

DTA100 Low Power Atomic Oscillator User's Guide

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Contents

1 Introduction	3
2 DTA100 Overview	3
2.1 Precautions	3
2.2 Packaging	4
2.3 Absolute Max Ratings.....	4
2.4 Mechanical Outline	4
2.5 Recommended Operating Parameters.....	5
3 The Developer's Kit.....	5
3.1 Installing DTA100 to the Evaluation Board.....	6
3.2 Cabling and Connection.....	6
3.3 Initial Power on.....	7
4 Functional Description.....	7
4.1 DTA100 Basics.....	7
4.1.1 Lock.....	7
4.1.2 RF Output	7
4.1.3 Frequency Adjust	8
4.1.4 Frequency Nominal	8
4.1.5 1 PPS Output	8
4.1.6 Phase Meter	9
4.1.7 1 PPS Disciplining	9
4.1.8 Cable Length Compensation	9
4.1.9 Analog Tuning	10
5 DTA100 Telemetry and Command	10
5.1 RS232 Hardware Interface	10
5.2 Overview of Telemetry Interface	10
5.3 Command Summary	10
5.4 Detailed Command Descriptions	10

1) Introduction

The Taitien DTA100 low power oscillator is an atom based battery powered clock designed for timekeeping applications. DTA100 product offers double oven temperature performance with a typical power consumption of <160 mW and superior warm up, retrace and aging performance over quartz based clock source. This user's guide is intended to provide basic guidelines and recommendations for users designing products with DTA100 as a reference. Please see datasheet for their specifications..

2) DTA100 Overview

The Taitien DTA100 is an atom based low power oscillator with excellent warm up, retrace, aging, drift as well g sensitivity performance. The low power consumption, low temperature coefficient and superior aging performance make DTA100 an ideal choice for battery powered, portable time keeping applications. DTA100 provides a RF output at 10MHz as well as a time synchronized 1 PPS output in standard CMOS levels. It accepts a 1 PPS input so that its 1 PPS output can be synchronized or disciplined to an accurate 1 PPS input. DTA100 can discipline its phase and frequency to within 1 ns RMS and 1×10^{-12} respectively to its reference. DTA100 offers a self-contained phase meter with a full range of 1 second and a resolution of 1 ns.

Figure 1 below shows a picture of Taitien's DTA100.

Figure 1. Taitien's DTA100 Low power atomic oscillator



2.1 Precautions

*Caution: *To avoid electrostatic discharge (ESD) damage, proper ESD handling procedures must be observed in unpacking, assembling, and testing the DTA100.*

*****Please do not drop the unit.***

The DTA100 is delivered in an ESD-safe package. The DTA100 should only be removed from the ESD protective package in an ESD-safe environment. Once installed on test fixtures, ESD sensitivity is considerably reduced. However, it is recommended that the entire assembly be treated as ESD-sensitive insofar as possible and standard ESD protection practices are followed. Please make sure not to drop the unit to hard surfaces due to its open frame design without a second enclosure.

2.2 Packaging

Please retain the original DTA100 ESD-safe packaging material if the device needs to be returned to Taitien Inc.

2.3 Absolute Max Ratings

Please refer to Table 1 below for maximum ratings for DTA100. Operating beyond maximum rated values can cause non-recoverable product damage.

Table 1. Absolute Maximum Ratings*

Parameter	Rating
Supply Voltage	+4.2 VDC
Maximum Current	1 PPS Input, RS232, Oven Ready, +/-2 mA 1 PPS Output, RF Output, +/-20 mA
Storage Temperature	-55 °C to +85 °C

**Refer to DTA100 datasheet for specified operating parameters*

2.4 Mechanical Outline*

The Physical dimensions of DTA100 are 2" x 2" x 0.8". The footprint and pin assignment of DTA100 are shown below in Figure 2 in Top view. Please note the footprint is compatible to Microchip's SA.45. Mounting pin diameter: 0.03"

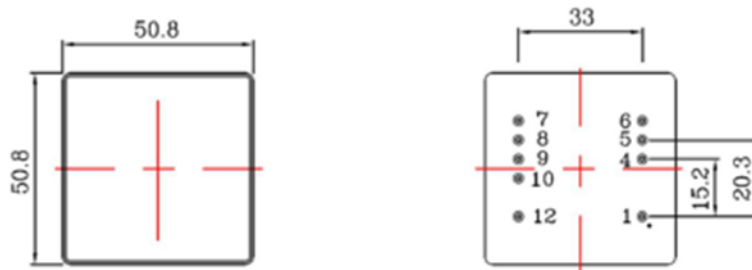


Figure 2, DTA100 outline and footprint

Pin Assignment

1	Do not use
4	Lock
5	Tx
6	Rx
7	Vcc, +3.3V
8	GND
9	1PPS Input
10	1PPS Output
12	RF Output

For Initial test and evaluation, it is recommended to plug the unit to a socket mounted on a Print Circuit Board (PCB). The recommended socket for PCB attachment is **Tyco P/N 4-5332070-4** (digikey part #A122453-ND)

2.5 Recommended Operating Parameters

DTA100 pin out is defined in section 2.4. This section provides more details on electrical functions. See Table 2 below.

Table 2 Recommended Operation Parameters

Pin	Function	Electrical Characteristic	Note
1	Do not use		
4	Oven Ready	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	0, Oven ready 1, warming up
5	RS232, Transmit	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	A transceiver such as MAX202 is required for level shift
6	RS232, Receive	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	A transceiver such as MAX202 is required for level shift
7	Vcc	3.3 +/-0.1 VDC	
8	Ground		
9	1 PPS input	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	
10	1 PPS output	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	
12	RF output	2.5 V<Logic H<Vcc 0 V<Logic L<0.3 V	

3 The Developer's Kit

DTA100 evaluation kits include all necessary hardware and cabling to support evaluation of DTA100 functionalities, performance, customer prototype demonstration and software interface development. Evaluation kits include the following,

Table 3. Evaluation Package Content

Item	Description, Taitien Part number	Note
Evaluation board	Taitien DTA100 evaluation board Rev. 1.	
USB to RS232 Adaptor Cable	Male end	A MAX202 is on evaluation board
Power Adaptor		+5 VDC, 5 mm, center positive
RS232 gender changer		Female, Female

Figure 3 below shows a picture of DTA100 evaluation board with a unit installed on it. LOCK is the unit ready indicator. On the evaluation board there is a divide by 2 output.

Figure 3, DTA100 Evaluation Board with a Unit on it



3.1 Installing DTA100 to the Evaluation Board

Caution: to avoid ESD damage, proper ESD handling procedure must be followed in unpacking, assembling and testing of DTA100!

Remove DTA100 and DTA100 Evaluation board from its ESD protected shipping package in an ESD safe environment. Gently insert DTA100 to its receiving socket on the evaluation board.

Please note, due to its pinout definition and footprint layout, DTA100 can only be installed into the evaluation board in one orientation.

3.2 Cabling and Connection

Connect included RS232 cable between evaluation board and a COM port of a computer. In case, there is no serial port available, a USB to RS232 adaptor can be used. The development kit includes this USB to Serial adaptor. Set the COM port configuration as below

Baud rate: 57600

Data Bits 8

Parity none

Stop Bits 1

Flow Control none

Make sure power switch is in the off position on the evaluation board before applying power. Connect power adaptor between DC power input connector on the evaluation board and 110/220 V AC wall plug.

DTA100 RF output and 1 PPS output are available on the evaluation board with BNC connectors. Connect output with BNC cable to test equipment.

3.3 Initial Power on

Connect power, RS232, and output cable as described in section 3.2. Turn on power switch on evaluation board. If the COM port is open, a welcome message is displayed when serial communication is established.

For the very first-time power on, please be aware the initial drift maybe slightly different from when it is fully stabilized.

Use a DC current meter, set to mA range, to measure power consumption. Most of the benchtop power supply current meter is not accurate enough.

During initial burn in time, functionality of DTA100 can be checked by digital interface.

4. Functional Description

4.1 DTA100 Basics

DTA100 is anatomic based low power oscillator. It typically consumes less than 160mW power while delivering superior performance. It consists a full 1 second phase meter with 1ns resolution and has the capability to synchronize or discipline an external 1 PPS.

To achieve minimum tempco, temperature change rate should be kept less than 0.5C/Minute.

**It is recommended not to install DTA100 near a cooling fan in a system. Air flow around the unit may impact its short-term stability. Similarly, installing DTA100 into a system that has an enclosure damps air flow around it and thus maintains its best short-term stability.*

4.1.1 Lock

Lock (pin 4) is a digital bit indicating atomic lock and oscillator is ready to use. When DTA100 achieves atomic lock, this bit is assigned. A logic 0 indicates oscillator is ready. A Logic 1 indicates oscillator is cold or warming up.

4.1.2 RF Output

RF output (pin 12) of DTA100 is a buffered CMOS level digital output with a source impedance of 100 ohms. The logic 1 level is about +3.3V. Due to the nature of DTA100 design, it is expected that RF output is driving a high impedance not a 50 ohms load.

4.1.3 Frequency Adjust

For frequency set or frequency calibration, DTA100 provide an analog tuning function as well as a digital frequency adjust capability. Analog tuning acts like any traditional crystal oscillator frequency control function. It can be enabled or disabled through digital command. When enabled, use analog frequency control to adjust frequency. Digital frequency adjust function remains but not recommended to use in concurrent with analog tuning. By default, analog tuning is disabled, and **it is expected that Analog Tuning is rarely used or not used.**

There are two digital frequency adjust commands, **!FD** and **!FA**. Command **!FD** is used for adjusting the current frequency value as an offset adjust.

!FD adjust A100 frequency from its current value in the unit of 1×10^{-15} . It is a relative frequency adjust.

For example

!FD1000000, adjust frequency by 1×10^{-9} higher from its current value. Similarly, a

!FD-1000000, adjust frequency by -1×10^{-9} lower from its current value.

!FA is an absolute frequency adjust comparing to DTA100's nominal frequency. See next section below.

4.1.4 Frequency Nominal

The frequency nominal is internally calibrated before DTA100 is shipped out from factory. The calibration value is stored in non-volatile memory so that when next power up, DTA100 frequency is return to this value. Beyond **!FD** command, which adjust frequency relative to its current value, DTA100 also provides an absolute frequency adjust command **!FA**. **!FA** command adjusts DTA100 frequency in the unit of 1×10^{-15} related to this non-volatile storage frequency nominal. For example, if the oscillator is set right on its nominal, a

!FA1000000 changes frequency to 1×10^{-9} higher than its nominal. A

!FA5000000 changes frequency to 5×10^{-9} higher than its nominal frequency. Similarly, A

!FA-3000000 changes frequency to -3×10^{-9} lower than its nominal.

In either case of **!FD** or **!FA**, a **!FL** command will save current frequency value to non-volatile memory and the pre-set nominal value is thus updated.

4.1.5 1PPS Output

A 3.3V CMOS level 1 PPS (one pulse per second) signal is available on Pin 10. It is synchronized to its RF output internal to DTA100. The source impedance of the 1 PPS output is 100 ohms. It is expected that this pin is driving a high impedance load.

The 1 PPS output rising edge can be manually synchronized to within ± 100 ns to its reference 1 PPS rising edge via command **!S**. The 1 PPS output of DTA100 can be disciplined to within 1 ns from its reference 1 PPS rising edge.

4.1.6 Phase Meter

DTA100 implemented both a coarse and fine time interval counter internal to DTA100. With a unique propriety design, the coarse and fine phase counters are smoothly combined without glitch for a full 1 second measuring and reporting capability. The resolution for the phase meter is about 1 ns RMS.

The phase meter measuring mode can be enabled with command **!MM** for telemetry reporting and disabled with command **!Mm**

4.1.7 1 PPS Disciplining

Based on its internal high-resolution phase meter, DTA100 can discipline a 1 PPS reference with its built-in algorithm. DTA100 implements a 2nd order control loop to steer simultaneously both phase and frequency of its output by adjusting oscillator frequency. Depending on loop time constant, DTA100 can eventually achieve phase and frequency accuracies of <1 ns and 1×10^{-12} , respectively.

1 PPS discipline can be enabled and disabled by digital command **!MD** and **!Md**. The default loop time constant is 50 seconds. 1 PPS loop time constant can be adjusted with digital command **!D**. With loop time constant of 50 second the performance of DTA100 is limited by its internal phase detector noise floor, though it can achieve a given accuracy quicker. To observe true oscillator short term performance, a time constant longer than 300 seconds is recommended. The Default damping factor is 1.0. Example of these digital commands is show below

!D300, to set loop time constant to 300 seconds

!D? to inquiry loop time constant

The loop lock detection threshold is defaulted to ± 20 ns, however it can be changed with digital command **!mX** per different applications.

Due to its low short-term frequency instability, it is recommended to determine loop time constant, the **!D** value considering the noise performance of the reference 1PPS source. Set the **!D** value to the cross point of reference 1pps source and DTA100 frequency stability performance is recommended for optimal performance.

However, in applications demanding fast lock up, a loop time constant of 10 seconds maybe suitable to quickly discipline DTA100 to better than 1×10^{-12} in frequency and 1 ns RMS in phase.

4.1.8 Cable Length Compensation

The phase detector and its zero value are referring to the phase detector input signal internal to DTA100. In the case that both reference 1 PPS and DTA100 1 PPS are displayed on a digital

scope, the phase difference may have an offset due to cable length and internal delay. DTA100 provides a cable length compensation command to allow adjust of phase zero point. The command for doing so is **!DC**. The unit for cable length compensation is roughly **100 ps**.

4.1.9 Analog Tuning

Analog Tuning function can be enabled by command **!MA**

5. DTA100 Telemetry Interface and Command

5.1 RS232 HARDWARE INTERFACE

Pins 5 and 6 provide a serial interface for communicating with DTA100. The protocol is fundamentally RS232, though the voltage levels are CMOS (0 to Vcc) at the interface of DTA100, rather than a standard ± 12 V. For interfacing with a standard RS232 controller interface, a level transfer transceiver such as MAX202 is required. On DTA100 evaluation board, a MAX202 is installed in place.

5.2 Overview of Telemetry Interface

The DTA100 communications protocol follows industry standard format. It exclusively uses printable (non-binary) ascii characters. In general, commands are to be preceded by an exclamation point ("!") and followed by a carriage-return/linefeed [CRLF] pair (ascii 0x0D 0x0A). After transmitting '!' but prior to sending [CRLF], a command may be aborted by sending the escape character (ascii 0x1B). Table 4 below summarizes DTA100 commands.

5.3 Command Summary

Table 4 DTA100 commands Summary

Command	Description
!6[CRLF]	Return telemetry headers as comma-delimited string
!^[CRLF]	Return telemetry value as comma-delimited string
!F? [CRLF]	Adjust oscillator frequency
!M? [CRLF]	Assign operating mode register bit
!S[CRLF]	Manual Sync DTA100 1 PPS to an external reference 1 PPS
!D? {CRLF]	Set 1 PPS discipline loop time constant

5.4 Detailed Command Descriptions

"!6"to retrieve the telemetry headers

Example Unit Response

SN, Mode, BITE, HeatP, Temp, Contrast, Steer, Sig, Phase, DiscOK, TOD, LTime, Ver

SN,MODE,BITE,HEAT P,TEMP,contrast,STEER,sig,PHASE,DISOK,TOD,LTIME,VER

"! ^" to retrieve the telemetry values. Both responses are comma-delimited strings.

Example Unit Response

MMMMDTANNNNNN,0x0010,0,8.8,30.48,3591,107,0, 1.313,0,1,3116,3032,1.02

0921DTA100500,0x0010,0,8.810,30.480,3591,107,1.313,0,1,3116,3032,1.02

Where MMMMA100NNNNN is a factory assigned serial number. M and N can be any number from 0 to 9.

BITE, 0 means LOCK, 1 means cold or warming up

The argument to the **!M** command includes

!MM/m for phase measurement mode enable/disable

!MD/d for 1 PPS discipline enable/disable

HeatP, heater power in mW

Contrast, internal resonator parameter

Steer, 1 PPS steer value in 1×10^{-12} when 1 PPS discipline enabled

Sig, internal resonator parameter

Tcomp, a factory reserved monitor value

Phase, phase measurement in ns

DiscOK, 1 PPS discipline status

0-aquiring

1-lock

2-hold over

--, no reference 1 PPS present

TOD, unit power on time in second

LTime, unit power on time after warmup bit is asserted to 0 in second

Ver, Firmware revision

!M?, Query unit mode register value

Unit response: 0x0012 (for example)

!MM, enable phase meter measurement mode

!Mm, disable phase meter measurement mode

!MD, enable 1pps discipline

Unit Response : 0x0010

!Md, disable 1pps discipline

Unit Response : 0x0000

!D100, Set 1pps discipline time constant, for example, to 100 second

!D?, Query 1pps discipline time constant

Unit response : 100

!m20, set 1pps lock threshold to +/-20ns, for example

Unit Response: 20

!DC150, Set 1pps steering cable length compensation to +150ns

Unit response; 150

!DC-150, Set 1pps steering cable length compensation to -150ns

Unit response; -150

!DC?, Query 1pps steering cable length compensation value

Unit Response: -150

!FA1000000

Unit Response: changes frequency to 1×10^{-9} higher than its nominal.

!FA-1000000

Unit Response: changes frequency to -1×10^{-9} lower than its nominal.

!FD1000000

Unit Response: changes frequency to 1×10^{-9} higher than its current value.

!FD-1000000

Unit Response: changes frequency to -1×10^{-9} lower than its current value.

**!FD command maybe more useful and easier to follow*

!FL, Latch and save current frequency value to become new default nominal

Unit Response: Steer Latched, Steer = 0

!S, Perform a Jam sync

Unit Response: **S** for sync, **E** for error

!T?, Query current ToD value

Unit Response: 37201 (in second)

!TA1000, Set absolute ToD value to 1000

Unit Response: 1000

!TD-1000, Adjust ToD value by -1000

Unit Response: -1000

!?, **Help to** list available command

Unit Response, a list of available command