

## AGS Master Clock System

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AGS Master Clock System

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A new master timing clock system for the AGS has been designed to replace the present system, using reliable, up-to-date, state-of-the-art components. The clock system is built around a free-running 10 MHz precision oven-controlled component oscillator, manufactured by Hewlett-Packard (HP-10811A), and by cascading six synchronous decade counters, timing combs of 1 MHz, 100 KHz, 10 KHz, 1 KHz, 100 Hz and 10 Hz are obtained as standard AGS pulses of 16-20 volts via pulse transformer output circuitry. The system is controlled by means of external reset/start and stop pulses. The function of the reset/start pulse is to reset the decade counters to zero, then start the timing combs, such that the first pulse of each output occurs correctly timed (i.e., the first 1 MHz pulse is 1  $\mu$ s after the start pulse, etc.). Since a 10 MHz oscillator is used, basic jitter of the first pulse with respect to the start pulse is 100 ns.

The function of the stop pulse is to stop the timing combs, creating a "gated" mode of operation, in that no timing comb pulses occur in the period between the stop pulse and the next start pulse. This mode was provided to allow for continued use of some electronic timing equipment which requires a short "dead" time interval in the pulse timing combs.

It should be noted that this stop pulse gates only the 100 KHz, 10 KHz, 1 KHz, 100 Hz and 10 Hz outputs. The 1 MHz output runs from one start pulse to the next. Besides the "gated" mode, the system can be operated with all timing combs "ungated", by removing the "stop" pulse. In this mode, all decade counters will be reset to zero at their starts, and the timing pulses would continue to the next reset/start pulse.

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The master timing clock system has been fabricated into two different NIM modules. The first "Master Oscillator Module" contains the 10 MHz HP-10811A oscillator; a (9615) differential input receiver which converts the sinusoidal output of the oscillator to a TTL compatible signal; and (75450B) buffers, to give a fanout of four 10 MHz signals from the module.

An LED for monitoring the initial warmup oven control of the oscillator is on the front panel of the module; it should light only for the first several minutes after power is applied to the module. A current limiting resistor (20 $\Omega$ , 5W) has been added in series with the oven supply in order to reduce the surge of current drawn to rapidly warm up the oven.<sup>1</sup>

The module also contains a back-up 10 MHz crystal oscillator (Motorola KY1100A) which can be switched in, should the HP-10811A oscillator fail.<sup>2</sup>

The front panel of the module contains the adjustment screw for the HP19811A; procedure for adjustment is given in the appendix. Oscillator specifications are also found in the appendix.

The second NIM module "Master Clock Module"<sup>3</sup> contains a printed circuit board with the cascading decade counters (74LS192); "one shots" (96S02) to shape the output pulses from the counters;<sup>4</sup> TTL buffers (7407); output transistor and associated pulse transformer circuitry for the timing comb outputs; and circuitry to process the reset/start and stop pulses.

The reset/start pulse is reduced in width to 75 ns via a one shot (96S02) in order that the reset time of the decades be less than the period of the 10 MHz oscillator pulses.

The 10 MHz pulses are sent to the first decade counter (74LS192) directly, and its output (1 MHz) is then fed through an "AND" gate (7408) which is opened by a flip/flop (7400) on the start pulse; thus allowing the 1 MHz pulses to reach the second decade counter.

All one shots (96S02) on the decade counter "carry" output trigger on the "rising" edge of their respective pulses. Though the "carry" pulse of the 74S192 is high-to-low-to-high, the synchronization is such that the rising edge corresponds to the rising edge of the input clock.

It should be noted that although the 74S192 decade counter is synchronous within the chip, there is a propagation delay from the "count up" to the "carry" output, typically 17 ns per chip which will give a small propagation error in the outputs. This will range from 17 ns, typically, for the 1 MHz output, to 102 ns, typically, for the 10 Hz output.

The purpose of the buffers (7407) prior to the output circuitry is to ensure full saturation of the transistors. Full power supply decoupling has been implemented on each output transistor circuit to minimize the noise being transferred from one signal to another.

Careful notice should be given to the fact that two different pulse transformers are used:

Aladdin 90-0611 for the 1 MHz and 100 KHz pulses and

Aladdin 90-0616 for the lower frequencies

Power to the modules is provided by two supplies mounted in a separate module:

A 5 volt 5.7 amp supply provides for all TTL logic circuitry. The master oscillator module draws approximately 380 mA at 5 volts, while each of the master clock modules draw about 530 mA at 5 volts.

A  $\pm 15$  volt, 0.5A supply provides a + 15V line and a + 30V line (with the common ground attached to the supply's - 15V line). The + 15V line is solely for the operation of the HP-10811A oscillator. + 12V is obtained from the + 15V line through a 12V regulator (MC7812CT).

The + 30V line is used to power the master oscillator's oven, as well as to supply power to the output transistor circuitry for the timing combs. For the output transistors, 21.5V is obtained through a regulator (LM317K).

Current drawn from the + 15V and + 30V lines by the master oscillator module is 350 mA during initial warmup of the oven, and falls to 150 mA after about 15 minutes, as indicated by the oven supply monitor LED going out. Each of the master clock modules draws about 35 mA from the + 30V line for the output circuitry.

Ref.: D09-E-1313-3 Master Oscillator Module (NIM)  
D09-E-1306-3 Master Clock Module (NIM)  
D09-E-1314-3 Power Supply Module (NIM)

Job No. D09-OE-4113

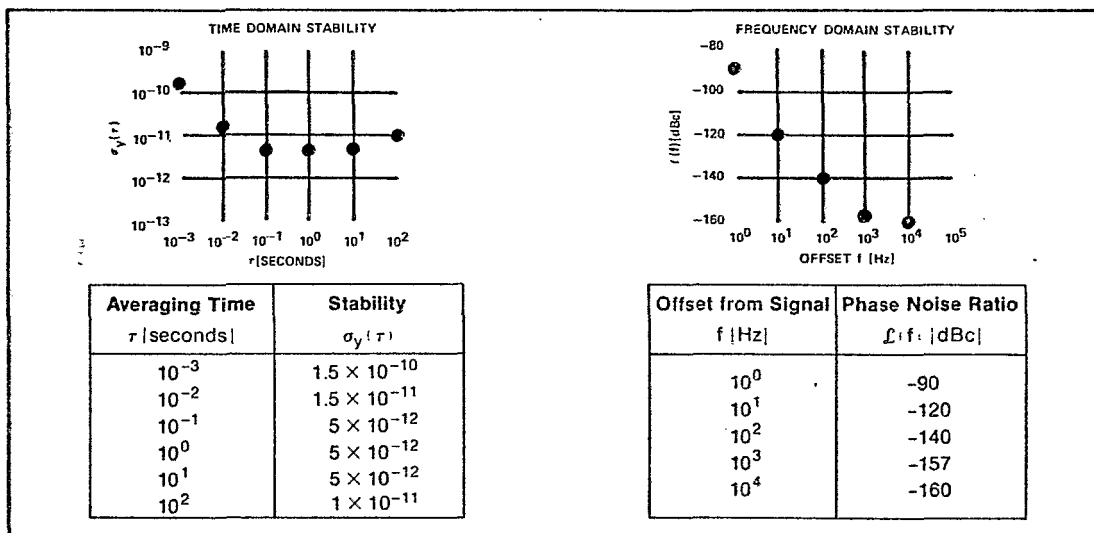
Notes

1. Since the clock systems would be on continuously, it was decided that "rapid" warming of the oscillator oven was unnecessary.
2. The front panel contains a switch for selecting one of the two oscillators, and should be left in the "down" position (HP-10811A), unless this is diagnosed as faulty, as the backup oscillator (KY1100A) will not have the precision or stability of the HP-10811A.
3. At the time of design, the plan was to have three master clock modules operate off the single master oscillator, to replace the then existing clocks. Four outputs were implemented from the master oscillator, but with more buffers, more clock modules could be driven.
4. Widths for the output pulses are determined by the RC time constants of the "one shots" (96S02). For the 10 KHz through 10 HZ pulses, the pulse width is 3-5  $\mu$ sec; for the 1 MHz and 100 KHz pulses, the pulse widths are 100 ns and 1  $\mu$ s, respectively (10% duty cycle).

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Table 1 10811A/B Specifications

**Frequency Stability:** (See Definition of Terms)

**Long Term (Aging Rate):**  $< 5 \times 10^{-10}$ /day after 24-hour warm-up. See Note 1.  
 $< 1 \times 10^{-7}$ /year for continuous operation.

**Short Term:** Refer to tables and figures above.

**Environmental Sensitivity:**

**Temperature:**  $< 4.5 \times 10^{-9}$  over a  $-55^\circ\text{C}$  to  $71^\circ\text{C}$  range.  $< 2.5 \times 10^{-9}$  over a  $0^\circ\text{C}$  to  $71^\circ\text{C}$  range.

**Operating:**  $-55^\circ\text{C}$  to  $+71^\circ\text{C}$ .

**Storage:**  $-55^\circ\text{C}$  to  $+85^\circ\text{C}$ .

**Load:**  $< 5 \times 10^{-10}$  for a  $\pm 10\%$  change in 50 ohm load.  $< 5 \times 10^{-10}$  for a  $\pm 25\%$  change in 1K $\Omega$  load.

**Power Supply:**  $< 2 \times 10^{-10}$  for a 1% change in oscillator supply voltage.

**Ripple and Noise:**  $< 100 \mu\text{V}$

**Oven:**  $< 1 \times 10^{-10}$  for 10% change in oven supply voltage.

**Gravitational Field:**  $< 4 \times 10^{-9}$  for 2g static shift (turn-over).

**Magnetic Field:**  $< -90$  dBc sidebands due to 0.1 millitesla (1 Gauss) rms at 100 Hz.

**Humidity (typical):**  $1 \times 10^{-9}$  for 95% RH at  $40^\circ\text{C}$ .

**Shock (survival):** 30 g, 11 ms,  $\frac{1}{2}$  sinewave.

**Altitude (typical):**  $2 \times 10^9$  for 0 to 15.2K m (50,000 ft)

**Adjustment**

**Coarse Frequency Range:**  $> \pm 1 \times 10^6$  ( $\pm 10$  Hz) with 18 turn control.

**Elec. Frequency Control (EFC):**  $\geq 1 \times 10^7$  (1 Hz) total, control range  $-5$  Vdc to  $+5$  Vdc.

**Output**

**Frequency:** 10 MHz

**Voltage:**  $0.55 \pm 0.05$  V rms into 50 ohm. 1V rms  $\pm 20\%$ , into 1K ohm.

**Harmonic Distortion:** Down more than 25 dB from output.

**Spurious Phase Modulation:** Down more than 100 dB from output (discrete sidebands 10 Hz to 25 kHz).

**Power Requirements**

**Oscillator Circuit:** 11.0 to 13.5 Vdc. 30 mA typical. 40 mA max. Noise  $< 100 \mu\text{V}$

**Oven Circuit:** 20 to 30 Vdc; turn on load is 42 ohm minimum. Steady-state power drops to a typical value of 2.0W at  $25^\circ\text{C}$  in still air with 20 Vdc applied.

**Warranty**

Hewlett-Packard warrants the 10811A/B Oscillator against defects in materials and workmanship for a period of one year from the date of delivery. The oscillator will be repaired or replaced at no charge during the warranty period.

**Connectors**

10811A: Mates with CINCH 250-15-30-210 (HP 1251-0160) or equivalent (not supplied).  
 10811B: Solder terminals and SMB Snap-on connectors. Mates with Cablewave Systems, Inc. #700156 or equivalent (not supplied).

**Accessories Available:**

**Service Manual:** HP 10811-90002: (not supplied).

**Size:**

72 mm x 52 mm x 62 mm, (see Figure 1).  
 (2-13/16" x 2-1/32" x 2-7/16", 14 cu. in.).

**Weight:** 0.31 kg (11 oz.)

**Definition of Terms**

**Long-Term Frequency Stability** is defined as the absolute value (magnitude) of the fractional frequency change with time. An observation time sufficiently long to reduce the effects of random noise to an insignificant value is implied. Frequency changes due to environmental effects must be considered separately.

**Time Domain Stability**  $\sigma_y(\tau)$  is defined as the two-sample deviation of fractional frequency fluctuations due to random noise in the oscillator. The measurement bandwidth is 100 kHz.

**Frequency Domain Stability** is defined as the single sideband phase noise-to-signal ratio per Hertz of bandwidth (a power spectral density). This ratio is analogous to a spectrum analyzer display of the carrier versus either phase modulation sideband. See "NBS-Monograph 140" for measurement details.

**Notes:**

1. For oscillator off-time less than 24 hours.
2. Final value is defined as frequency 24 hours after turn-on.

**Warmup**

10 min. after turn-on within  $5 \times 10^{-9}$  of final value, at  $25^\circ\text{C}$  and 20 Vdc. See Notes 1 & 2.

\*Specifications describe the instrument's warranted performance. Supplemental characteristics are intended to provide information useful in applying the instrument by giving TYPICAL or NOMINAL, but nonwarranted performance parameters. Definition of terms is provided at the end of the specification section.

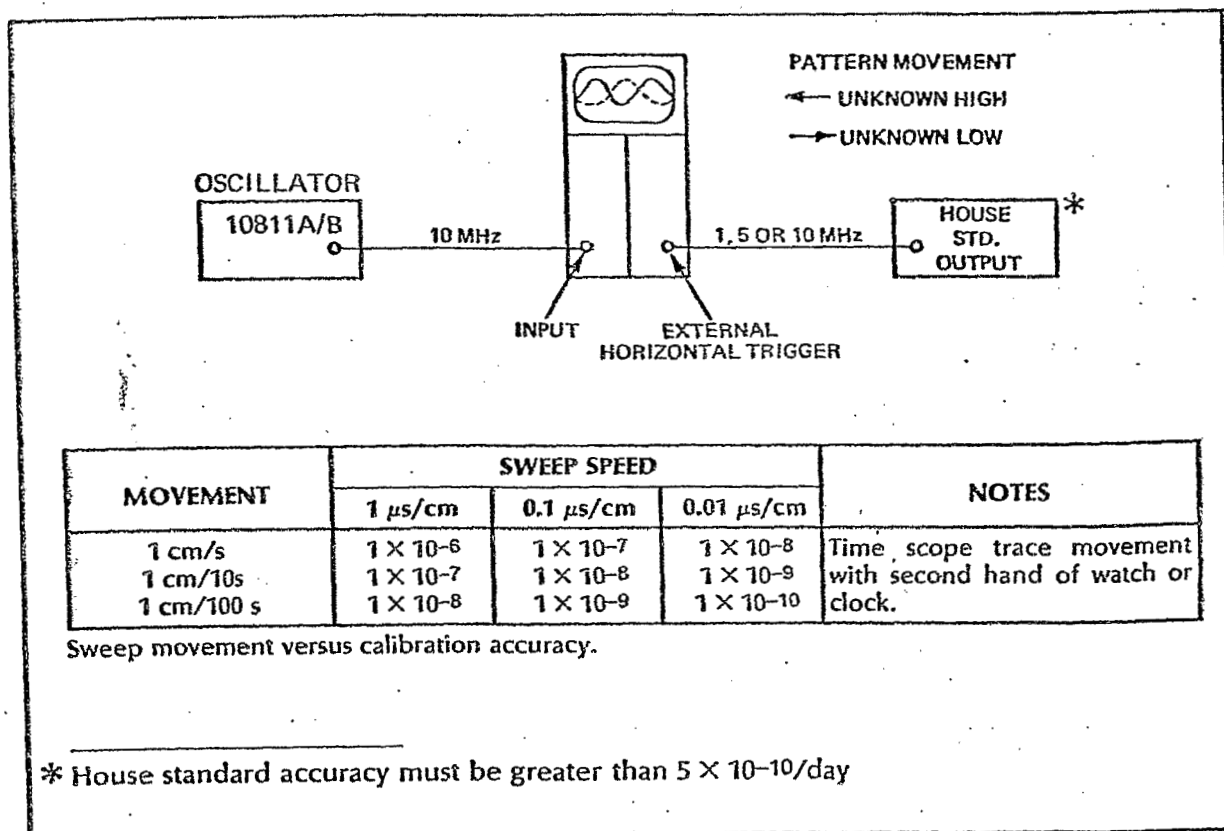


Fig 1 Oscillator Frequency Adjustment Set-Up

## FREQUENCY ADJUSTMENT

The frequency adjustment is the only periodic adjustment required. This may be initially adjusted after 10 minutes of warm-up, then readjusted after 24 hours.

### FREQUENCY ADJUSTMENT PROCEDURE

- Connect reference frequency standard (multiple or submultiple of 10 MHz) to the EXTERNAL SYNC INPUT of the oscilloscope.
- Connect oscillator output (10811A/B) to Channel A. Set the sweep speed to .1  $\mu\text{s}/\text{div.}$
- Set the oscilloscope to EXTERNAL TRIGGER and adjust the oscilloscope so that its sweep is synchronized to the reference frequency. The pattern will appear to move.
- Using an insulated tuning tool, adjust oscillator frequency adjustment (FREQ ADJUST on the 10811A/B) for minimum sideways movement of the oscilloscope pattern.
- By timing the sideways movement (divisions per second on the oscilloscope), the approximate offset can be determined based on the oscilloscope sweep speed shown in Figure 1.
- For example, if the trace moves 1 division in 10 seconds and the sweep speed is 0.01  $\mu\text{s}/\text{div.}$ , the oscillator's frequency is  $1 \times 10^{-9}$  different from that of the reference frequency, as can be seen from the calibration, Table 1. The calculation can also be made by the following formula:

$$\frac{\Delta \text{ TIME}}{\text{TIME}} = \frac{\Delta \text{ FREQUENCY}}{\text{FREQUENCY}} =$$

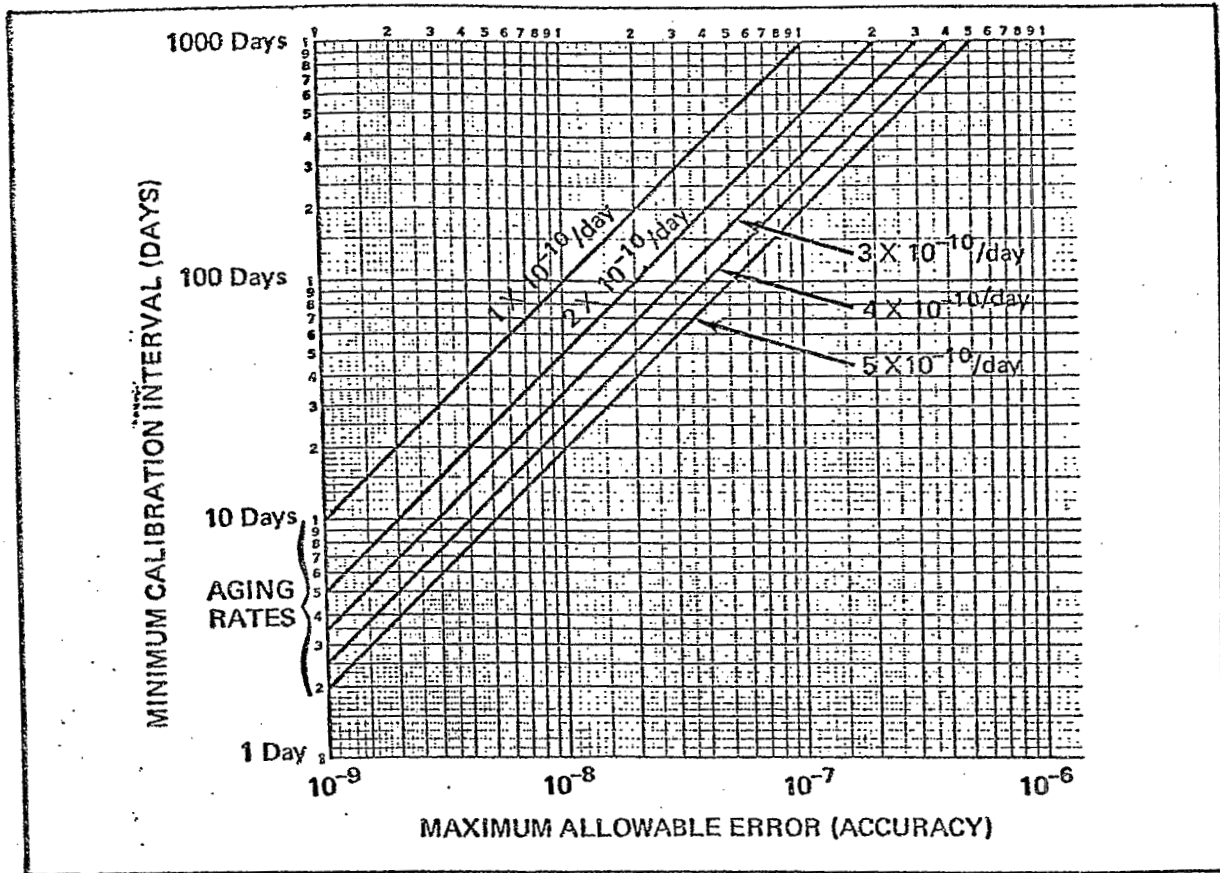
$$\text{OR} \quad \frac{\Delta t}{t} = \frac{\Delta f}{f}$$

where  $\Delta t/t$  = offset of the oscillator with respect to the reference standard  
 $\Delta t$  = the movement of the oscilloscope pattern (1 div.  $\times$  .01  $\mu\text{s}/\text{div.}$ ) = .01  $\mu\text{s}$   
 $t$  = time required for  $\Delta t$  to occur.

$$\frac{1 \text{ div} \times 0.01 \mu\text{s}/\text{div.}}{10 \text{ s}} = 1 \times 10^{-9}$$



Table 1. Accuracy vs Adjustment



### ACCURACY VS ADJUSTMENT INTERVAL

Table 1 shows the required adjustment interval to maintain a required accuracy. If the aging rate is known to be  $3 \times 10^{-10}/\text{day}$ , then a more precise adjustment interval can be determined. (The specification for aging is  $< 5 \times 10^{-10}/\text{day}$ , but aging is typically less than this.) The aging rate can be expected to gradually decrease, and typically will reach  $1 \times 10^{-10}/\text{day}$  within 1-year.

Example:

Known aging rate .....  $3 \times 10^{-10}/\text{day}$   
 Maximum allowable error .....  $5 \times 10^{-9}$

Find the line on Table 1 corresponding to the oscillators aging rate. Then find the maximum allowable error (accuracy) on the horizontal axis. Follow the maximum allowable error vertically until it crosses the oscillators known aging rate. Move horizontally to the left and read the minimum calibration interval in days.

From Table 1, the oscillator should be adjusted approximately every 17 days.

The minimum calibration interval may also be determined from the following formula:

$$\frac{\text{maximum allowable error}}{\text{known aging rate (per day)}} = \text{calibration interval in days}$$

Example:

$$\frac{5 \times 10^{-9} \text{ (maximum allowable error)}}{3 \times 10^{-10}/\text{day (known aging rate)}} = 16.67 \text{ days (~17 days)}$$

