Welcome to the presentation
Quartz Watch Knowledge for Professionals
Contents

Components in detail
- Batteries
- Quartz
- IC / rate adjustment systems
- Control of the stepping motor (asservissement)

Systematic trouble shooting

Calculation of the battery service life

Service philosophy – Quartz & Mechanical Watches
Batteries
Construction (Cutaway view of a silver oxide cell Zn/Ag2O)

1: Can
2: Cathode (AG20)
3: Support ring
4: Separator
5: Gasket
6: Electrolyte (NaOH /Sodium or KOH / Potassium)
7: Anode material (Zn)
8: Cap
# Batteries

## Capacity dependence on temperature

<table>
<thead>
<tr>
<th>125%</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>-20°C</th>
<th>-10°C</th>
<th>0°C</th>
<th>+10°C</th>
<th>+20°C</th>
<th>+30°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4°F</td>
<td>14°F</td>
<td>32°F</td>
<td>50°F</td>
<td>68°F</td>
<td>86°F</td>
</tr>
</tbody>
</table>

Example:
175 mAh Capacity for type 357

Typical temperature effect on miniature silver oxide batteries
Batteries
Typical self discharge rate at different storage temperatures

Nominal Capacity in mAh (100%)
(Silver oxide / Zn Ag2O system)

~ minus 7-8% after 10 years
at 0°C / 32°F

~ minus 15% after 7 years
at 20°C / 68°F

~ minus 30% after 4 years
at 40°C / 104°F
Batteries
Difference between High Drain and Low Drain Batteries

Efficiency (Voltage drop) of typical Low Drain battery with NaOH (Sodium) Electrolyte vs (equivalent size / 357) High Drain battery with KOH (Potassium) Electrolyte

<table>
<thead>
<tr>
<th>Current</th>
<th>1µA</th>
<th>10µA</th>
<th>100µA</th>
<th>1mA</th>
<th>10mA</th>
<th>100mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of rated capacity</td>
<td>100</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
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Continuous Drain (Battery 357)
## Batteries

Calculation of battery life under different user conditions:

**Example: Quartz Alarm Chrono / Battery type: 1.55 Volt 55mAh**

<table>
<thead>
<tr>
<th>Function</th>
<th>Current consumption</th>
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<td>Stepping motor</td>
<td>1.5µA</td>
<td>24 h</td>
<td>36µAh</td>
<td>36µAh</td>
</tr>
<tr>
<td>Chrono</td>
<td>Not needed</td>
<td></td>
<td></td>
<td>36µAh</td>
</tr>
<tr>
<td>Alarm</td>
<td>Not needed</td>
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Battery Capacity: 55 mAh = 55000µAh : **36µAh** = Service life of: 1527 days or **50 months**
Batteries
Calculation of battery life under different user conditions:

Example: Quartz Alarm Chrono / Battery type: 1.55 Volt 55mAh

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<td>60µAh</td>
</tr>
<tr>
<td>Chrono</td>
<td>8 µA</td>
<td>3 h</td>
<td>24µAh</td>
<td>60µAh</td>
</tr>
<tr>
<td>Alarm</td>
<td>Not needed</td>
<td></td>
<td></td>
<td></td>
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</tbody>
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Battery Capacity: 55 mAh = 55000µAh : 60µAh = Service Life of: 916 days or 30 months
## Batteries

Calculation of battery life under different user conditions:

**Example: Quartz Alarm Chrono / Battery type: 1.55 Volt 55mAh**

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<td>Chrono</td>
<td>8 µA</td>
<td>3 h</td>
<td>24µAh</td>
<td>66.6µAh</td>
</tr>
<tr>
<td>Alarm</td>
<td>1200µA</td>
<td>20 seconds =0.0055 h</td>
<td>6.6µAh</td>
<td></td>
</tr>
</tbody>
</table>

Battery Capacity: 55 mAh = 55000µAh : **66.6µAh** = Service Life of: 826 days or **27 months**
Quartz
Quartz Construction

Fig. 1 and 1.1
Shows a typical quartz tuning fork used for quartz watches on the base of its container.
Its two branches are animated by an anti-parallel oscillatory movement (flexion) in the plane of the tuning fork.

Fig. 1.2
Represents a section of the branches of the tuning fork, shows how the electrodes are connected, as well as the electric fields which are formed inside the crystal.
Quartz
Technical features

Dependency
Frequency / Temperature

Formula:
\[ \Delta F = \frac{0.038 \text{ ppm} \ (T-\text{To})^2}{\text{F}_o} \pm 10\% \]

Calculation Example:
Temperature difference to the Inverse point = 10°C / 18°F
0.038 ppm x 0.0864 s/d x 10°C/2 (100°C)
= - 0.32 s/d
At room temperature, the rate accuracy on movements with trimmer systems should be adjusted on a level of +0.10 to +0.20 seconds / day. **Never** on 0.00 seconds per day or less (minus values).
IC and Stepping motor
IC

Rate adjustment systems

Adjustable quartz oscillator frequency by trimmer (out dated)

Adjustable quartz oscillator frequency by fix cap (e.g. Used for stop watches)

Rate adjustment by programmable inhibition system
- EEPROM (reprogrammable)
- OTP (one time programmable)
IC
Rate adjustment systems

Trimmer system
Rate is adjustable by service center

Fix cap system
Adjustment in the production process

Inhibition system (digital)
Adjustment in the production process

Same test result with signal capture over quartz frequency or over motor pulses.

Same test result with signal capture over quartz frequency or over motor pulses.

After Inhibition time (10/60/120s) Different test result with signal capture over quartz frequency or over motor pulses.
IC Motor-Management systems (Asservissement)

IC without asservissement. Motor pulse not chopped and with constant pulse width – it is not suitable for lower current consumption. Mainly used in low cost calibers.

IC Type with asservissement. Chopped motor pulses with two-way control between rotor and IC. Power management to reduce the energy for moving the hands and to extend the battery life. Mainly used in sophisticated movements.
IC
Motor-Management function (Asservissement)

Motor pulse
Detection
Correction
Next pulse

4 - 12 ms / 20-30ms / 30-35 ms / 1 second
Timing

56.25%
62.50%
68.75%
75.00%
81.25%
100%

Chopping level

Time: 4 – 12 milliseconds (ms)
IC - Motor-Management

Symbolically drawn motor pulses (+ / - )

Typical watch IC with adaptive motor pulses (asservissement).

Constant pulse width (example 7.8ms)

Stage 1 = Lowest stage: 56.25% of 7.8ms = 4.38 ms
Stage 2 = 62.50 % of 7.8 ms = 4.87 ms
Stage 6 = 100 % of 7.8 ms

Data sheet (Philips). Typical watch IC with adaptive motor pulses (asservissement).
IC - Motor-Management

How does it work?

The return of the rotor **to the initial position** (-Voltage) will be detected by the IC as „successful executed step“.
Systematic troubleshooting

Select **Battery test** in main menu.

**Caution:**
**Always** check the movement for corrosion and the **insulation** of the battery case!

**Test of the coil resistance and of the insulation values:**
Select **Resistance (coil) test** in main menu.

**Situation: Watch is not running**

- Remove and test the battery

  - **Battery not ok**
    - **Test of the coil resistance**
      - **coil and movement insulation, without external power supply and without battery**
      - **Values ok**
      - **Values not ok**
    - **Battery ok**
### Test of the coil resistance and of the insulation values:
Select **Resistance (coil) test** in main menu.

### Functional test of quartz and IC
Select **Rate and consumption test** in main menu.

- **SIGNAL:** Auto (Cons)
- **TIME:** Auto
- **VOLT:** 1.55V-3.00V
- **Winding stem** - **POS:** Reset

---

**Test of the coil resistance**
coil and movement insulation, **without** external power supply and **without** battery.

- Values ok
- Values not ok

**Test of quartz and IC**
Place the watch on the mirror support and connect both battery connectors to **+ supply -** with the movable contact probes.

- Values ok
- Values not ok

**Replace the electronic module**
Systematic troubleshooting | Quartz Watches

Test of the stepping motor:
- Winding stem - POS: Neutral
SIGNAL: Auto (Cons)
TIME: 4 s
VOLT 1.55V - 3.00V

Test of the stepping motor
Place the watch on the mirror support and connect both battery connectors to + supply - with the movable contact probes.

Test of the lower starting voltage
Place the watch on the mirror support and connect both battery connectors to + supply - with the movable contact probes and the negative test probe with RT/T
Set voltage to 1.55V / 3.00V. Decrease slowly the voltage until hand stops moving.

Value ok
- Replace battery
- Close watch

Value not ok
Systematic troubleshooting

**Important visual check**

**Check if:**
- steel particles block the rotor or the gear train
- particles between crown and case block the reset mechanism
- hands touch the inside face of the glass
- hands have no axial freedom
- whether the calendar mechanism functions correctly
Service philosophy for quartz watches

What is the difference between the service quality for Mechanical Watches and for Quartz Watches?

The difference is **nothing**! Equivalent to the requested service quality from the customer.
Thank you for your attention