AXTAL ADVANCED XTAL PRODUCTS

Company Presentation
AXTAL CONSULTING

Two decades of consulting services for the industry

Your Independent Test House in the field of Quartz Crystal Products, SAW Devices, Ceramic Resonators and Piezo Materials & Sensors

Who we are

- **AXTAL Consulting** was founded by Bernd Neubig* in April 2002 and is the independent Consulting Company and Test House in the field of frequency control products (FCP).
- **AXTAL Consulting** offers Consulting & Test Services for application and design FCP, i.e. quartz crystal units, piezoelectric resonators & sensors, crystal oscillators, filters and SAW devices.
- **AXTAL Consulting** helps suppliers and users to optimize the match between product and application, and thus reduces the risk of failures in the volume application and in the field in an early stage.
- **AXTAL Consulting** provides failure analyses, suggests corrective actions and assists its customers in process audits of manufacturing lines.
- **AXTAL Consulting** is an independent test house for FCP, offering testing, screening and characterization of FCP according to acknowledged IEC-, MIL-, Automotive and ESA Standards, e.g. measurement of linear and non-linear electrical parameters, temperature tests, phase noise, short- & long-term stability and mechanical & environmental tests.
- **AXTAL Consulting** organizes training courses, seminars and workshops on Frequency Control Products, its measurement and application.

** Personal profile of the founder see at the end of the presentation*

Qualification approvals

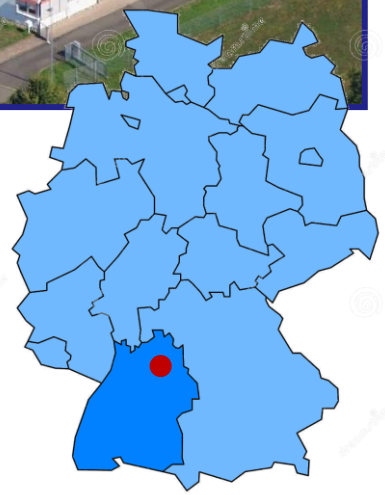
- **AXTAL Consulting** executes qualification approvals of Frequency Control Products based on:
  - IEC 60122 and IEC 61178-2 and -3 (Crystals)
  - AEC-Q200 (Crystals for Automotive Applications)
  - MIL-PRF-3098 (Crystals for HighRel Applications)
  - ESCC3501 (Crystals for Space Applications)
  - IEC 60679-4 (Oscillators)
  - MIL-PRF-55310 (Oscillator for HighRel & Space Applications)
  - IEC 60368-4 (Filters)

Where we are

AXTAL Consulting

Principal Office, Administration:
(Billing address)
Buchfinkenweg 8
D-74931 Lobbach

Mosbach Laboratory:
(Shipping address)
Roemerring 9
D-74821 Mosbach
Germany



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Markets served

AXTAL CONSULTING

Automotive

Sensor Applications

High Reliability, e.g. downhole, off-shore

Telecommunication, Telemetry

Industrial Electronics

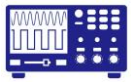
Manufacturers of FCP products

Electronic Manufacturing Services

Aerospace

Space

Defense

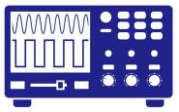


RF Test & Measurement Equipment

Distributors & Re-Sellers of FCP products

Testing Capabilities

- **AXTAL Test Capabilities – Electrical**:
  - **Crystal Testing** with Saunders, Kolinker and AXTAL Network Analyzer System
  - **Frequency Stability** over various parameters up to 20 GHz
  - **Output Waveform & Spectrum** up to 26 GHz
  - **Phase Noise** with R&S FSWP, Agilent E5052B and Noise XT up to 26 GHz
  - **Short-term Stability** (ADEV) with Microchip 53100A down to 1E-18
  - **Long-term Stability** (Aging) measured against GPS-disciplined Atomic Clock
  - **G-Sensitivity** & Phase Noise under vibration (random & sine) 5 ~ 6000 kHz
  - **Temperature Testing** -55˚C to +125˚C



- **AXTAL Test Capabilities – Environmental:**
  - **Vibration Testing:** Mechanical Shock, Random & Sine
  - **Temperature Testing:** Thermal Shock, Storage & Burn-in -55˚C to +150˚C
  - **Vacuum Testing**
  - **Leak Testing**
  - **Visual inspection**

Consulting - Crystal Units

- **Test & Measurement compliant to IEC 60444-X**:
  - Frequency, resistance, motional parameters, load resonance etc.
  - Start-up behaviour – Drive Level Dependence (DLD)
  - Temperature tests -55°C to +125°C, Hysteresis
  - Frequency Dips & Activity Dips (band breaks) vs. load & temperature
  - Spurious resonances
  - Aging tests (passive and active)

- **Qualification testing based on IEC 61178-2/-3, AEC-Q200, MIL-PRF-3098 & ESCC3501**
  - Leak test
  - Isolation resistance
  - High temperature storage
  - Temperature cycling & shock
  - Vibration (random & sine)
  - Mechanical shock
  - Other environmental tests on request

Consulting - Crystal Units

- **Application & Design Support**
  - Matching crystal vs. oscillator circuit
  - Support with specifications
- **Oscillator circuit characterization**
  - Oscillation allowance
  - Crystals drive level and effective load capacitance
  - Behaviour over temperature
- **Failure Analysis**
  - In-circuit, electrical, mechanical, X-ray and visual
  - Determination of corrective actions
  - Support in process audits
- **Reliability Analysis (MTBF, MTTF, Fit Rate)**
- **Application of novel piezoelectric material & resonators**
  - Langasite (LGS), Langatate (LGT)
  - CTGS, CNGS, GaPO4 etc.

Consulting – Failure Analysis

- **The most frequent causes of crystal failures are:**
  - Insufficient safety margin (“oscillation allowance”) of the oscillator stage for oscillation start-up
  - Strong Drive Level Dependence (DLD) of the crystals resonance resistance
  - Too low or excessive crystal drive level (crystal current or power)
- **Further causes of crystal failures are:**
  - Frequency jumps (discontinuities) or stopping of oscillation in a certain temperature range due to so-called “Activity Dips” or “Frequency Dips” of the crystal
  - Mismatch between the specified crystal load capacitance and the effective load conditions given by the oscillator circuit.

Consulting – Oscillators

- **Oscillator characterization:**
  - Worst-Case Analysis of the safety factor of oscillation start-up
  - Testing of the crystals for Drive-Level Dependency (DLD) and Activity Dips
  - Measurement of crystal drive level in the circuit
  - Determination of working frequency and equivalent circuit load capacitance
  - Proposal/support for circuit modification and crystal specification

- **Qualification testing based on IEC 60679-4 and MIL-PRF-55310:**
  - Frequency, tuning range, voltage & load dependency (pushing & pulling)
  - Start-up behaviour, start-up time, stabilization time, time-domain behaviour
  - Waveform, output spectrum & phase noise
  - Short- and long-term stability (ADEV & Aging)
  - Temperature tests -55°C to +125°C, hysteresis, activity dips (band breaks)
  - Temperature cycling, leak test, environmental test (e.g. vibration, shock etc.)

Consulting – Filters

- **Qualification testing based on IEC 60368-4:**
  - Frequency response of attenuation
  - Phase & group delay
  - Bandwidth, ripple, insertion attenuation, selectivity, shape factor, ultimate attenuation, spurious attenuation
  - Reflection attenuation, VSWR
  - Intermodulation
  - Temperature tests -55˚C to +125˚C
  - Temperature cycling
  - Leak test
  - Environmental tests (e.g. vibration, shock etc.)

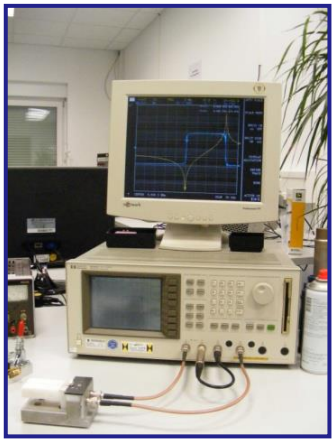
Consulting – SAW Devices

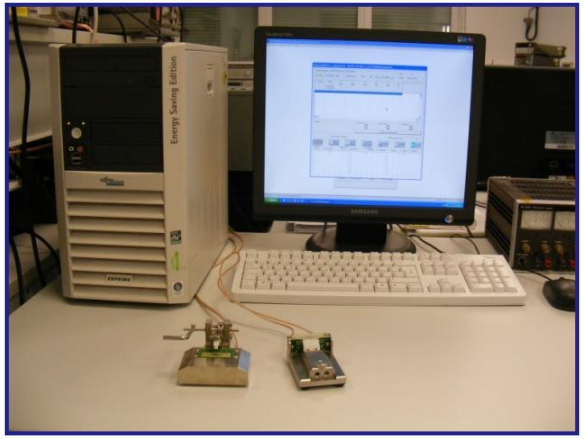
- **Testing of SAW resonators & SAW filters:**
  - Resonators: Frequency, resistance, motional and other parameters, Drive Level Dependence (DLD), temperature tests
  - Filters: Frequency response of attenuation, phase, group delay, reflection attenuation, VSWR, intermodulation, temperature tests
- **Design support for SAW resonators & filters:**
  - Powerful simulation and analysis tools
  - Cooperation with experienced SAW Consultant in Switzerland
    - More than 40 years in the area of SAW physics (PhD, Dr.Sci., Prof.)
    - More than 300 published papers
    - Numerous designs of SAW and STW resonators, SAW filters and SAW tags
  - Access to various SAW foundries in different countries

Consulting – Piezo Sensors

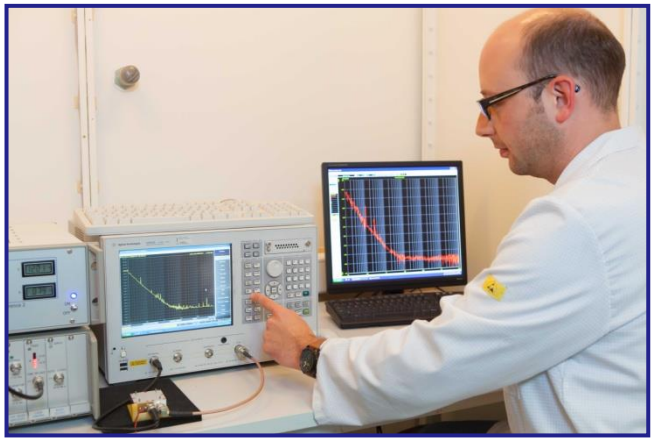
- Bulk Acoustic Wave (BAW) Piezoelectric Sensors and Substrates
- Surface Acoustic Wave (SAW) Sensors and Tags
- Sensors for High Temperature Environment based on Langasite (LGS), Langatate (LGT), CTGS, CNGS and Gallium Phosphate (GaPO4)
- Piezo transducers and modules

Laboratory





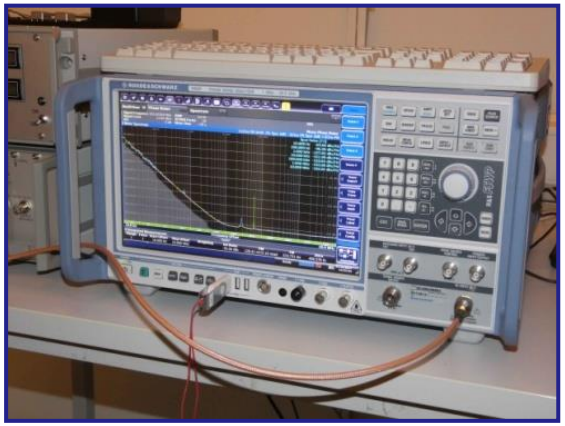
Electrical test systems for crystals and resonators



Phase noise test systems
in shielded chamber

Electrical test systems for oscillators & SAW

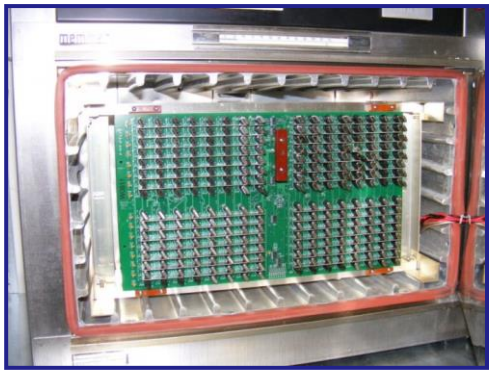
ADEV test systems



Laboratory

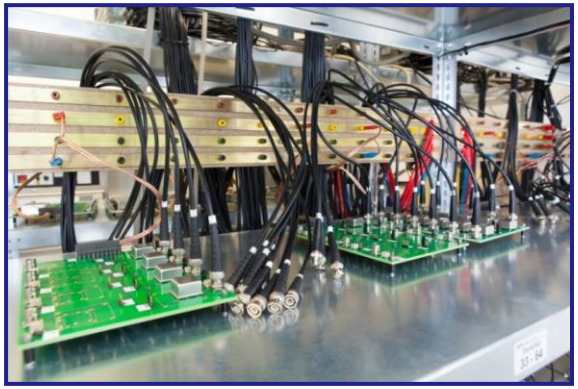
Temperature test &
Thermal shock test

Burn-in test under vacuum

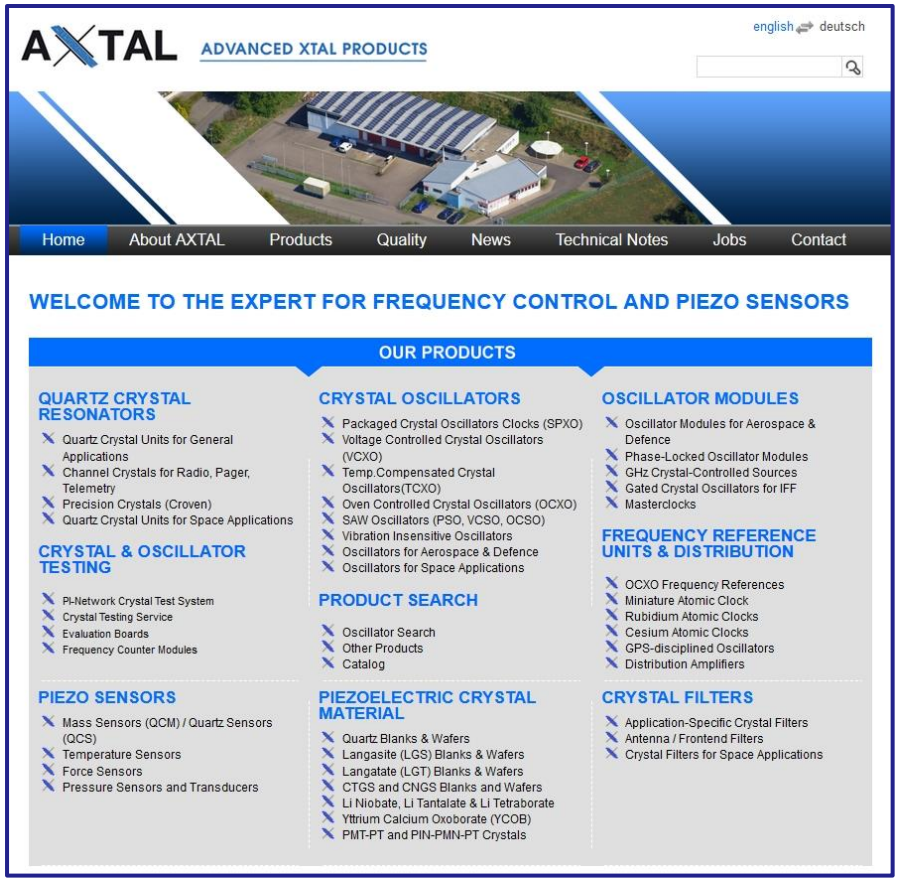


Active aging & test
Thermal shock test

Vibration and mechanical shock test



AXTAL Website



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- **Download Catalog and Datasheets**
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- **Check out where you can meet us on Trade Shows & Conferences**

Personal Profile

Bernd Neubig

* Back to "Who we are"

- **Founded AXTAL in 2003 – More than 40 years in the Frequency Control Business**
- **Since 1983** - Vice President of **Tele Quartz (TQ)** (later Oak Frequency Control → Corning Frequency Control → **Vectron** → Microsemi → now Microchip). Establishment of oscillator and filter product line. Full responsibility for R&D, operations and engineering.
- **7 Years with KVG (Kristallverarbeitung Neckarbischofsheim)** - Crystal design engineer and later R&D manager for oscillators and filters
- **1975 Graduation as Diplom Physicist** (Dipl.-Phys.) at the Technical University in Berlin
- **1969 Graduation as Diplom Engineer** (Dipl.-Ing.) for Electrical Engineering/Telecommunications at the University of Applied Sciences in Berlin
- Chairman of the German Section of **IEC TC 49 Standardization Committee**
  Member of the Scientific Committee of the **European Time and Frequency Forum (EFTF)**
  Member of the Technical Program Committee of the **IEEE Frequency Control Symposium (FCS)**
- **More than 30 scientific & technical publications** – Co-author of a book on frequency control components called „Das Grosse Quarzkochbuch", 1997
- **Lecturer of Seminars** on quartz crystals, oscillators, filters and related frequency control components

IEC 1906 Award	David P. Larsen Award	DKE Needle Award	Marcel Ecabert Award	W. G. Cady Award
Nov 2004	Jun 2006	Apr 2010	Apr 2015	May 2016