		$F_0 = V_{\text{CC}}$	●	157.03	160.23	163.44	ms
		External Oscillator (Note 11)	●		20510/ $f_{\text{EOSC}}$ (in kHz)		ms
$f_{\text{ISCK}}$	Internal SCK Frequency	Internal Oscillator (Note 10)		19.2		kHz	
		External Oscillator (Notes 10, 11)		$f_{\text{EOSC}}/8$		kHz	
$D_{\text{ISCK}}$	Internal SCK Duty Cycle	(Note 10)	●	45	55	%	
$f_{\text{ESCK}}$	External SCK Frequency Range	(Note 9)	●		2000	kHz	
$t_{\text{LESCK}}$	External SCK Low Period	(Note 9)	●	250		ns	
$t_{\text{HESCK}}$	External SCK High Period	(Note 9)	●	250		ns	
$t_{\text{DOUT\_ISCK}}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (Notes 10, 12)	●	1.64	1.67	1.70	ms
		External Oscillator (Notes 10, 11)	●	256/ $f_{\text{EOSC}}$ (in kHz)		ms	
$t_{\text{DOUT\_ESCK}}$	External SCK 32-Bit Data Output Time	(Note 9)	●	32/ $f_{\text{ESCK}}$ (in kHz)		ms	
$t_1$	$\overline{\text{CS}} \downarrow$ to SDO Low Z		●	0	200	ns	
$t_2$	$\overline{\text{CS}} \uparrow$ to SDO High Z		●	0	200	ns	
$t_3$	$\overline{\text{CS}} \downarrow$ to SCK $\downarrow$	(Note 10)	●	0	200	ns	
$t_4$	$\overline{\text{CS}} \downarrow$ to SCK $\uparrow$	(Note 9)	●	50		ns	
$t_{\text{KQMAX}}$	SCK $\downarrow$ to SDO Valid		●		220	ns	
$t_{\text{KQMIN}}$	SDO Hold After SCK $\downarrow$	(Note 5)	●	15		ns	
$t_5$	SCK Set-Up Before $\overline{\text{CS}} \downarrow$		●	50		ns	
$t_6$	SCK Hold After $\overline{\text{CS}} \downarrow$		●		50	ns	

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

**Note 2:** All voltage values are with respect to GND.

**Note 3:**  $V_{\text{CC}} = 2.7\text{V}$  to  $5.5\text{V}$  unless otherwise specified.

$V_{\text{REF}} = \text{REF}^+ - \text{REF}^-$ ,  $V_{\text{REFCM}} = (\text{REF}^+ + \text{REF}^-)/2$ ;  $V_{\text{IN}} = \text{IN}^+ - \text{IN}^-$ ,  $V_{\text{INCM}} = (\text{IN}^+ + \text{IN}^-)/2$ ,  $\text{IN}^+$  and  $\text{IN}^-$  are defined as the selected positive ( $\text{CH0}^+$  or  $\text{CH1}^+$ ) and negative ( $\text{CH0}^-$  or  $\text{CH1}^-$ ) input respectively.

**Note 4:**  $F_0$  pin tied to GND or to  $V_{\text{CC}}$  or to external conversion clock source with  $f_{\text{EOSC}} = 153600\text{Hz}$  unless otherwise specified.

**Note 5:** Guaranteed by design, not subject to test.

**Note 6:** Integral nonlinearity is defined as the deviation of a code from a straight line passing through the actual endpoints of the transfer curve. The deviation is measured from the center of the quantization band.

**Note 7:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 153600\text{Hz} \pm 2\%$  (external oscillator).

**Note 8:**  $F_0 = V_{\text{CC}}$  (internal oscillator) or  $f_{\text{EOSC}} = 128000\text{Hz} \pm 2\%$  (external oscillator).

**Note 9:** The converter is in external SCK mode of operation such that the SCK pin is used as digital input. The frequency of the clock signal driving SCK during the data output is  $f_{\text{ESCK}}$  and is expressed in kHz.

**Note 10:** The converter is in internal SCK mode of operation such that the SCK pin is used as digital output. In this mode of operation the SCK pin has a total equivalent load capacitance  $C_{\text{LOAD}} = 20\text{pF}$ .

**Note 11:** The external oscillator is connected to the  $F_0$  pin. The external oscillator frequency,  $f_{\text{EOSC}}$ , is expressed in kHz.

**Note 12:** The converter uses the internal oscillator.

$F_0 = 0\text{V}$  or  $F_0 = V_{\text{CC}}$ .

**Note 13:** The output noise includes the contribution of the internal calibration operations.

**Note 14:** Guaranteed by design and test correlation.

## TIMING CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$f_{\text{EOSC}}$	External Oscillator Frequency Range	●	2.56	500 <del>2000</del>		kHz
$t_{\text{HEO}}$	External Oscillator High Period	●	0.25		390	$\mu\text{s}$
$t_{\text{LEO}}$	External Oscillator Low Period	●	0.25		390	$\mu\text{s}$
$t_{\text{CONV}}$	Conversion Time	$F_0 = 0\text{V}$ External Oscillator (Note 10)	●	146.71		ms
			●	$20510/f_{\text{EOSC}}$ (in kHz)		ms
$f_{\text{ISCK}}$	Internal SCK Frequency	Internal Oscillator (Note 9) External Oscillator (Notes 9, 10)		17.5		kHz
				$f_{\text{EOSC}}/8$		kHz
$D_{\text{ISCK}}$	Internal SCK Duty Cycle	(Note 9)	●	45	55	%
$f_{\text{ESCK}}$	External SCK Frequency Range	(Note 8)	●		2000	kHz
$t_{\text{LESCK}}$	External SCK Low Period	(Note 8)	●	250		ns
$t_{\text{HESCK}}$	External SCK High Period	(Note 8)	●	250		ns
$t_{\text{DOUT\_ISCK}}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (Notes 9, 11) External Oscillator (Notes 9, 10)	●	1.80	1.83	ms
			●	$256/f_{\text{EOSC}}$ (in kHz)	1.86	ms
$t_{\text{DOUT\_ESCK}}$	External SCK 32-Bit Data Output Time	(Note 8)	●	$32/f_{\text{ESCK}}$ (in kHz)		ms
$t_1$	$\overline{\text{CS}} \downarrow$ to SDO Low Z		●	0	200	ns
$t_2$	$\overline{\text{CS}} \uparrow$ to SDO Hi-Z		●	0	200	ns
$t_3$	$\overline{\text{CS}} \downarrow$ to SCK $\downarrow$	(Note 9)	●	0	200	ns
$t_4$	$\overline{\text{CS}} \downarrow$ to SCK $\uparrow$	(Note 8)	●	50		ns
$t_{\text{KOMAX}}$	SCK $\downarrow$ to SDO Valid		●		220	ns
$t_{\text{KOMIN}}$	SDO Hold After SCK $\downarrow$	(Note 5)	●	15		ns
$t_5$	SCK Set-Up Before $\overline{\text{CS}} \downarrow$		●	50		ns
$t_6$	SCK Hold After $\overline{\text{CS}} \downarrow$		●		50	ns

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

**Note 2:** All voltage values are with respect to GND.

**Note 3:**  $V_{\text{CC}} = 2.7\text{V}$  to  $5.5\text{V}$  unless otherwise specified.

$V_{\text{REF}} = \text{REF}^+ - \text{REF}^-$ ,  $V_{\text{REFCM}} = (\text{REF}^+ + \text{REF}^-)/2$ ;

$V_{\text{IN}} = \text{IN}^+ - \text{IN}^-$ ,  $V_{\text{INCM}} = (\text{IN}^+ + \text{IN}^-)/2$ .

**Note 4:**  $F_0$  pin tied to GND or to external conversion clock source with  $f_{\text{EOSC}} = 139800\text{Hz}$  unless otherwise specified.

**Note 5:** Guaranteed by design, not subject to test.

**Note 6:** Integral nonlinearity is defined as the deviation of a code from a straight line passing through the actual endpoints of the transfer curve. The deviation is measured from the center of the quantization band.

**Note 7:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 139800\text{Hz} \pm 2\%$  (external oscillator).

**Note 8:** The converter is in external SCK mode of operation such that the SCK pin is used as digital input. The frequency of the clock signal driving SCK during the data output is  $f_{\text{ESCK}}$  and is expressed in kHz.

**Note 9:** The converter is in internal SCK mode of operation such that the SCK pin is used as digital output.

**Note 10:** The external oscillator is connected to the  $F_0$  pin. The external oscillator frequency,  $f_{\text{EOSC}}$ , is expressed in kHz.

**Note 11:** The converter uses the internal oscillator.  $F_0 = 0\text{V}$ .

**Note 12:** The output noise includes the contribution of the internal calibration operations.

**Note 13:** Guaranteed by design and test correlation.

## DIGITAL INPUTS AND DIGITAL OUTPUTS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{OL}$	Low Level Output Voltage SDO	$I_O = 1.6\text{mA}$	●		0.4	V
$V_{OH}$	High Level Output Voltage SCK	$I_O = -800\mu\text{A}$ (Note 10)	●	$V_{CC} - 0.5$		V
$V_{OL}$	Low Level Output Voltage SCK	$I_O = 1.6\text{mA}$ (Note 10)	●		0.4	V
$I_{OZ}$	Hi-Z Output Leakage SDO		●	-10	10	$\mu\text{A}$

## POWER REQUIREMENTS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{CC}$	Supply Voltage		●	2.7	5.5	V
$I_{CC}$	Supply Current					
	Conversion Mode	$\overline{CS} = 0\text{V}$ (Note 12)	●	200	300	$\mu\text{A}$
	Sleep Mode	$\overline{CS} = V_{CC}$ (Note 12)	●	4	10	$\mu\text{A}$
	Sleep Mode	$\overline{CS} = V_{CC}$ , $2.7\text{V} \leq V_{CC} \leq 3.3\text{V}$ (Note 12)		2		$\mu\text{A}$

## TIMING CHARACTERISTICS

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	
$f_{EOSC}$	External Oscillator Frequency Range		●	2.56	<del>2000</del> 500	kHz	
$t_{HEO}$	External Oscillator High Period		●	0.25	390	$\mu\text{s}$	
$t_{LEO}$	External Oscillator Low Period		●	0.25	390	$\mu\text{s}$	
$t_{CONV}$	Conversion Time	$F_0 = 0\text{V}$ $F_0 = V_{CC}$ External Oscillator (Note 11)	●	130.86	133.53	136.20	ms
			●	157.03	160.23	163.44	ms
			●	20510/ $f_{EOSC}$ (in kHz)		ms	
$f_{ISCK}$	Internal SCK Frequency	Internal Oscillator (Note 10) External Oscillator (Notes 10, 11)		19.2		kHz	
				$f_{EOSC}/8$		kHz	
$D_{ISCK}$	Internal SCK Duty Cycle	(Note 10)	●	45	55	%	
$f_{ESCK}$	External SCK Frequency Range	(Note 9)	●		2000	kHz	
$t_{LESCK}$	External SCK Low Period	(Note 9)	●	250		ns	
$t_{HESCK}$	External SCK High Period	(Note 9)	●	250		ns	
$t_{DOUT\_ISCK}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (Notes 10, 12) External Oscillator (Notes 10, 11)	●	1.64	1.67	1.70	ms
			●	256/ $f_{EOSC}$ (in kHz)		ms	
$t_{DOUT\_ESCK}$	External SCK 32-Bit Data Output Time	(Note 9)	●	32/ $f_{ESCK}$ (in kHz)		ms	

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**TIMING CHARACTERISTICS**

The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are at  $T_A = 25^\circ\text{C}$ . (Note 3)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$f_{\text{EOSC}}$	External Oscillator Frequency Range		● 2.56	● 500 <del>2000</del>		kHz
$t_{\text{HEO}}$	External Oscillator High Period		● 0.25		● 390	$\mu\text{s}$
$t_{\text{LEO}}$	External Oscillator Low Period		● 0.25		● 390	$\mu\text{s}$
$t_{\text{CONV}}$	Conversion Time (LTC2415)	$F_0 = 0\text{V}$	● 65.43	● 66.77	● 68.1	ms
		$F_0 = V_{\text{CC}}$	● 78.52	● 80.12	● 81.72	ms
		External Oscillator (Note 11)		● $10278/f_{\text{EOSC}}$ (in kHz)		ms
$t_{\text{CONV}}$	Conversion Time (LTC2415-1)	$F_0 = 0\text{V}$	● 71.3	● 72.8	● 74.3	ms
		External Oscillator (Note 11)		● $10278/f_{\text{EOSC}}$ (in kHz)		ms
$f_{\text{ISCK}}$	Internal SCK Frequency	Internal Oscillator (Note 10), LTC2415		● 19.2		kHz
		Internal Oscillator (Note 10), LTC2415-1		● 17.5		kHz
		External Oscillator (Notes 10, 11)		● $f_{\text{EOSC}}/8$		kHz
$D_{\text{ISCK}}$	Internal SCK Duty Cycle	(Note 10)	● 45		● 55	%
$f_{\text{ESCK}}$	External SCK Frequency Range	(Note 9)			● 2000	kHz
$t_{\text{LESCK}}$	External SCK Low Period	(Note 9)	● 250			ns
$t_{\text{HESCK}}$	External SCK High Period	(Note 9)	● 250			ns
$t_{\text{DOUT\_ISCK}}$	Internal SCK 32-Bit Data Output Time	Internal Oscillator (Notes 10, 12), LTC2415	● 1.64	● 1.67	● 1.70	ms
		Internal Oscillator (Notes 10, 12), LTC2415-1	● 1.80	● 1.83	● 1.86	ms
		External Oscillator (Notes 10, 11)		● $256/f_{\text{EOSC}}$ (in kHz)		ms
$t_{\text{DOUT\_ESCK}}$	External SCK 32-Bit Data Output Time	(Note 9)		● $32/f_{\text{ESCK}}$ (in kHz)		ms
$t_1$	$\overline{\text{CS}} \downarrow$ to SDO Low Z		● 0		● 200	ns
$t_2$	$\overline{\text{CS}} \uparrow$ to SDO High Z		● 0		● 200	ns
$t_3$	$\overline{\text{CS}} \downarrow$ to SCK $\downarrow$	(Note 10)	● 0		● 200	ns
$t_4$	$\overline{\text{CS}} \downarrow$ to SCK $\uparrow$	(Note 9)	● 50			ns
$t_{\text{KQMAX}}$	SCK $\downarrow$ to SDO Valid				● 220	ns
$t_{\text{KQMIN}}$	SDO Hold After SCK $\downarrow$	(Note 5)	● 15			ns
$t_5$	SCK Set-Up Before $\overline{\text{CS}} \downarrow$		● 50			ns
$t_6$	SCK Hold After $\overline{\text{CS}} \downarrow$				● 50	ns

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

**Note 2:** All voltage values are with respect to GND.

**Note 3:**  $V_{\text{CC}} = 2.7$  to  $5.5\text{V}$  unless otherwise specified.

$V_{\text{REF}} = \text{REF}^+ - \text{REF}^-$ ,  $V_{\text{REFCM}} = (\text{REF}^+ + \text{REF}^-)/2$ ;

$V_{\text{IN}} = \text{IN}^+ - \text{IN}^-$ ,  $V_{\text{INCM}} = (\text{IN}^+ + \text{IN}^-)/2$ .

**Note 4:**  $F_0$  pin tied to GND or to  $V_{\text{CC}}$  or to external conversion clock source with  $f_{\text{EOSC}} = 153600\text{Hz}$  unless otherwise specified.

**Note 5:** Guaranteed by design, not subject to test.

**Note 6:** Integral nonlinearity is defined as the deviation of a code from a straight line passing through the actual endpoints of the transfer curve. The deviation is measured from the center of the quantization band.

**Note 7:**  $F_0 = 0\text{V}$  (internal oscillator) or  $f_{\text{EOSC}} = 153600\text{Hz} \pm 2\%$  (external oscillator).

**Note 8:**  $F_0 = V_{\text{CC}}$  (internal oscillator) or  $f_{\text{EOSC}} = 128000\text{Hz} \pm 2\%$  (external oscillator).

**Note 9:** The converter is in external SCK mode of operation such that the SCK pin is used as digital input. The frequency of the clock signal driving SCK during the data output is  $f_{\text{ESCK}}$  and is expressed in kHz.

**Note 10:** The converter is in internal SCK mode of operation such that the SCK pin is used as digital output. In this mode of operation the SCK pin has a total equivalent load capacitance  $C_{\text{LOAD}} = 20\text{pF}$ .

**Note 11:** The external oscillator is connected to the  $F_0$  pin. The external oscillator frequency,  $f_{\text{EOSC}}$ , is expressed in kHz.

**Note 12:** The converter uses the internal oscillator.

$F_0 = 0\text{V}$  or  $F_0 = V_{\text{CC}}$ .

**Note 13:** The output noise includes the contribution of the internal calibration operations.

**Note 14:** Refer to Offset Accuracy and Drift in the Applications Information section.