ACC M-S Driver X12.506

Features

- Vbatt = 7 to 24V
- 4.194304 MHz oscillator
- Digital 5 bits E^{2}PROM Tuning
- Operating temperature range -40 to +105°C

Description

The ACC M-S Driver X12.506 is a monolithic CMOS device intended to be used as a driving circuit for the **A**nalogue **C**ar **C**lock M-S X16.xxx.
In the normal operating mode, the circuit delivers a pulse train every 60 seconds in order to obtain a 6° rotation on the minute hand shaft.
Two setting inputs allow to correct the displayed time, in both directions of rotation, in a continuous way.
The E^{2}PROM trimming circuit allows to adjust the quartz oscillation in the range of ±57.2 ppm with a resolution of 3.8 ppm/step to assure an accuracy of less than ±1 s/day at 25°C and less than ±4 s/day on the full automotive temperature range.

Applications

- Car dashboard clock
- Wall clock, all types of clocks

Typical Operating Configuration

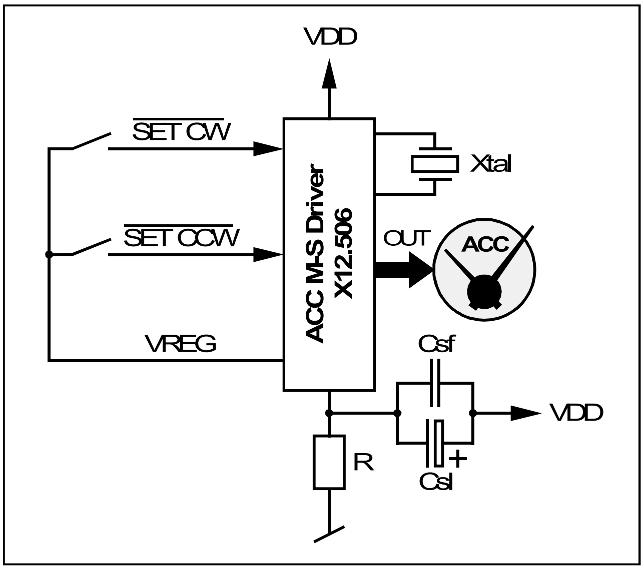


Fig. 1

Specific Operating Configuration

The IC can be used with setting inputs connected to ground level if required. A serial resistor Rs is to be used for this purpose as shown below.

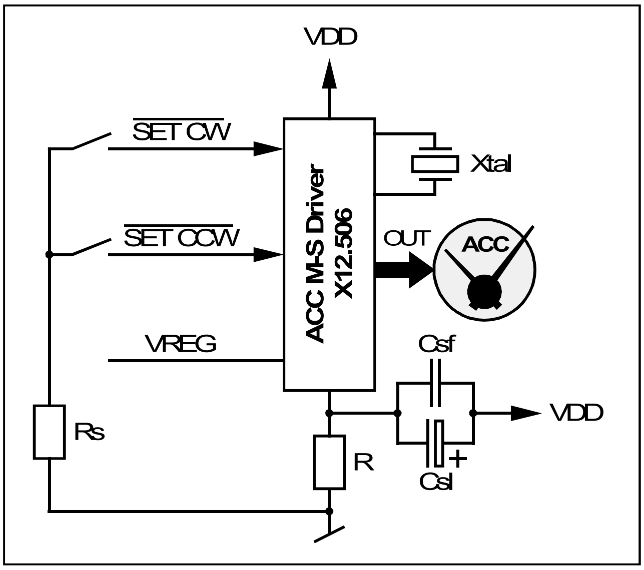


Fig. 2

Pin Assignment

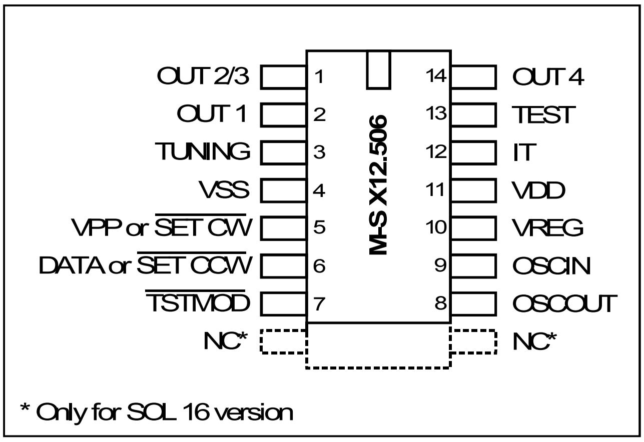


Fig. 3

Absolute Maximum Ratings

Parameter	Symbol	Value
Voltage V_{DD} to V_{SS}	V_{DD}	-0.3 to +30V
Voltage at any pin to V_{DD}	V_{MAX}	+0.3V
Voltage at any pin to V_{REG}	V_{MIN}	-0.3V
Current at OUTs 1 and 4	I_{OUTMAX}	±25mA
Current at OUT 2/3	$I_{OUTMAX2}$	±50mA
Operating temp. range	T_A	-40 to +105°C (1)
Storage temp. range	T_{STO}	-65 to +125°C

(1) E^2PROM programming at 25°C ± 5°C Table 1

Stresses beyond these listed maximum ratings may cause permanent damage to the device. Exposure to conditions beyond specified operating conditions may affect device reliability or cause malfunction.

Operating Conditions

Parameter	Symbol	Test conditions	Min.	Type	Max.	Units
Operating temperature	T_A	Functional	-40		+105	°C
Supply voltage	V_{DD}	Car battery with R=100Ω				
- Start-up voltage	V_{ST}		7		24	V
- Working voltage	V_W		4.3		24	V
Input voltage at any pin	V_{IN}		V_{REG}		V_{DD}	V
Coil resistance	R_{B25}	M-S X16.xxx, T_A=25°C	260	290	320	Ω
Phase inductance	L_{25}	M-S X16.xxx, T_A=25°C		0.4		H
Specific operation conditions :						
Set function resistor	R_S	V_{DD} = 6 to 20V	12	13	14	kΩ

Table 2

Electrical Characteristics

12V supply with 100Ω series resistor and 220µF//100nF capacitors, T_A = 25°C, unless otherwise specified

Parameter	Symbol	Test Conditions	Min.	Type	Max.	Units
Power Consumption (Average value incl. motor pulses)	I_V	Quartz 4 MHz and motor connected.		0.8	1.2	mA
Inputs Characteristics						
Low-level input voltage	V_{IL}		V_{REG}		V_{REG}+0.5	V
High-level input voltage	V_{IH}		V_{DD}-0.3		V_{DD}	V
Pull-up resistors	R_{IN}	SET_CW and SET_CCW	30	50	100	kΩ
		TUNING and TSTMOD	6	10	20	kΩ
Outputs TEST and IT						
Low-level output voltage	V_{OL}	$\lvert I_{OUT} \rvert \le$ 1mA			V_{REG}+0.5	V
High-level output voltage	V_{OH}	$\lvert I_{OUT} \rvert \le$ 1mA	V_{DD}-0.5			V

Table 3

Timing Characteristics for Programming

V_{DD} = 12V, V_{SS} = 0V, t_{rise} and t_{fall} $\leq$ 200ns, input signal swing -5V (referenced to V_{DD})

Parameter	Symbol	Test Conditions	Min.	Type	Max.	Units
Set-up time to V_{PP} ; TUNING	t_1	see fig. 4	150			µs
Set-up time to DATA ; V_{PP}	t_2		10			µs
Hold-time to DATA ; V_{PP}	t_3		10			µs
Memory refresh time	t_{RF}		150			µs
Enable time	t_E		3			ms
Wait time	t_W		3			ms
High-state DATA pulses	t_H		1			µs
Low-state DATA pulses	t_L		1		1000	µs
Memory write time	t_{TR}		100		300	ms
Cycling capability	Ncyc		50			
Time between two successives write	t_{CYC}		100			ms

Table 4

Programming Timing Waveforms

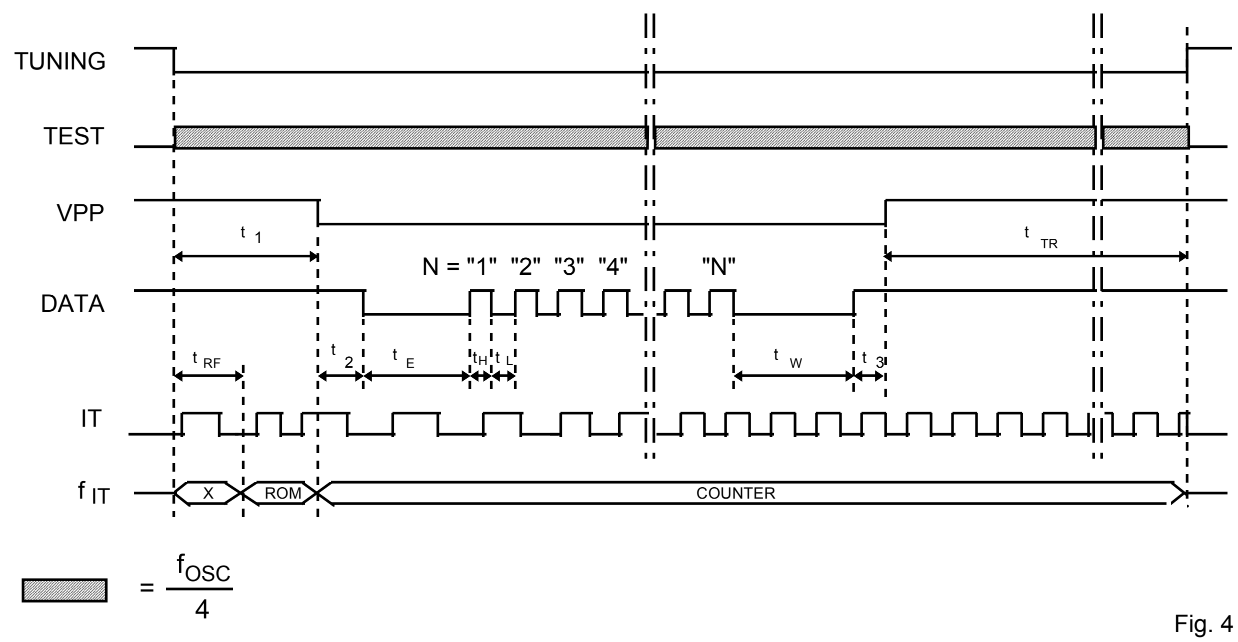


Fig. 4

Block Diagram

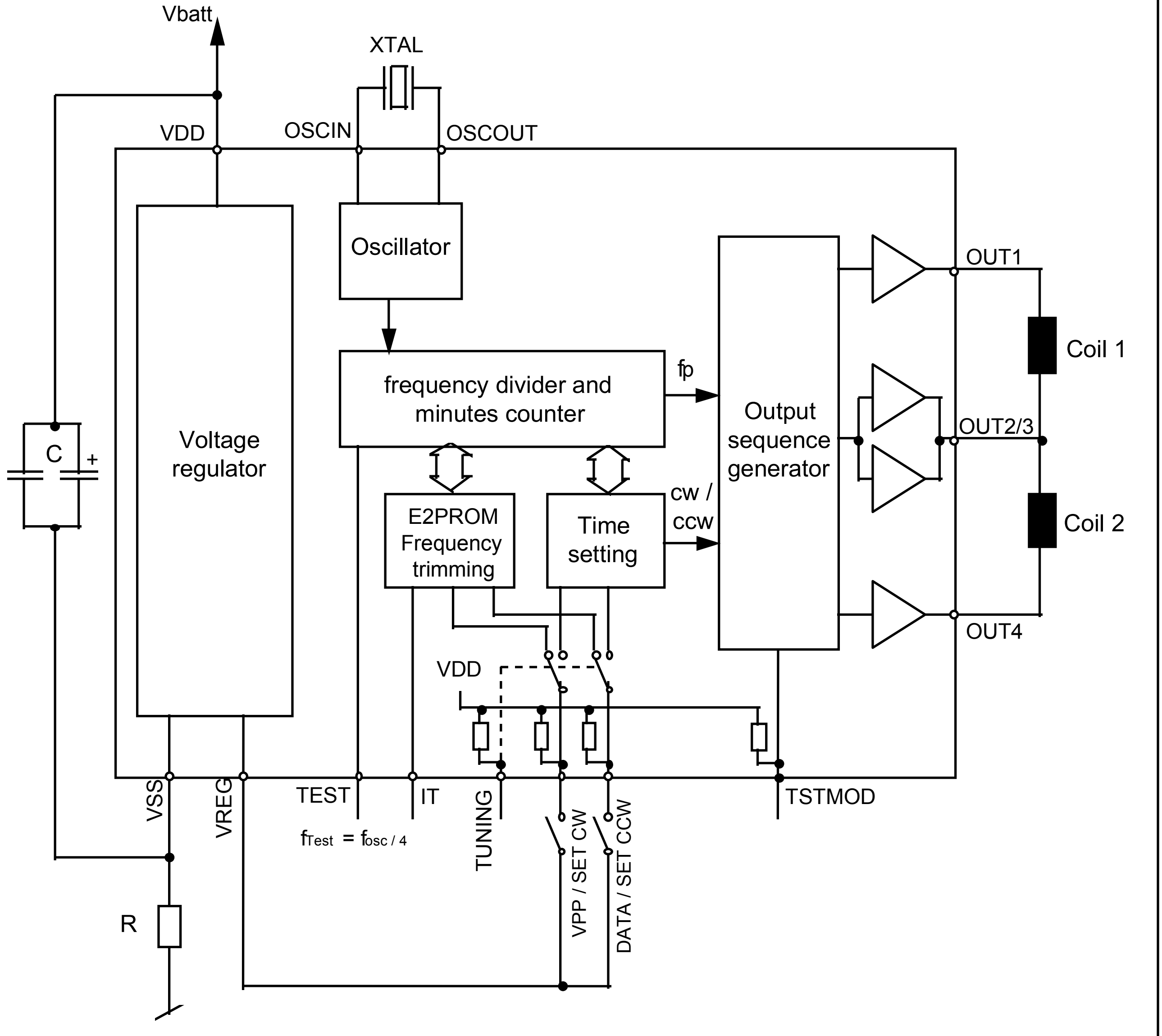


Fig. 5

Output Sequence Generator

The output sequence generator provides the required pulse train to the ACC M-S motor to move the indicator shafts. The M-S X16.xxx turns by 6° each minute.

The pulse train timing given in fig. 6 describes the clockwise operation of the ACC M-S.
For counterclockwise operation, the pulse sequence must be read from the right to the left.

Timing Waveforms

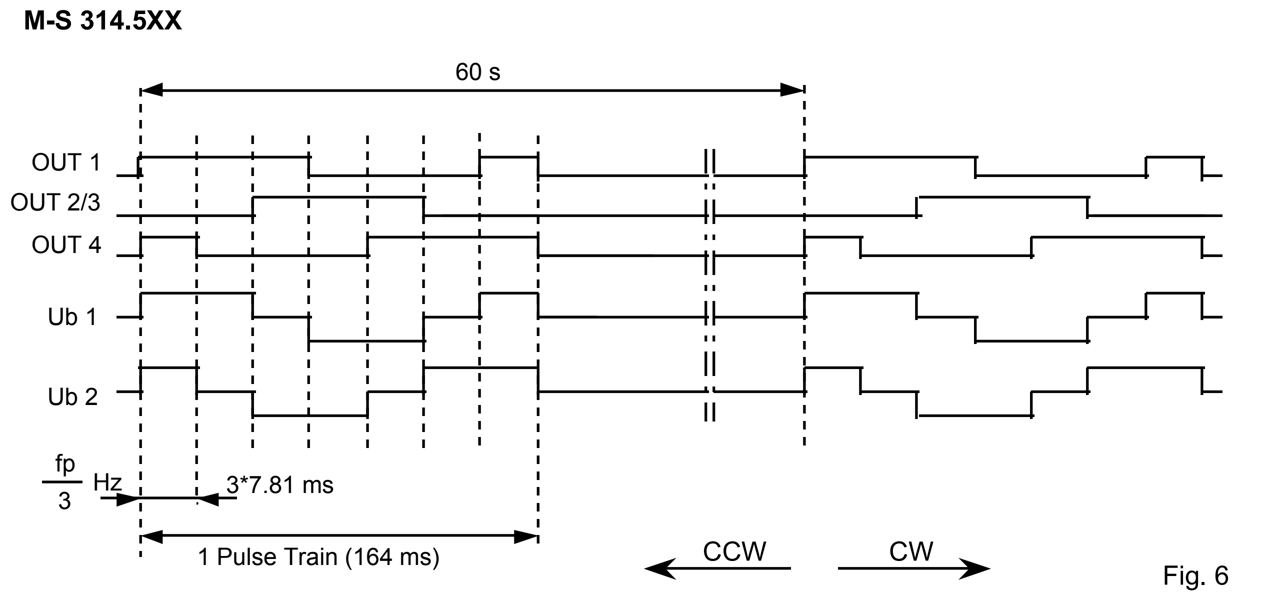


Fig. 6

Pin Description

Pin Number DIP14 Version	Pin Number SOL16 Version	Name	Function
1	1	OUT2/3	Coil outputs 2 and 3
2	2	OUT1	Coil output 1
3	3	TUNING	Selection between normal operation and programming mode
4	4	VSS	Negative supply voltage
5	5	VPP or SETCW	Programming or time setting input (clockwise)
6	6	DATA or SETCCW	Programming or time setting input (counterclockwise)
7	7	TSTMOD	Test input (used for production testing only)
-	8	NC	Not connected internally
-	9	NC	Not connected internally
8	10	OSCOUT	4 MHz oscillator output
9	11	OSCIN	4 MHz oscillator input
10	12	VREG	Regulated voltage for SET inputs
11	13	VDD	Positive supply voltage
12	14	IT	The frequency on IT reflects the content of the internal E^2PROM
13	15	TEST	Oscillator frequency divided by 4
14	16	OUT4	Coil output 4

Table 5

Tuning Pin

The TUNING pin allows to select between the normal mode and the programming mode.
When low, the TUNING pin enables the VPP and DATA inputs for programming.
When high, it is the SET CW and SET CCW functions that are active.
This input is internally pulled-up by a 10kΩ resistor and is active low (VREG).

Tstmod Pin

The TSTMOD pin is used for production testing only. In normal operation, this pin must be connected to VDD or left unconnected.
This input is internally pulled-up by a 10kΩ resistor and is active low (VREG).

Time Setting

Time setting is done with the SET CW and SET CCW inputs.
These two inputs are internally pulled-up by 50kΩ resistors and are active low (VREG).

Caution

The **low level** for all inputs is VREG and **not VSS** or the battery ground ! The direct connection of an input to VSS could permanently damage the chip. In order to use VSS or battery ground as the low level, a serial resistor Rs with a typical value of 13 kΩ is to be connected and will allow operation over a supply voltage range from 6V to 20V (see fig. 2).

Entering Set Mode

Entering set mode is achieved by pulling one SET xx pad to VREG.
The debounce time is 15.6 to 23.4 ms for a positive or negative transition of the SET xx pins.

As soon as the SET xx level is validated as low (t0 in fig. 7), one motor pulse train is generated and the motor pulse sequence described in fig. 6 is started.

If a low level is validated on SET xx during a normal motor pulse train, this pulse train is normally completed, no additional pulse is generated and the sequence continues as in fig. 7.

Exit from the Set Mode

Exit from the set mode is achieved by returning the SET xx pin to VDD (or floating as it is internally pulled-up).
The next normal pulse train will appear on the motor outputs 60 seconds after the SET xx pin has been validated as high.
If a pulse train is being outputted when the SET xx pin is validated, this pulse train will be completed and the next normal pulse train will appear 60 seconds after this last one.

Time Setting Waveforms M-S X12.506

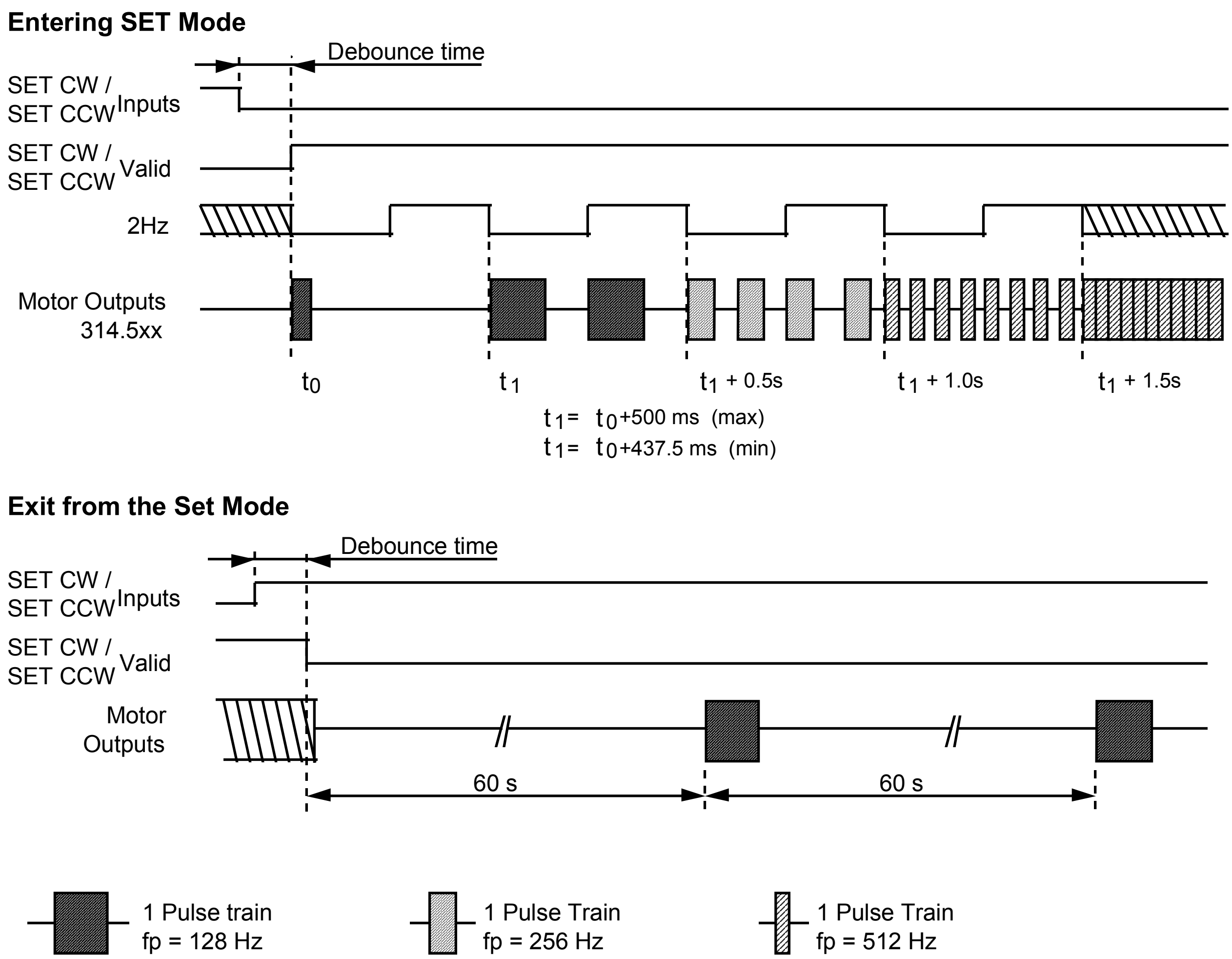


Fig. 7

Oscillator

4.194304 MHz oscillator with external quartz crystal.

Required crystal characteristics for driving levels between 100nW and 10µW :

- Frequency : 4194304 Hz
- Frequency tolerance @ 25°C : ± 30 ppm
- Working temperature range : -40 to +105°C
- Load capacitor : typ 12 pF
- Series resistance : R < 100 Ω

Due to the very low power consumption of this circuit, attention has to be paid to the selection of the quartz quality in respect to the stability of the series resistance at very low driving levels.

Digital Tuning

The tuning of the oscillator consists in a modification of the division rate of the frequency divider. The modification is made by suppressing N pulses every X seconds. This number N is kept in a non-volatile 5 bits memory (E^2PROM). With 5 bits, the correction range is ± **57.2** ppm with a correction step of 3.8 ppm. The N = 31 value of the E^2PROM is reserved as an output driver disable value.

Programming of the E^2PROM

To tune the frequency, 5 pads are used :

TUNING input
VPP input
DATA input
TEST output
IT output

The tuning procedure is as follows (see also fig. 4):

Programming mode is entered by pulling input TUNING to VREG. At this moment, the output TEST starts delivering the oscillator frequency divided by 4 and the output IT becomes active.
In order to calculate number N, proceed as following:

- Measure $f_{(TEST)}$

- The nearest value of $f_{(TEST)}$ found in table 6 gives the value of N.

When number N is known, it has to be written in the E^2PROM. To do so, input VPP must be pulled down to enable entrance of data.
The required number N of pulses is then applied to the DATA input.
When input VPP is returned to VDD, E^2PROM writing is started. After the rising edge of VPP input, the TUNING input has to remain low at least 100 ms to ensure proper E^2PROM writing.
Remark : At delivery, the E^2PROM of the chip is programmed with N = 31 (meaning that the motor outputs are disabled).

Caution

The **low level** for all inputs is VREG and **not VSS** or the battery ground ! The direct connection of an input to VSS could permanently damage the chip. In order to use VSS or battery ground as the low level, a serial resistor Rs with a typical value of 13kΩ is to be connected and will allow operation over a supply voltage range from 6V to 20V (see fig. 2).

Description of IT Output

The output IT is used to check the content of the E^2PROM.
This output is normally at level VREG. When the chip is in programming mode (TUNING input low), a signal of frequency f_{IT} with duty cycle of 50% appears on the output IT. The frequency f_{IT} is an image of the actual value of N programmed in the E^2PROM (see table 6).
The exact expression for the frequency f_{IT} is :

$$f_{IT} = \frac{2^{22}}{32\,(49 + N)}$$

The difference between f_{IT} for N and N+1 is in the order of 1%. Since the frequency deviation of the oscillator is max. 60 ppm, there is no problem in distinguishing one N from another.
Table 6 shows f_{IT} for all possible values of N calculated at nominal oscillator frequency.

Verification of the E^2PROM Content

The verification of the E^2PROM content can be made by measuring the frequency delivered on IT, 150 µs after pulling the TUNING pin low.
The TUNING pin must be returned high without entering any data.

Values of N with the Corresponding Frequency Correction

N	Δf/f (ppm)	f(TEST) (Hz)	f(IT) (Hz)	
0	+57.2	1'048'516	2674.9	Trimming range (N = 0 to 30)
1	+53.4	1'048'520	2621.4	
2	+49.6	1'048'524	2570.0	
3	+45.8	1'048'528	2520.6	
4	+42.0	1'048'532	2473.0	
5	+38.1	1'048'536	2427.2	
6	+34.3	1'048'540	2383.1	
7	+30.5	1'048'544	2340.6	
8	+26.7	1'048'548	2299.5	
9	+22.9	1'048'552	2259.9	
10	+19.1	1'048'556	2221.6	
11	+15.3	1'048'560	2184.5	
12	+11.4	1'048'564	2148.7	
13	+7.6	1'048'568	2114.1	
14	+3.8	1'048'572	2080.5	
15	0	1'048'576	2048.0	
16	-3.8	1'048'580	2016.5	
17	-7.6	1'048'584	1985.9	
18	-11.4	1'048'588	1956.3	
19	-15.3	1'048'592	1927.5	
20	-19.1	1'048'596	1899.6	
21	-22.9	1'048'600	1872.5	
22	-26.7	1'048'604	1846.1	
23	-30.5	1'048'608	1820.4	
24	-34.3	1'048'612	1795.5	
25	-38.1	1'048'616	1771.2	
26	-42.0	1'048'620	1747.6	
27	-45.8	1'048'624	1724.6	
28	-49.6	1'048'628	1702.2	
29	-53.4	1'048'632	1680.4	
30	-57.2	1'048'636	1659.1	
31	**Motor outputs disabled**		1638.4	- Memory status at delivery

Table 6

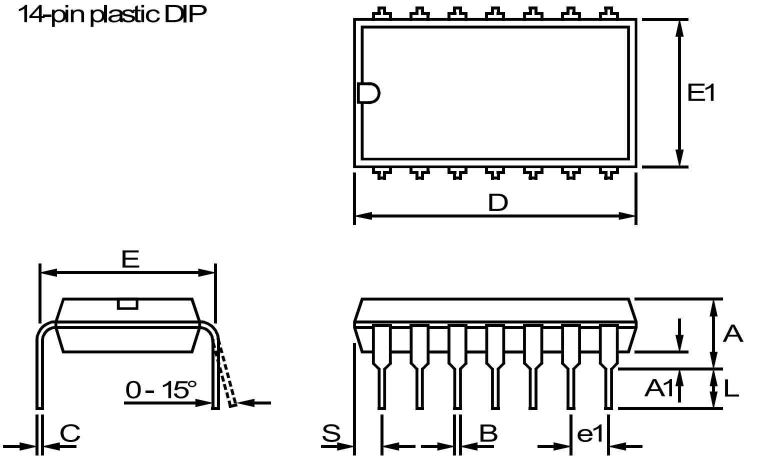
N	:	Number of suppressed pulses per 60 seconds
Δf/f	:	Relative correction of the frequency corresponding to N
$f_{(TEST)}$	:	Frequency measured on the TEST pad
Δf	:	Absolute error on $f_{(TEST)}$ which is exactly corrected with N
$f_{(IT)}$	:	Frequency on IT pad calculated at nominal oscillator frequency (4'194'304)

The values of N can be computed with the following formula:

$$N = \text{INTEGER}\left(\frac{f_{(TEST)} - 1'048'514}{4}\right) \quad \text{with } f_{(TEST)} \text{ in Hz}$$

Dimensions of DIP Package

14-pin plastic DIP

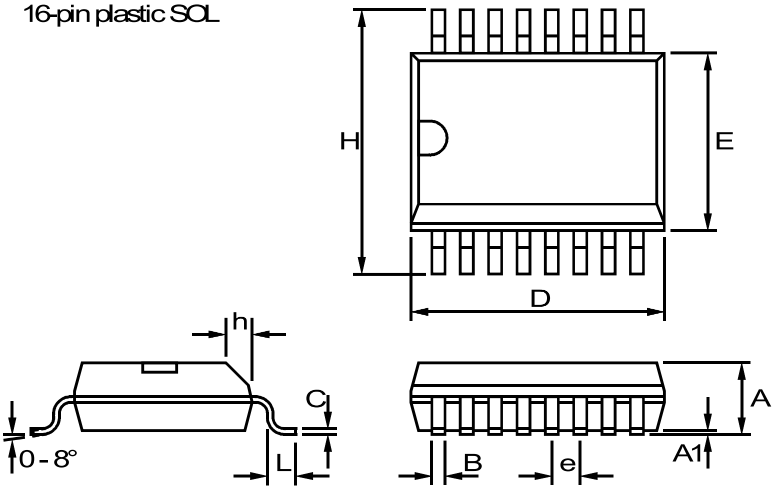


	Inches		mm	
	Min	Max	Min	Max
D	0.745	0.755	18.92	19.18
E1	0.240	0.260	6.10	6.60
E	0.300	0.325	7.62	8.26
C	0.008	0.012	0.20	0.30
S	0.068	0.083	1.73	2.11
B	0.015	0.022	0.38	0.56
e1	0.100 BSC		2.54 BSC	
A1	0.015	-	0.38	-
A	-	0.170	-	4.32
L	0.125	0.135	3.18	3.43

Fig. 8

Dimensions of SOL Package

16-pin plastic SOL



	Inches		mm	
	Min	Max	Min	Max
D	0.402	0.412	10.21	10.46
E	0.292	0.299	7.42	7.59
H	0.400	0.410	10.16	10.41
C	0.009	0.013	0.23	0.32
h	0.010	0.016	0.25	0.41
B	0.014	0.019	0.35	0.48
e	0.050 BSC		1.27 BSC	
A1	0.005	0.012	0.12	0.29
A	0.097	0.104	2.46	2.64
L	0.024	0.040	0.61	1.02

Fig. 9

Ordering Information

The ACC M-S Driver X12.506 is available in the following packages:

- DIP 14-pin plastic package	ACC M-S Driver X12.506 - DIP14
- SOL 16-pin wide plastic package	ACC M-S Driver X12.506 - SOL16 (available on reel)

Chip form on request.

When ordering, please specify the complete part number and package.
Special feature: These products from Jan. 2006 are in conformance to RoHS and Green mold regulations.

Table of Contents

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