W. Tatham

EXHIBIT No. 3

HIRST RESEARCH CENTRE

COMMERCIAL IN CONFIDENCE

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

QDA–PD–190 ISSUE: d Apr 90

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Section 1

HIRST RESEARCH CENTRE

COMMERCIAL IN CONFIDENCE

SURFACE ACOUSTIC WAVE FILTERS
FOR ESA/SCCG QUALIFICATION APPROVAL
PROCESS IDENTIFICATION DOCUMENT

ISSUE: Draft d Apr 1990

A J Dyer..Date............................

R A E QSA..Date............................

F S McClemont..Date............................

T A Elson..Date............................

Approved By:	.... (Manufacturer)	.... (Qualifying Space Agency)
Date:		

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

AMENDMENT RECORD

Date	Details	C/N	Approved By: (Project Quality and Project Manager)

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

Contents

Section 2

MANUFACTURING ORGANISATION

ORGANISATION AND MANAGEMENT

An organisational diagram for GEC is shown in Figure 1.

The GEC Hirst Research Centre

This is a central research facility for the main group of GEC companies, with direct responsibility to the General Electric Company plc. The Hirst Research Centre has contracts with the UK Ministry of Defence as well as communications systems companies and international authorities such as the European Space Agency. Collaborative research in the UK and in Europe is playing an increasing role in our activities and we are a major partner in JOERS and ALVEY in the UK, and ESPRIT, RACE and BRITE in the EEC.

Current activities include research on aspects of silicon integrated circuits, gallium arsenide microwave integrated circuits, infra-red and optical devices, and high temperature superconductors.

Materials Science Laboratory provides under-pinning to all programmes, as well as providing a wide range of analytical techniques of service throughout the Company. In particular, strategic materials are grown such as Very High Purity Quartz, which will be used in this programme.

An organisational diagram for the GEC Hirst Research Centre is shown in Figure 2.

The Device Applications Laboratory

The Device Applications Laboratory undertakes fundamental research and development of piezoelectric devices for high precision frequency control and signal processing applications in the space and defence markets. The main areas of work are:

Bulk Wave Research

Advanced studies of both the theory and technology of precision piezoelectric resonators are being undertaken to develop components for use in the next generation of communication systems. Current activities include the development of miniature low-power oscillators, and resonators for use in ionising radiation environments.

Surface acoustic wave (SAW) filters

A comprehensive capability is maintained for the design and fabrication of high performance SAW bandpass filters. Research work is concentrated on advanced device modelling and computer aided design techniques which have been used with proven success in recent high precision applications.

Piezoelectric materials

Fundamental studies on existing and new piezoelectric materials are being carried out. These include the investigation of radiation effects in quartz and the evaluation of lithium tetraborate for wide-band filter applications.

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Electron beam micro-fabrication (EBMF) unit

The EBMF unit offers an electron-beam lithography service for the fabrication of photomasks with fine linewidths down to 0.4μm. Highly accurate reticles for projection alignment systems are also made. There is a direct-write-on-wafer capability for certain specialised tasks, for example, the definition of sub-micron gates in microwave FETs and MMICs.

An organisational diagram for the Device Applications Laboratory is given in Figure 3.

Quality Assurance

The organisation of HRC's Quality Assurance Department is described in the Quality Manual ref QAM-01. Our approach to quality assurance is designed to satisfy AQAP1, NATO requirements for an Industrial Quality Control System.

An organisational diagram for HRC's Quality Assurance Department is given in Figure 4.

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Figure 1 ORGANISATIONAL DIAGRAM OF THE GEC

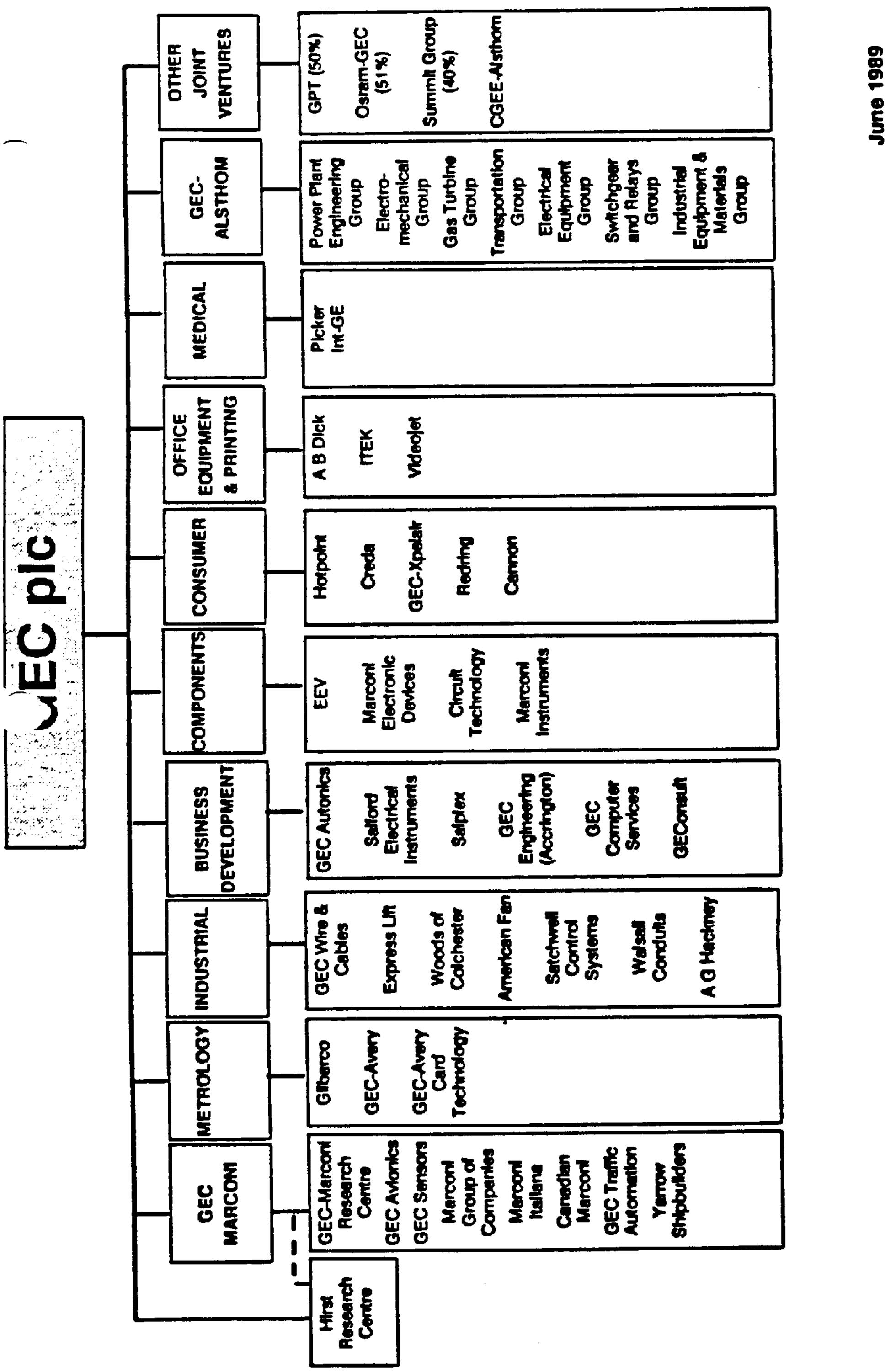

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Figure 2 ORGANISATIONAL DIAGRAM OF THE GEC HIRST RESEARCH CENTRE

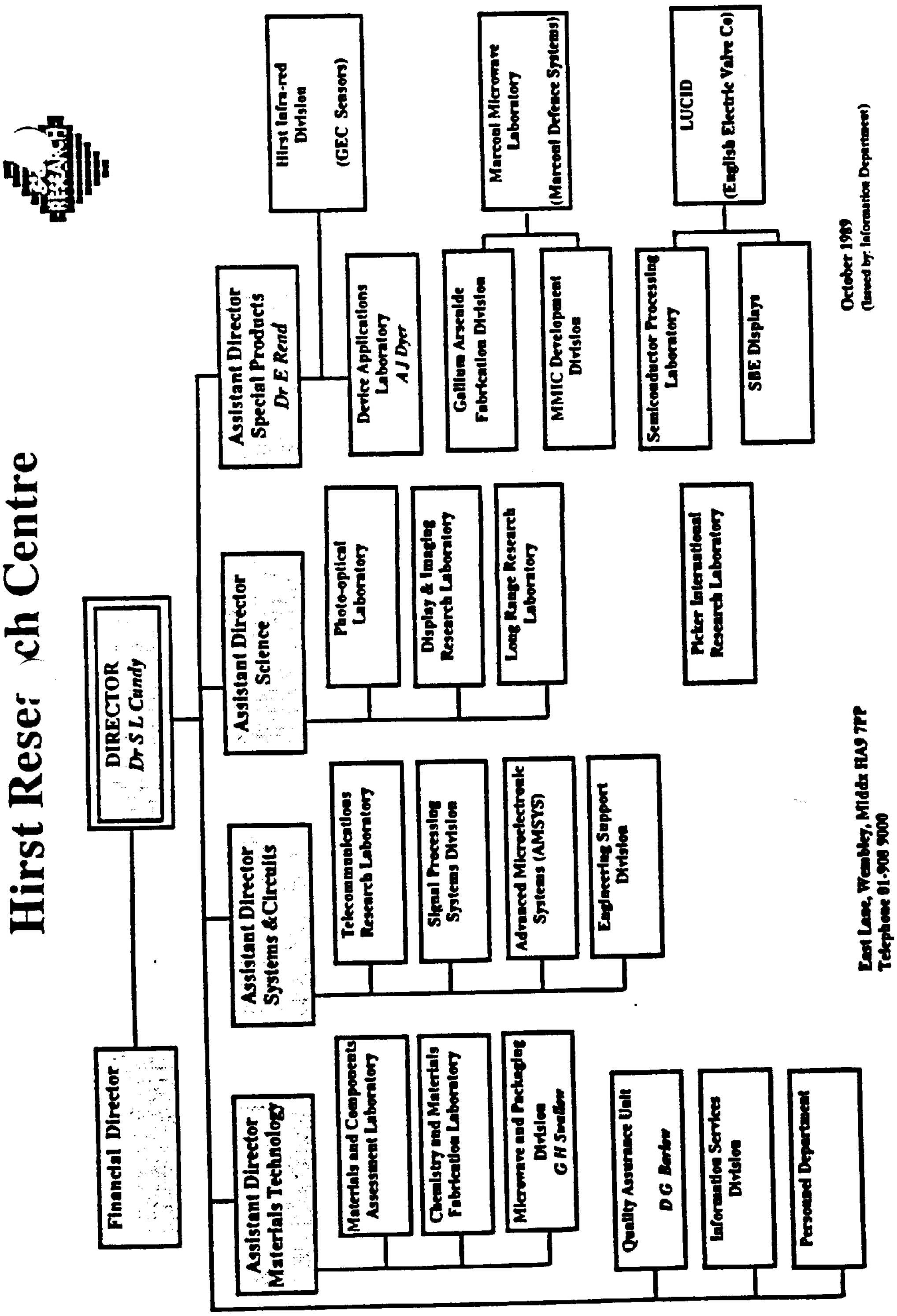

Figure 3 ORGANISATIONAL DIAGRAM OF THE DEVICE APPLICATIONS LABORATORY

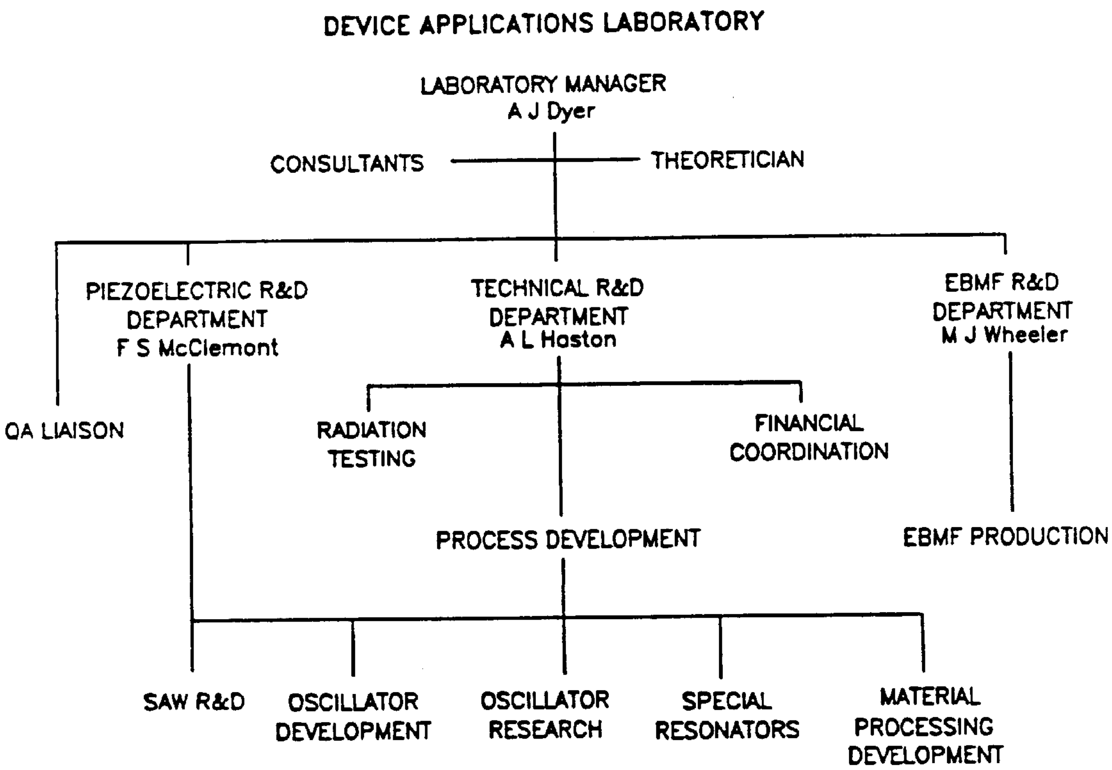

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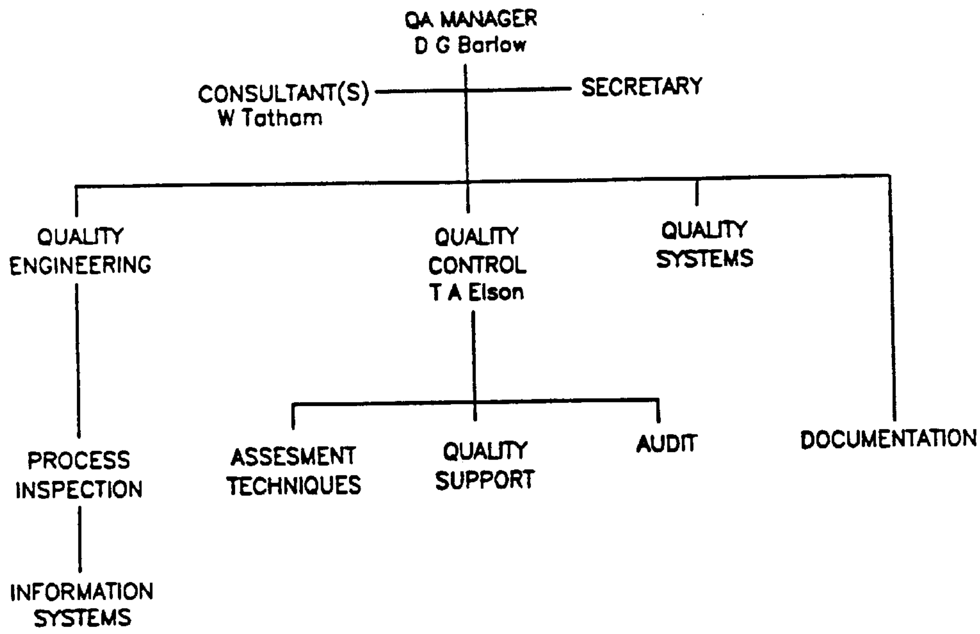
Figure 4 ORGANISATIONAL DIAGRAM OF HRC's QUALITY ASSURANCE UNIT

QUALITY ASSURANCE UNIT



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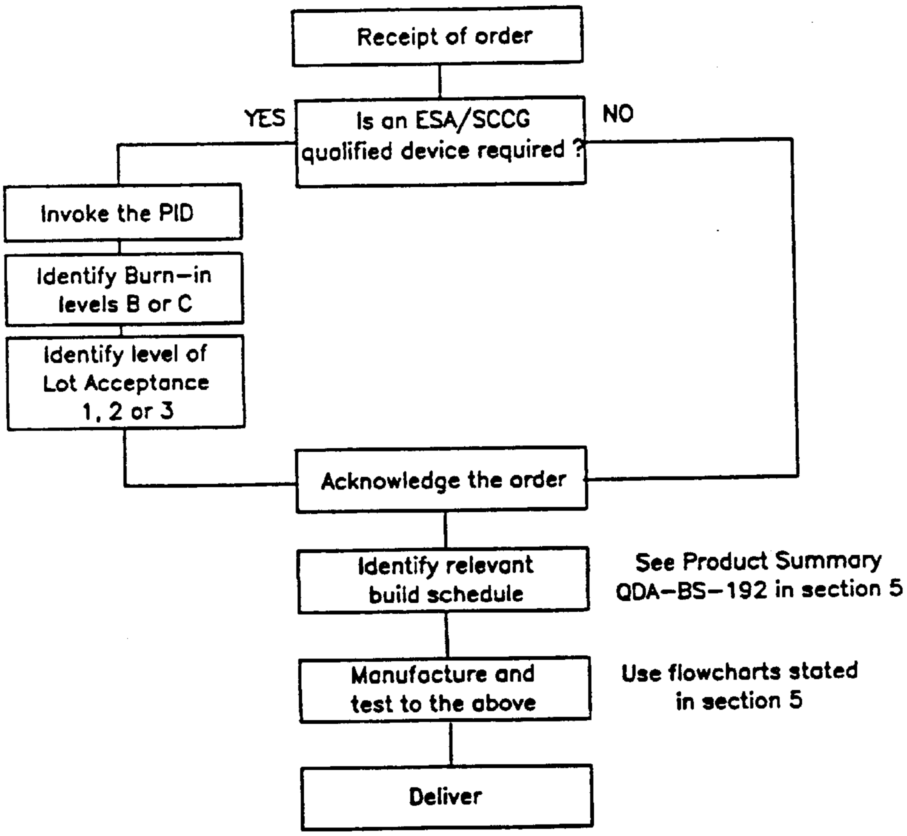
Section 3

MANUFACTURE AND TESTING



Related Procedures; QPM–01–17 Contract Negotiation and Orders
QPM–02–25 Project Management
QPM–09–36 Control of Fabrication

PROCESSING AREAS

1. Quartz Growth

The Chemistry and Materials Fabrication Laboratory at HRC maintains a facility for the growth of high purity synthetic quartz, which is [redacted] and is used for high quality SAW filter applications. The material is grown hydrothermally in highly specialised pressure vessels under extremely carefully controlled conditions in Laboratory C8.

2. Materials Processing Development

This area which is currently based in building 72 and occupies an area of 10,000 sq ft, provides a specialist service working to achieve optical tolerances on single crystals, glass, semiconductors and ceramics. Facilities include an X-ray goniometer to allow crystal orientation to be measured, auto-collimation for checking angular tolerances and parallelism, and interferometry for flatness measurement, as well as sawing, drilling, grinding, lapping and polishing machines to handle a wide range of materials and sizes. The area is under the direct management of the Device Applications Laboratory and is used extensively for the fabrication of quartz crystal blanks and SAW substrates.

3. B13 Clean Room

This area which is under the direct control of the Device Applications Laboratory is a class 100 clean room of approximate area 1000 sq ft and is the main facility for the processing/assembly of quartz resonators and SAW filters. Facilities in the cleanroom include chemical work stations for wet chemical operations, eg cleaning of crystals and substrates; deposition of metallisation by electron beam evaporation; assembly, adjustment and encapsulation of quartz resonators; photolithography, assembly and testing of SAW filters.

The clean room has recently been refurbished to implement extensive measures for protection against electro-static discharge, including conducting floor and bench surfaces, wrist straps etc.

4. Electron Beam Microfabrication Unit

The EBMF Unit, which is under the direct control of the Device Applications Laboratory, is housed in HRC Laboratory D11. The core of the facility is the Cambridge Instruments EBMF 6.5 electron beam microfabricator, which offers an e-beam lithography service for fabrication of photomasks with linewidths down to 0.4μm, and a direct-write-on-wafer capability. The EBMF 6.5 is housed in a small custom built clean room, and is supported by an ancillary clean area for processing by wet chemicals (dry etching available), and optical inspection.

5. B63 Laboratory

This is the general assembly/test/measurement area for quartz crystals, oscillators, and SAW filters within the Device Applications Laboratory, with an area of about 2500 sq ft the laboratory includes extensive modern r.f. measurement apparatus, including network, spectrum and noise analysis; frequency sources, including a primary reference standard; monitoring of frequency stability (short and long term). These measurements can be coupled together with environmental testing such as temperature cycling, vibration, shock etc. Almost all measurements are under computer control and a local area network has recently been installed to provide sharing of resources between equipments, and a central data storage facility. The laboratory is linked to HRC's central computing facility, but some powerful programs, eg a thermal modelling package are available on desk top computers.

There is a dedicated, environmentally controlled measurements room including ESD protection measures.

6. Thin Film Unit

The Special Techniques Division of the HRC operates a unit for the design and manufacture of thin film hybrid circuits. Facilities include circuit layout /design, semi clean work area, chemical workstations, photolithography, packaging, assembly, inspection and test areas. The thin film unit is based in Laboratory A8.

7. Quality Assurance

The QA area of HRC is based in laboratory B61 and includes a specialised area for the inspection and measurement of incoming goods, part of which is protected against damage to ESD sensitive devices.

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Section 4

COMPONENT DESCRIPTION

General

Surface Acoustic Waves

In a solid material elastic waves can propagate, with the displacement parallel or perpendicular to the direction of propagation. If a boundary is introduced parallel to the direction of propagation, modes other than bulk waves become possible. Surface Acoustic Waves (SAW) devices make use of the Rayleigh wave, which travels along the free surface of the material. The wave amplitude is a maximum at the surface and decays rapidly with depth into the material; almost all the energy is confined to a region extending about one wavelength into the bulk. As the velocity of the surface wave is around 3000 m/s, the wavelength is less than the free space electromagnetic wavelength by a factor of 10^5.

The surface motion is rather like that associated with waves on the sea. The only transverse displacement in isotropic materials is normal to the surface, and the longitudinal displacement is in phase quadrature with the vertical one. A particle of the material being subject to a SAW wave will therefore trace out an ellipse. Of the two most popular materials for SAW devices, YZ lithium niobate has only sagittal plane (i.e. vertical and longitudinal plane) displacement, whereas X directed waves on ST cut quartz have all three components of displacement. If the material is piezoelectric, the travelling acoustic wave will be accompanied by an electric wave, and by the same token electric fields may be used to excite surface acoustic waves.

Transducers

An interdigital transducer consists of two interleaved sets of parallel metal electrodes, connected to the two electrical terminals. The electric field gradient can be considered to be the driving force for the surface waves, so a wavelet is generated at every electrode edge where the field gradient is highest. The contributions of these wavelets add up to give a wave travelling in each direction.

A SAW device is naturally a tapped delay line, so the impulse response of a transducer is a stream of impulses; one for each finger edge, separated in time by d/v where d is the gap finger width and v is the SAW velocity. The response can be tailored by weighting the transducer, i.e by making some finger pairs emit more strongly than others.

As it is impracticable to apply different voltages across different finger pairs, weighting is normally achieved by adjusting the overlap length, a technique called 'apodisation'. Dummy electrodes are used to ensure uniform mass loading of the surface, reducing diffraction or focusing effects.

SAW filters

SAW phenomena are ideally suited to the manufacture of transversal filters where the output is the weighted sum of delayed versions of the input. Unlike L-C ladder networks, transversal filters are non minimum phase structures: this means that the amplitude and phase responses are capable of being independently specified. SAW bandpass filters can have very nearly linear phase shift (constant group delay) across the passband. On the other hand, SAW dispersive delay lines in which the finger pitch is varied can be used to generate FM chirp pulses and to compress the received pulses in pulse compression radar systems .

For over fifteen years GEC have been involved in the development of high quality SAW devices, resulting in a comprehensive computer aided design facility, and manufacturing techniques specialising in processing of quartz and lithium niobate. Filters may be designed within the following limits of performance:

Frequency range	10 MHz - 1 GHz
Fractional bandwidth	0.3% - 50%
Transitional bandwidth	>50 KHz
Stopband rejection	Up to 70 dB
Insertion loss	6 to 30 dB
Phase ripple	<1 deg p-p
Amplitude ripple	0.05 dB p-p
Temperature performance (25°C)	
$LiNbO_3$	90 ppm/C
$LiTaO_3$	35 ppm/C
Quartz	parabolic <4x10-8/°C

It should be noted that the above are limits, and due to conflicting design goals, are not all attainable in a single device. When considering variants of standard devices, all parameters detailed need to be specified to allow design trade-offs to be made. Careful consideration should be given to systems tolerances to avoid over specification of desired rather than required performance.

Filter Configuration to be Qualified

Design Techniques

The two transducers of the SAW filter are designed using a custom, proprietary suite of programs described in the relevant flowchart, and installed on HRC's mainframe computer system. The first, simple transducer can be designed using empirical design rules, or if necessary by a modified version of the optimisation technique used for the second transducer. The second transducer is synthesised by subtracting the frequency response of the first transducer from the overall desired frequency response, which gives the ideal response of the second transducer. This is Fourier transformed to give the ideal impulse response of the second transducer, which unfortunately is infinite and cannot be implemented in the real world. This impulse response must be truncated to a duration (transducer length) which can be physically tolerated. The truncation introduces certain distortions back into the corresponding frequency response; using this condition as the starting point, the frequency response of the second transducer is optimised by a linear programming technique.

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This 'ideal' response must then be analysed for the main second order effects such as diffraction and circuit loading (connecting one transducers to actual electrical impedances). Corrections for these effects can be introduced by pre-distorting the design at the synthesis stage, or (diffraction only), by an iterative procedure, in which the tap weights of the second transducer are adjusted so as to give the correct (ideal) SAW signal as seen from the first transducer.

Once the final geometry of the device has been finalised, the design is turned into pattern data in a format compatible with the electron beam machine which will be used to direct-write the devices, using custom software.

Materials and Manufacturing Methods

The SAW filters to be qualified utilise a CST - cut quartz substrate. These substrates are derived from synthetic quartz, which is grown in-house. HRC's High Purity Quartz, which is radiation hard, is grown hydrothermally in large autoclaves by a proprietary process. The resulting quartz stones are qualified to stringent standards, using x-ray topography to find crystal defects, and infra-red spectroscopy to measure impurities.
Stones are processed into precision - oriented, optically polished wafers by specialised sawing, grinding, lapping, polishing and x-ray crystallography techniques.

Wafers are cleaned and metallised in clear conditions using standard wet chemical processes followed by electron-beam evaporation/deposition of a film of aluminium. The launching and detecting transducers of the filter (IDT's) are formed using a specially developed direct-write-on-wafer electron beam lithography technique, using a Cambridge Instruments EBMF 6.5 Microfabricator, which provides a sub-micron linewidth capability. Wafers are diced into substrates by standard techniques, and the resulting 'chips' are subject to rigorous visual inspection procedures.

Substrates are mounted in bought-in custom solid sidewall metal packages designed for seam sealing.

The mounting adhesive, and SAW end absorber, is a thin film of one-part silicone rubber compound, which provides the necessary compliance over a wide temperature range. Connection of the transducers to the relevant package pins is by gold thermocompression tape bonding.

Some devices, for operation with reduced insertion loss, require additional, integral tuning components in the form of thin film spiral inductors. These are designed using custom software, which generates its own artwork. The inductors are formed on fused silica substrates which are machined in-house, and processed in HRC's Thin Film Unit. The inductors are mounted and connected in a similar manner to the SAW substrate.

The saw filters are electrically tested using custom test fixtures and automatic network analyser techniques using error correction software, both before and after encapsulation, which is by a standard seam sealing process.

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Figure 5 Typical SAW Filter.

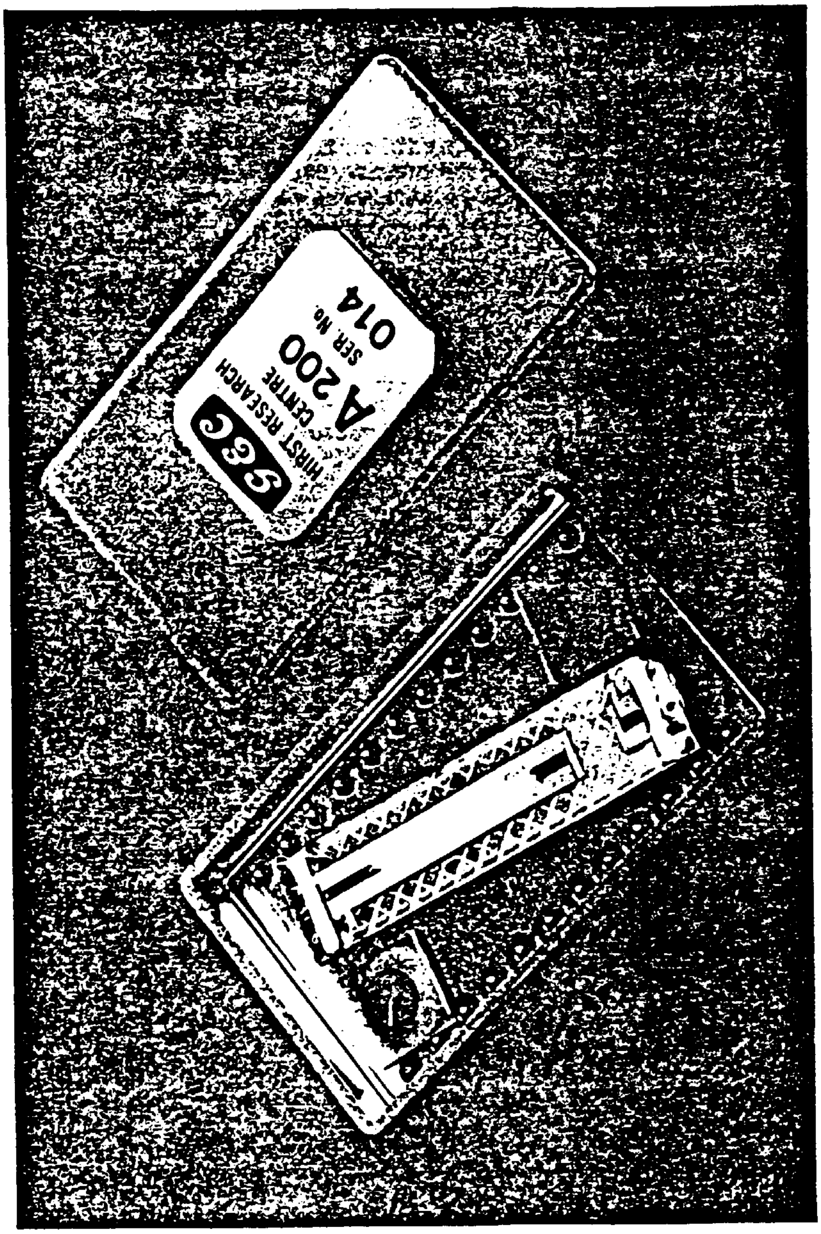

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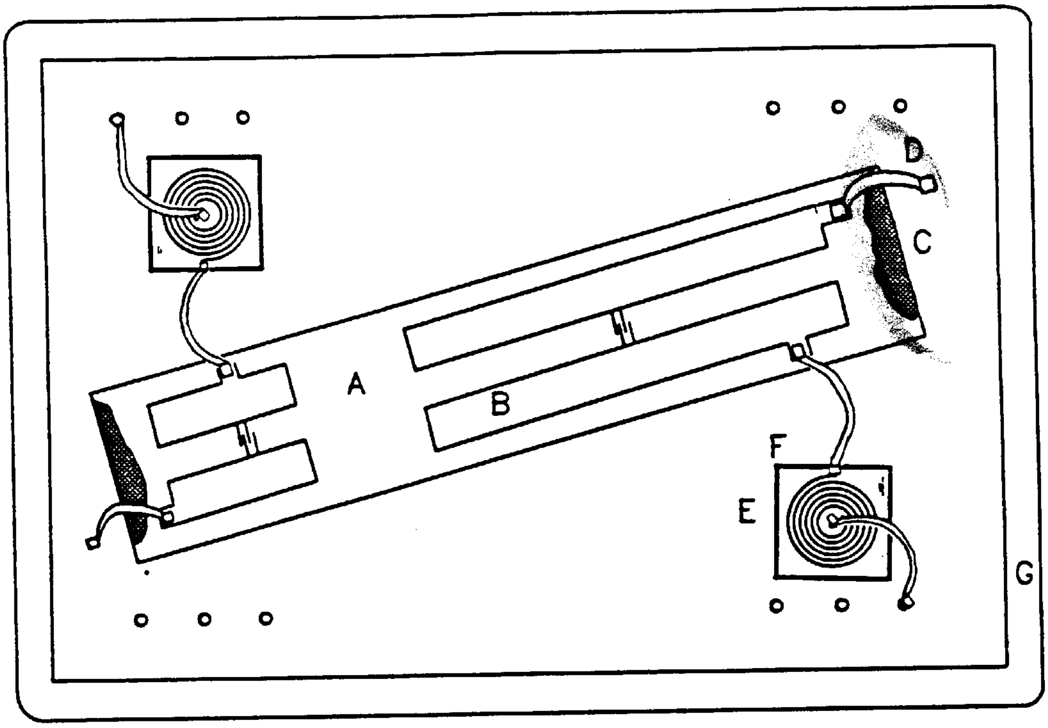
Figure 6 Schematic diagram of a typical SAW Filter.



Component	Supplier
A. Quartz Substrate	HRC
B. Aluminium Metallisation	HRC
C. Dow Corning 738 RTV acoustic absorber (2 places) This material is also used for mounting the substrate	Dow Corning
D. Gold tape	Johnson Matthey
E. Spiral inductor substrate	Heraeus
F. Thin film spiral inductor	HRC
G. Package and lid	Doloy

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Section 5

CONTROL DOCUMENTATION

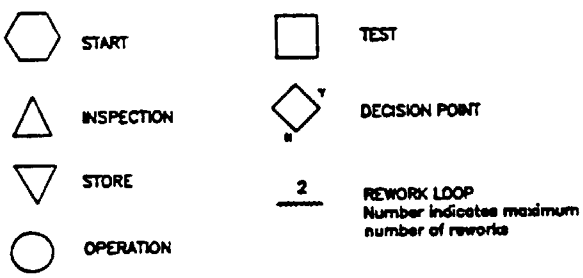
This section includes the design, manufacture and testing flowcharts for the Space Qualified SAW filter, in which the nominated processes cross refer to the Product Summary.

This section also includes a list of specifications for each process step, control inspection and test in the manufacturing and testing of Space Qualified SAW filters. The list defines the build standard of a particular device.

Finally, this section includes inspection and control specifications jointly agreed by HRC and the QSA to be part of the PID.

A list of the symbols used in the flowcharts is printed below:

FLOWCHART SYMBOLS



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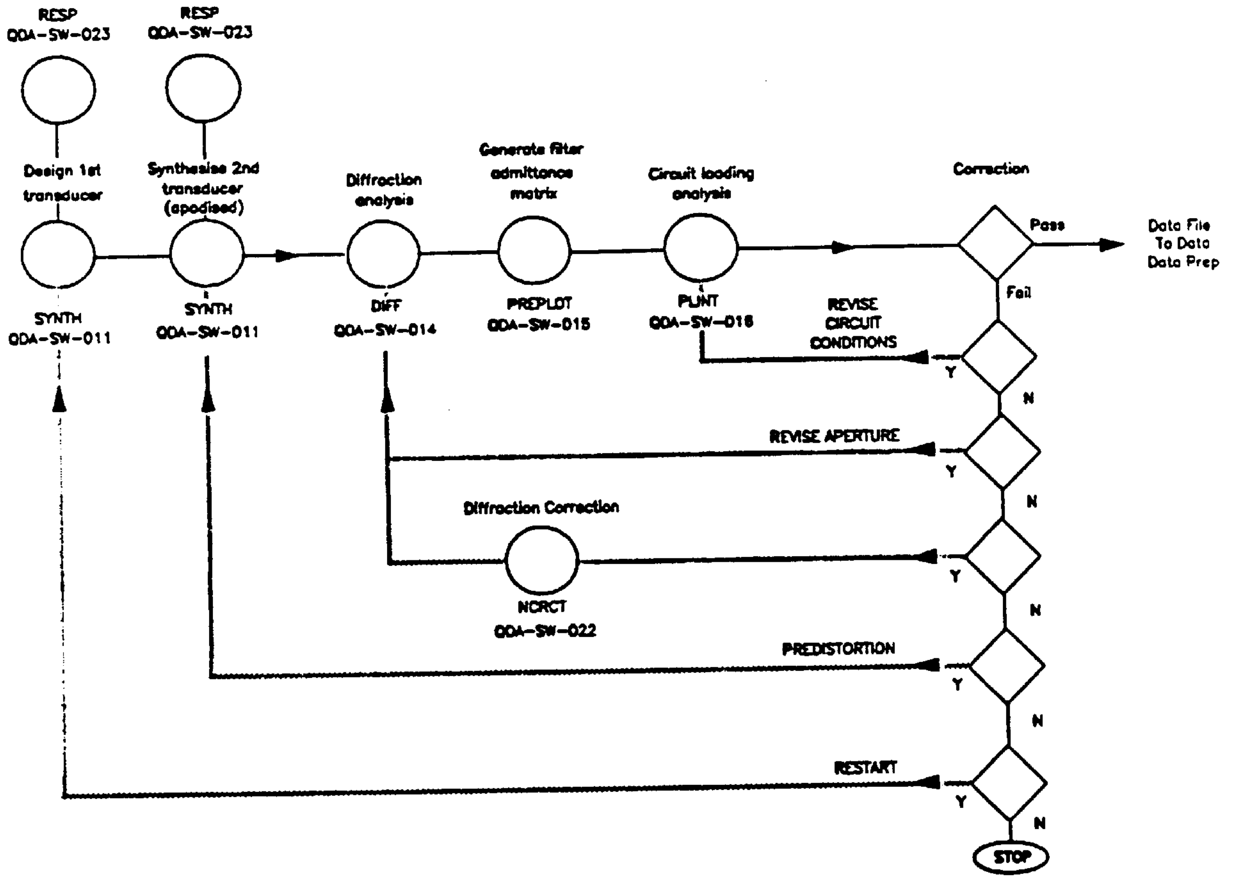
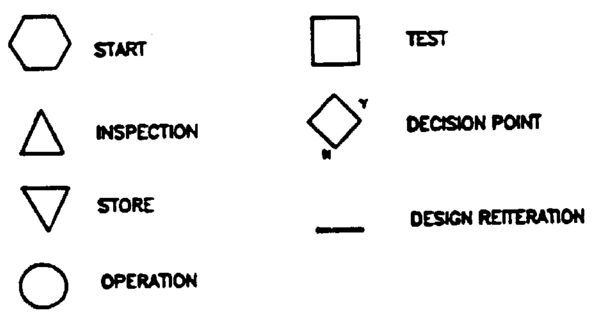
Design Flowchart for SAW filters (Please see next page for key)

SAW Filters
Flowchart A – Design (Quartz Substrate)



FLOWCHART SYMBOLS



Key to Design Flowchart

PROGRAM	DESCRIPTION	INPUT	OUTPUT
SYNTH	Master synthesis program using linear programming	Desired frequency response	Transducer tap weights
DIFF	Analysis of diffraction effects	Transducer geometry, substrate material data, frequency range	Input data for PREPLOT
PREPLOT	Plotting of diffraction effects	Frequency range	Frequency response with diffraction
PLINT	Circuit loading analysis	Admittance matrix of filter from PREPLOT	Frequency response with circuit loading
NCRCT	Diffraction correction	Uncorrected tap weights	Corrected tap wts.
RESP	Plotting for SYNTH	Transducer tap weights	Frequency response

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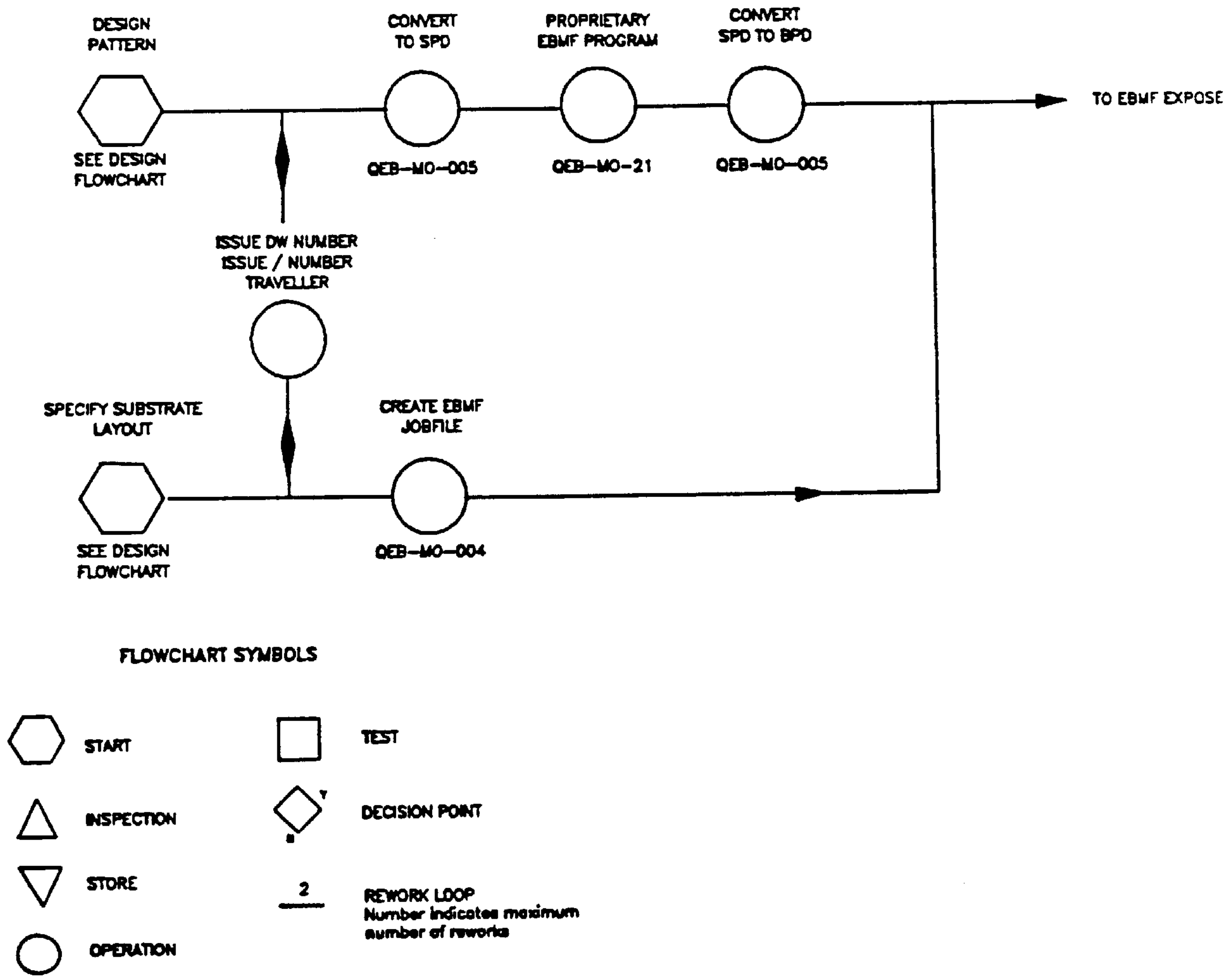
Data preparation flowchart

SAW Filters
Data Preparation for Direct Write



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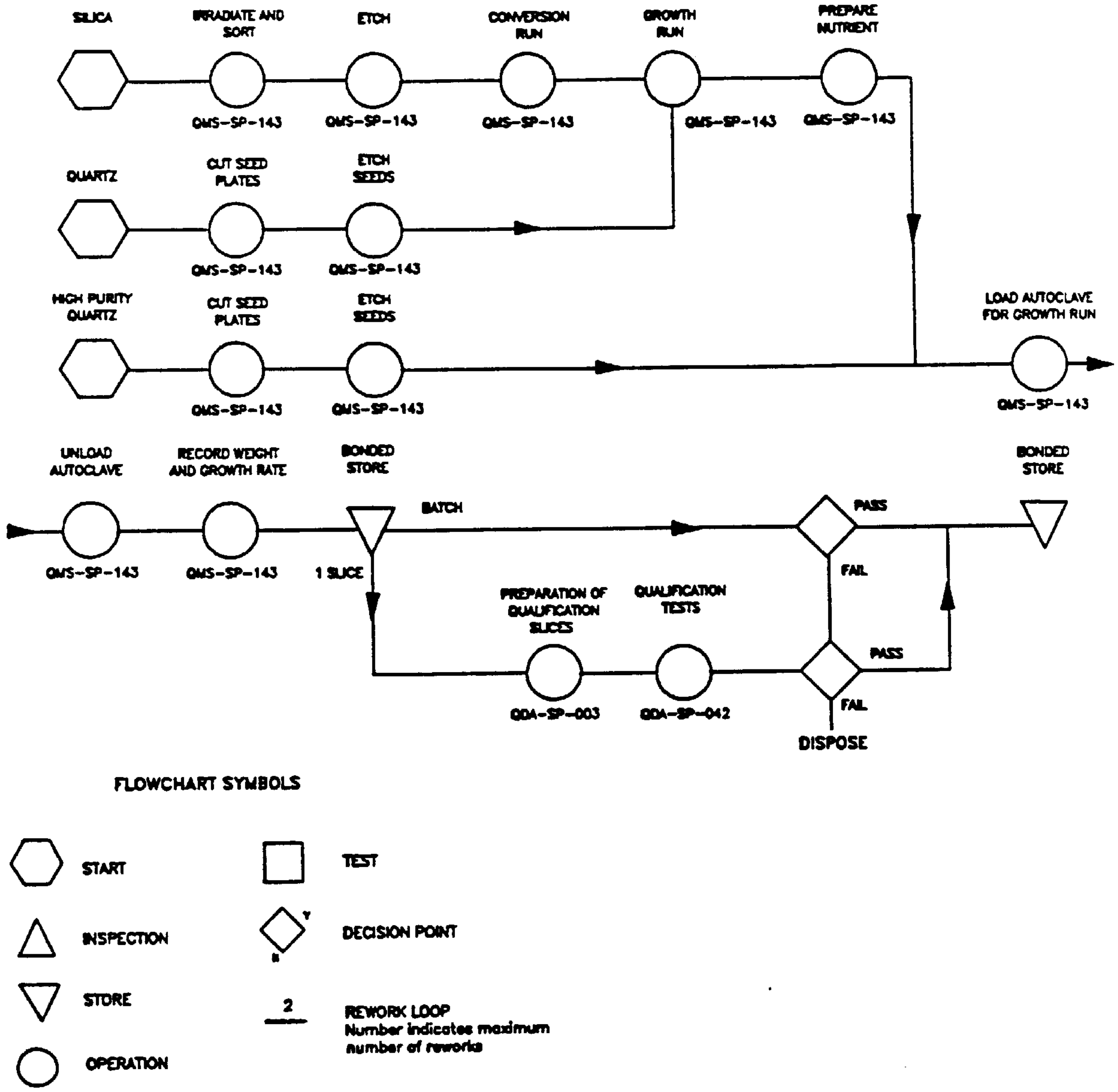
Manufacturing Flowchart - Quartz Growth

SAW Filters
Quartz Growth



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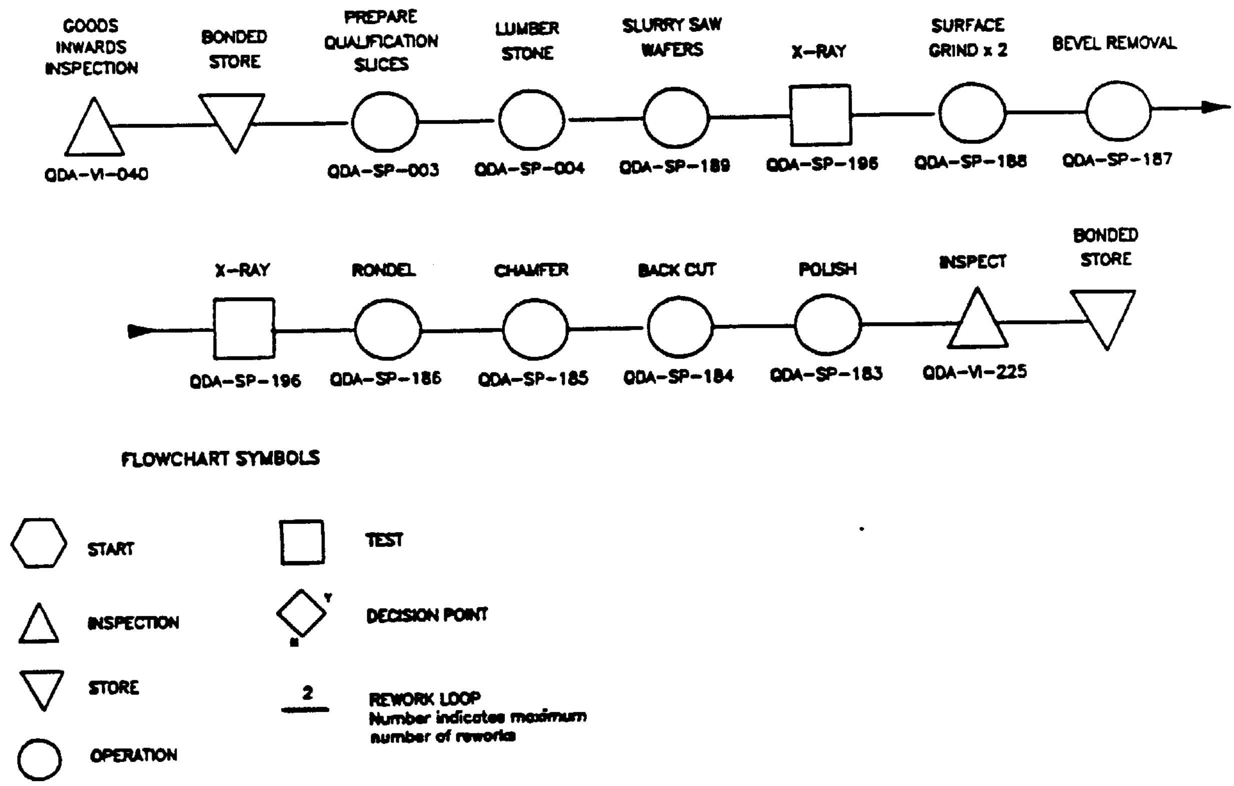
Manufacturing Flowchart - Stone to Wafer

SAW Filters
Stone to Wafer



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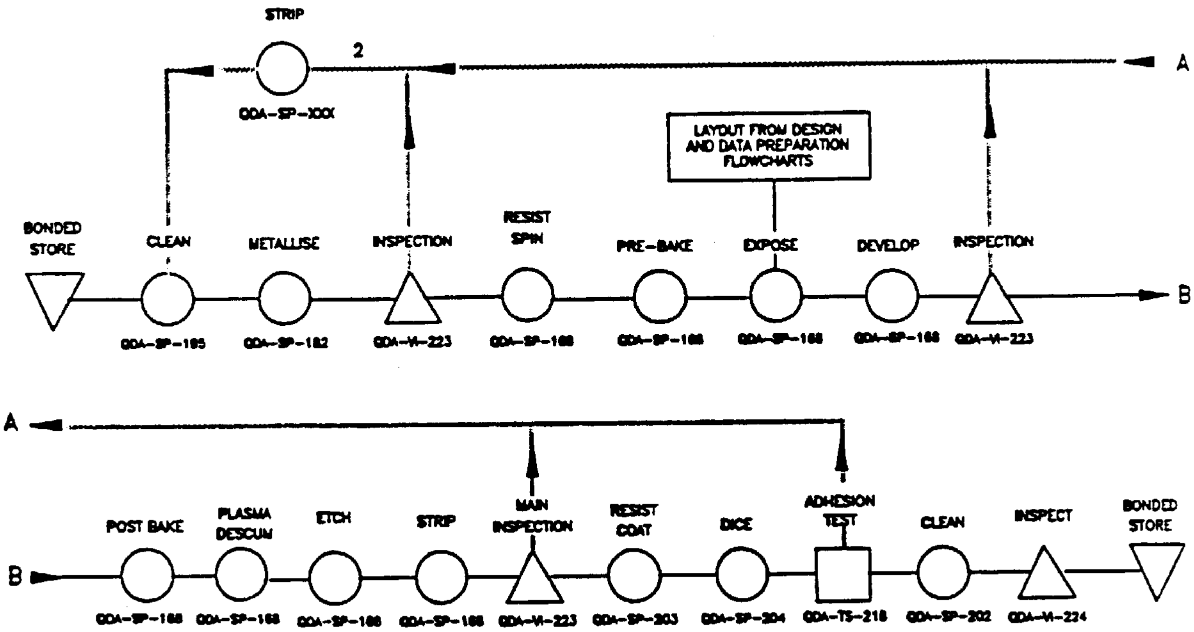
Manufacturing Flowchart - Wafer to Substrate by Direct Write

SAW Filters
Wafer to Substrate by Direct Write



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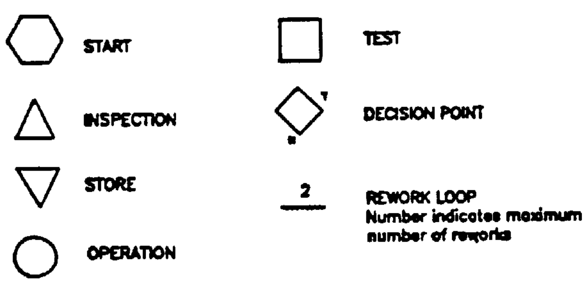
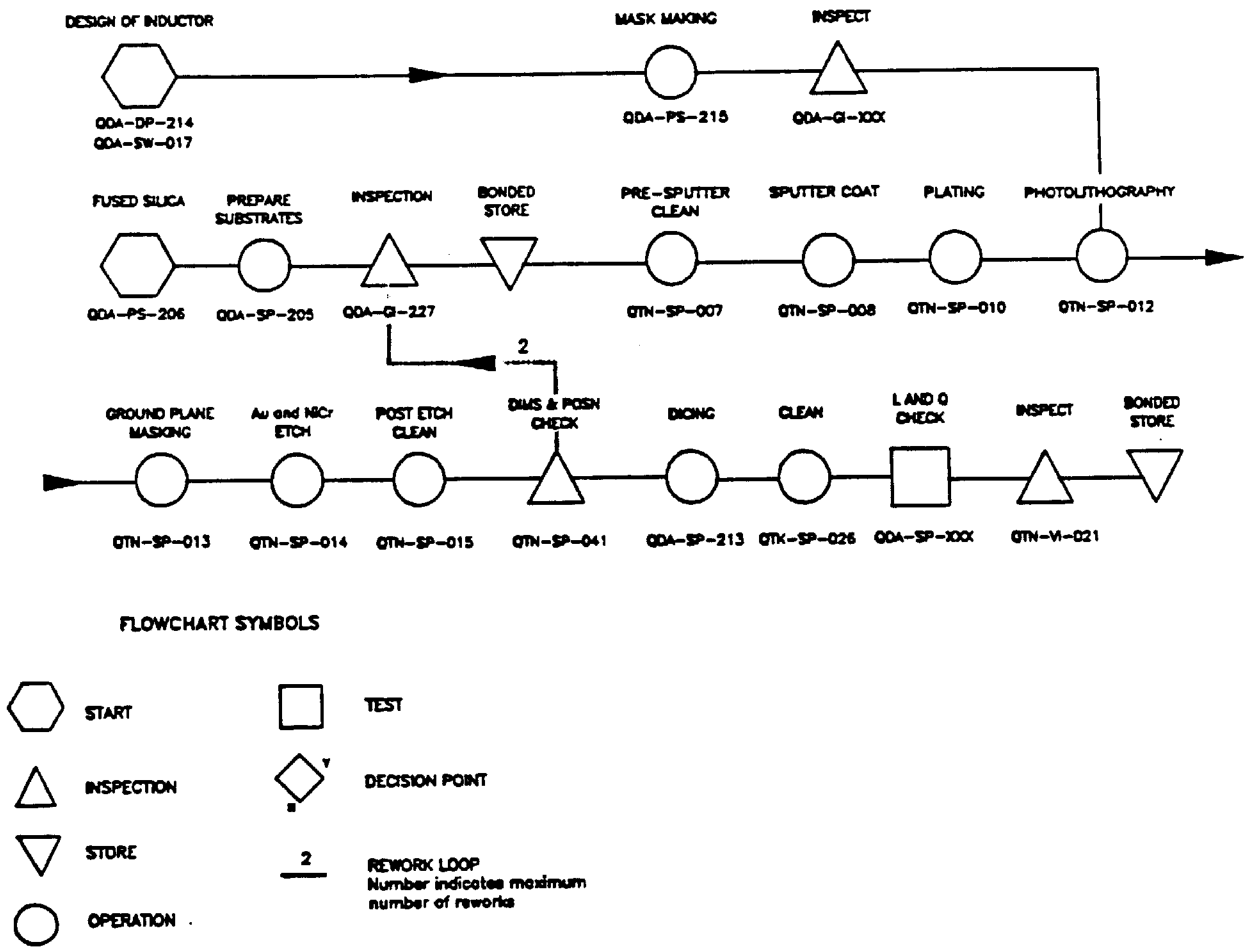


Manufacturing Flowchart - Design and Manufacture of Spiral Inductors

SAW Filters Design and Manufacture of Spiral Inductors to QTN-SC-056



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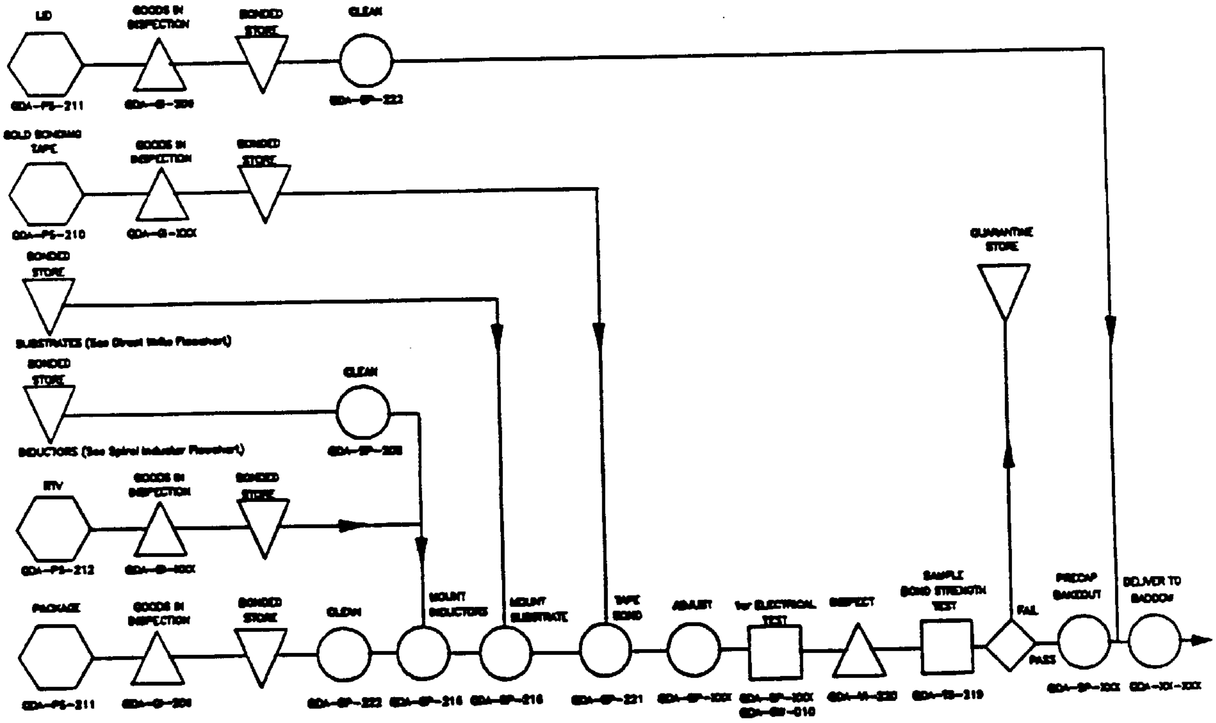
Manufacturing Flowchart - Final Assembly

SAW Filters
Final Assembly / Test



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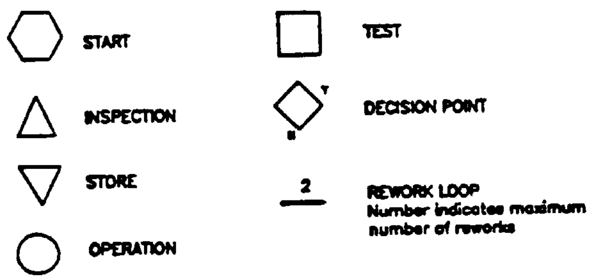

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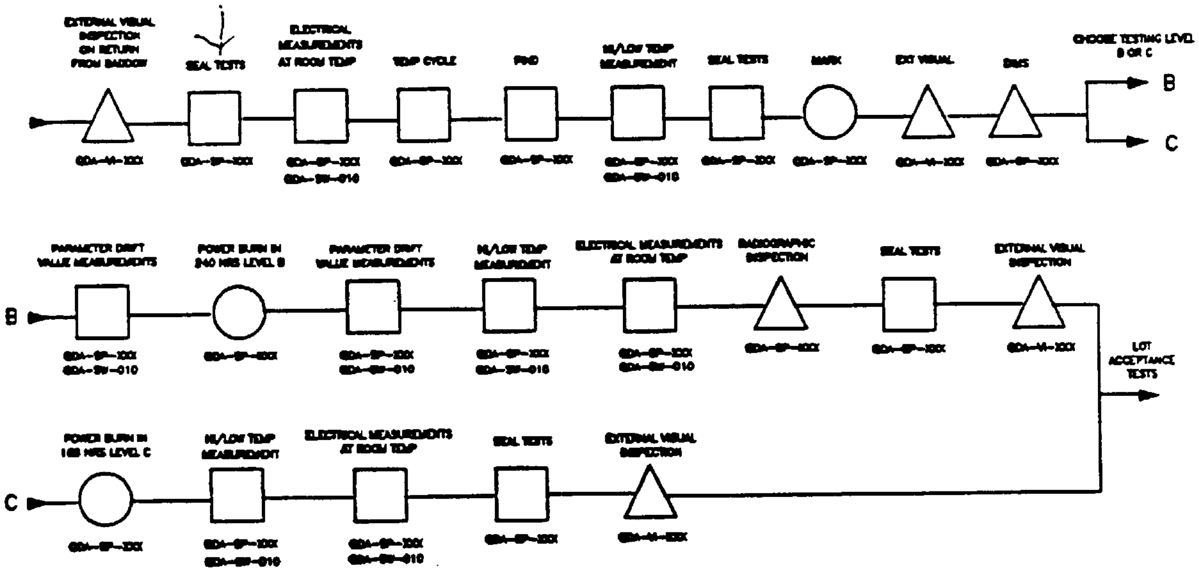
Manufacturing Flowchart - Final Test

SAW Filters
Final Test



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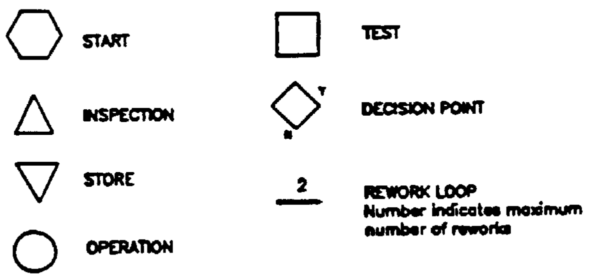

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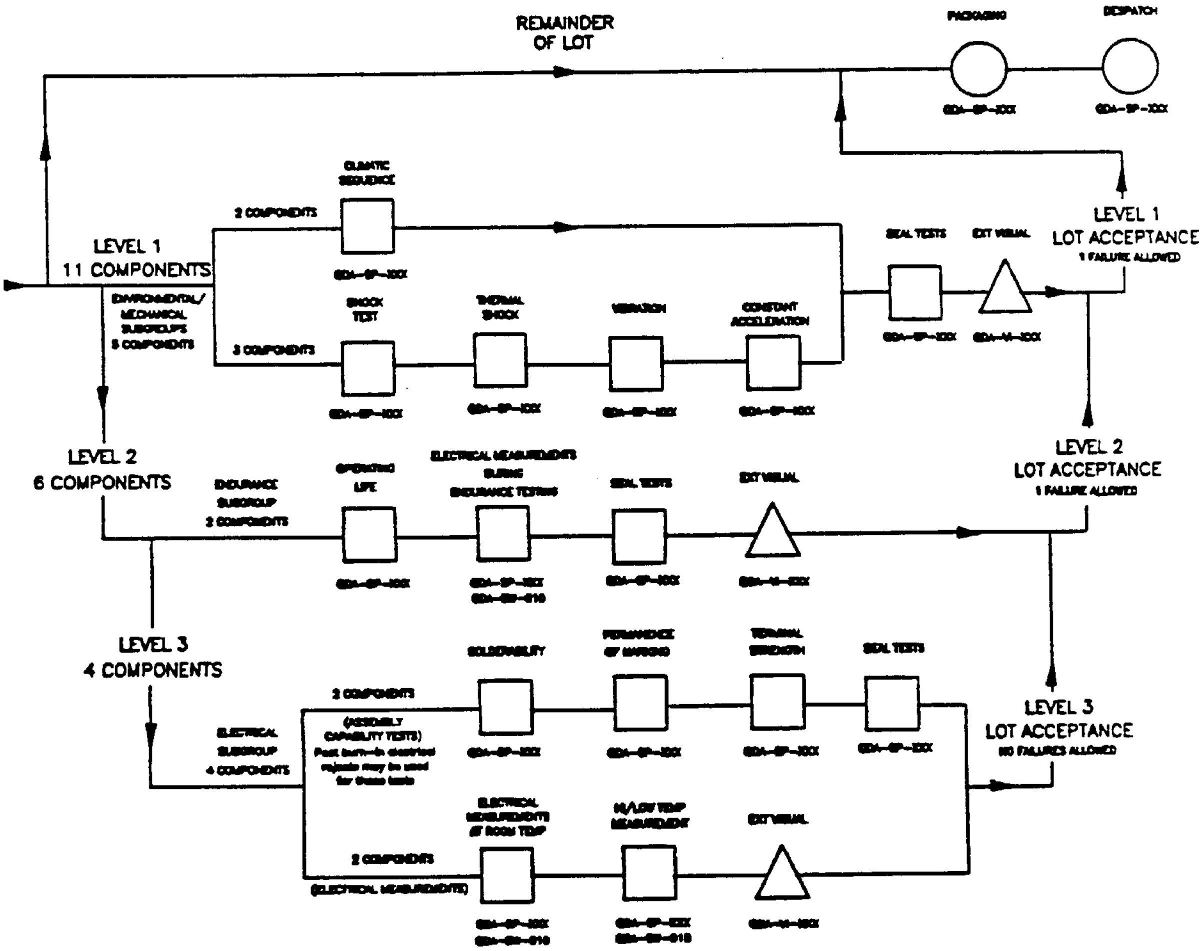
Manufacturing Flowchart - Lot Acceptance Tests

SAW Filters
Lot Acceptance Tests



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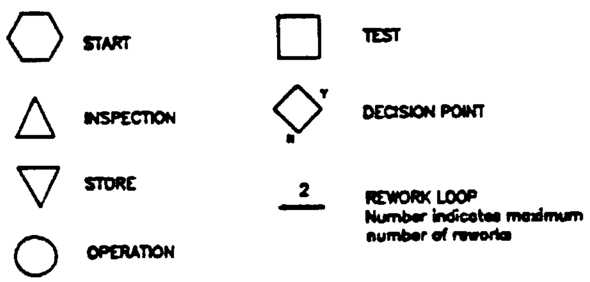

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PRODUCT SUMMARY

Documents

REF NO	TITLE	ISS	DATE	C/N	FROM
PS-002	Procurement Specification for High Purity Quartz	1	May 88	197	Feb 89
SP-003	Preparation of Quartz Qualification Slices	1	May 88	198	Feb 89
SP-004	Lumbering	A	Aug 87	004	Sep 87
SP-196	SAW filters for space qualification X-ray Orientation	a A	Sep 89 Dec 89	297 343	Sep 89 Dec 89
GI-016	Deposition Metal Inspection	1	Dec 88	228	Feb 89
DC-036	Control System for QDA Documents	2	Dec 88	220	Feb 89
CR-038	Environmental Standards for B13 Clean Room	A	Aug 87	029	Feb 89
DC-039	Drawing Control	1	June 88	202	Sep 87
DC-158	Software Control	e	May 89	249	May 89
GI-040	Incoming Inspection for Quartz Stones	1	Jul 88	210	Feb 89
SP-042	Quartz Qualification Tests	1	May 88	187	Feb 89
MO-046	Syton Polisher	A	Aug 87	033	Sep 87
MO-047	Secasi X-ray Goniometer	A	Aug 87	034	Sep 87
MO-048	Meyer and Burger Slurry Saw	A	Aug 87	079	Sep 87
MO-052	Cylinder Grinder	A	Aug 87	039	Sep 87
MO-059	Hand Lap	A	Aug 87	060	Sep 87

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REF NO	TITLE	ISS	DATE	C/N	FROM
MO-064	Jones and Shipman Surface Grinder	A	Aug 87	113	Sep 87
MO-157	Meyer And Burger TS3 Saw	a	May 88	196	May 88
SP-189	SAW Filters for Space Qualification Slurry Sawing Substrates	a A	Jul 89 Dec 89	278 342	Jul 89 Dec 89
SP-188	SAW Filters for Space Qualification Surface Grinding Substrates	a A	Jul 89 Dec 89	277 341	Jul 89 Dec 89
SP-187	SAW Filters for Space Qualification Substrate Bevel Removal	a A	Jul 89 Dec 89	276 340	Jul 89 Dec 89
SP-186	SAW Filters for Space Qualification Substrate Rondelling	a A	Jul 89 Dec 89	275 339	Jul 89 Dec 89
SP-185	SAW Filters for Space Qualification Substrate Chamfering	a A	Jul 89 Dec 89	274 338	Jul 89 Dec 89
SP-184	SAW Filters for Space Qualification Substrate Back-cutting	a A	Jul 89 Dec 89	273 337	Jul 89 Dec 89
SP-183	Polishing of SAW Wafers	a	Jul 89	272	Jul 89
VI-225	SAW Filters for Space Qualification Post Polishing Inspection	a	Dec 89	335	Dec 89
SP-195	SAW Filters for Space Qualification substrate cleaning	a	Sep 89	290	Sep 89
SP-182	Metallisation of SAW Wafers	a	Jul 89	271	Jul 89
SP-168	Electron Beam Lithography of SAW Filters on Quartz Substrates	a	May 89	250	May 89

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

IF THIS DOCUMENT IS NOT PRINTED ON YELLOW PAPER THIS COPY IS UNCONTROLLED AND WILL NOT BE UPDATED

REF NO	TITLE	ISS	DATE	C/N	FROM
SP-203	SAW Filters for Space Qualification Resist Coat (for dicing)	a	Oct 89	305	Oct 89
SP-204	SAW Filters for Space Qualification Substrate Dicing	a	Oct 89	304	Oct 89
SP-202	SAW Filters for Space Qualification Substrate Cleaning (after Dicing)	a	Oct 89	306	Oct 89
GI-209	SAW Filters for Space Qualification Goods Inwards Inspection of Packages and Lids	a	Oct 89	318	Oct 89
SP-222	SAW Filters for Space Qualification Cleaning of Packages and Lids	a	Oct 89	316	Oct 89
SP-208	SAW Filters for Space Qualification Cleaning of Inductors (Prior to Filter Assembley)	a	Oct 89	317	Oct 89
SP-216	SAW Filters for Space Qualification Mounting of SAW Substrates (and Tuning Inductors if required)	a	Oct 89	315	Oct 89
SP-221	SAW Filters for Space Qualification Tape Bonding	a	Oct 89	314	Oct 89
MO-XXX	Precima TCB21 Wire Bonder				
MO-XXX	Hewlett Packard HP8507 Network Analyser				
SP-XXX	Pre-cap Bake Out of SAW Filters				
PS-210	SAW Filters for Space Qualification Procurement of Gold Bonding Tape	a	Oct 89	319	Oct 89

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

REF NO	TITLE	ISS	DATE	C/N	FROM
PS-211	SAW Filters for Space Qualification Procurement of Packages and Lids	a	Oct 89	320	Oct 89
PS-212	SAW Filters for Space Qualification Procurement of Adhesive	a	Oct 89	321	Oct 89
TS-218	SAW Filters for Space Qualification Metallisation Peel Test	a	Oct 89	311	Oct 89
TS-219	SAW Filters for Space Qualification Bond Strength Test	a	Oct 89	312	Oct 89
VI-220	SAW Filters for Space Qualification Pre-Cap Visual Inspection	a	Oct 89	313	Oct 89
VI-223	SAW Filters for Space Qualification Visual Inspection (Direct Write)	a	Nov 89	327	Nov 89
VI-224	SAW Filters for Space Qualification Visual Inspection (Direct Write after Dicing)	a	Nov 89	328	Nov 89
SP-226	SAW Filters for Space Qualification Preparation of Quartz Qualification Slices	a	Dec 89	336	Dec 89
QEB-MO-004	Operating instructions for the EBMF Jobfiles Software	A	Dec 88	021	Dec 88
QEB-MO-005	Data Preparation (DWG to BPD Format)	A	Nov 88	019	Nov 88
QEB-MO-021	Use of SAWLABEL software	a	Oct 89	037	Oct 89
QTN-SC-056	Processing Schedule Etch Back of Fused Silica Substrates	a	Oct 89	091	Oct 89
QMS-SP-143	Process Schedule for the Growth of High Purity Quartz	a	Oct 89	147	Oct 89

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

REF NO	TITLE	ISS	DATE	C/N	FROM
VI-XXX	Visual Inspection on Return from Baddow				
SP-XXX	Seal Testing of SAW Filters				
SP-XXX	Temperature Cycling of SAW Filters				
SP-XXX	PIND Test - SAW Filters				
SP-XXX	Marking of Cans for SAW Filter				
SP-XXX	Power Burn In 240 HRS/ 168HRS				
SP-XXX	Radiographic Inspection				
SP-XXX	Radiation Test				
SP-XXX	Thermal Shock				
SP-XXX	Climatic Sequence				
SP-XXX	Shock Test				
SP-XXX	Vibration				
SP-XXX	Constant Acceleration				
SP-XXX	Operating Life				
SP-XXX	Solderability				
SP-XXX	Permanence of Marking				
SP-XXX	Terminal Strength				

4.2 Forms (Please see appendix 1 for examples of the following forms)

REF NO	TITLE	ISS	DATE	C/N	FROM
FF-XXX	Travel Card: Quartz Growth				
FF-021	Travel Card: Stone to Wafer	a	Dec 89	333	Dec 89
FF-022	Travel Card: Polishing	a	Dec 89	334	Dec 89
FF-023	Travel Card: Metallisation	b	Apr 90	90.100	Apr 90
FF-022	Travel Card: Wafer to Substrate by Direct Write				
FF-XXX	Travel Card: Design and Manufacture of Spiral Inductors				
FF-XXX	Travel Card: Final Assembly/Test				
FF-XXX	Travel Card: Lot Acceptance Test				

4.3 Drawings

See Specific Section

4.4 Software

REF NO	TITLE	ISS	DATE	C/N	FROM
SW-010	SAWTEST01	a-001	Sep 89		
SW-011	SYNTH	a-001 1-002	Sep 89 Oct 89	014	Oct 89
SW-014	DIFF	a-001 1-002	Sep 89 Oct 89	015	Oct 89
SW-015	PREPLOT	a-001 1-004	Sep 89 Oct 89	016	Oct 89
SW-016	PLINT	a-001 1-003	Sep 89 Oct 89	017	Oct 89
SW-017	JWW SPIRAL	a-001 1-002	Sep 89 Oct 89	013	Oct 89
SW-022	NCRCT	a-001 1-002	Sep 89 Oct 89	020	Oct 89
SW-023	RESP	a-001 1-002	Sep 89 Oct 89	021	Oct 89

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

List of Inspection and Control Specifications

SAW

Name	No	Issue	Date	Rev	Date
Surface Acoustic Wave (SAW) devices (Filters) Generic Specification	3502	1 Draft H	Dec 88		
Surface Acoustic Wave (SAW) Bandpass Filter operating in the Frequency Range 10-400MHz Detail Specification	3502/001	1 Draft F	Dec 88		
Internal Visual Inspection	20400	1	Sep 85		
External Visual Inspection	20500	2	Apr 89		
Radiographic Inspection of Electronic Components	20900	2	Feb 83		
Internal Visual Inspection of Piezoelectric Devices; crystal units and Surface Acoustic Wave (SAW) devices	20435	3	Aug 88	A	Apr 89
External Visual Inspection of Piezoelectric Devices; crystal units and Surface Acoustic Wave (SAW) devices	20535	2	Aug 88	A	Apr 89
Radiographic Inspection of Piezoelectric Devices; crystal units and Surface Acoustic Wave (SAW) devices	20935	2	Aug 88	A	Apr 89

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

General

Name	No	Issue	Date	Rev	Date
Requirements and Guidelines for the "Process Identification Document" (PID)	22700	1	Mar 83	A	Aug 89
Total Dose Steady-state Irradiation Test Method	22900	1	Sep 88		
Electrostatic Discharge Sensitivity Test Method	23800	1	Aug 87	A	Aug 87?
Preservation Packaging and Despatch of SCC Electronic Components	20600	2	Aug 87	A	Jul 89
Requirements for lead materials and Finishes for Components for Space Application	23500	2	Jul 85	A	Aug 88
General Requirements for the Marking of SCC Components	21700	3	Jul 81	C	Mar 89
Calibration System Requirements	21500	1	Mar 77		

PSS Series

Name	No	Issue	Date
Measurement of the Peel and Pull-off strength of coatings and finishes with pressure-sensitive tapes	PSS-01-713	1	Oct 82

The following is a list of inspection and test equipment used in the manufacture of the SAW filter.

1. Assembly/Test/Measurement Area (Laboratory B63)

    (i) Euromex Zoom Microscope
    (ii) HP8753A Network Analyser (H2988)

2. Quartz Growth

    (i) Inspection Tank
    (ii) Perkin Elmer 30/30 Spectrometer with HGA 500 Graphite Furnace
    (iii) MS 702 Mass Spectrometer
    (iv) Nicolet 170SX FTIR Spectrometer
    (v) X-ray Lang Camera
    (vi) Low Power Microscope

3. Materials Processing Development (HRC Building 72)

    (i) Secasi X-ray Goniometer
    (ii) Specac Interferometer
    (iii) Various Micrometers
    (iv) Feeler Gauge
    (v) Slip Gauge
    (vi) Olympus Microscope BH2

4. Processing/Assembly Area (Laboratory B13)

    (i) Leitz Labolux Microscope 100x 500x
    (ii) Various Low Power Microscopes
    (iii) HP8507 Network Analyser

5. Electron Beam Microfabrication Unit (Laboratory D11)

    (i) Vickers Image Shear Microscope
    (ii) Dektak Step Height Measuring Equipment

6. Thin Film Unit (Laboratory A8)

    (i) Kyowa SD2 TRP Microscope
    (ii) Watchet Microscope
    (iii) Talysurf 10 Surface Profiler

SECTION 6 LIST OF INSPECTION AND TEST EQUIPMENT

7. Quality Assurance Unit (Laboratory B61)

(i) Nikon V16-E Profile Projector (H1671)
(ii) Mondo 3 Co-ordinate Measuring Machine (H3404)
(iii) Edwards Fine Leak Tester (H2871)
(iv) Talysurf 5-20 Surface Profiler (H722)

8. Miscellaneous

(i) Fluorinert Gross Leak Tester
(ii) Dage Precima MCT20 Micro Tester - metal adhesion tester and bond pull tester (H724)
(iii) Watson ST 150 Radiographic Equipment
(iv) Hartley Measurements Autozap ESD Tester (H2948)

Section 7 QUALIFICATION APPROVAL BY SIMILARITY

The devices which will be approved by similarity will have the following characteristics.

Frequency	10 - 200MHz. The 200MHz device has the finest geometry and hence has the most complex manufacturing procedure, design rules however are the same at lower frequencies.
Substrate	High purity quartz, back cut.
Package	DIL solid sidewall metal packages for hermetic seam sealing, manufactured by SEPT (Doloy) of France. The size of the package will be chosen according to the characteristics of the filter. In general, the higher the selectivity of the filter, the longer the package. In all cases the package will have the same number of pins. The package will be selected from the following:- i. 34.8mm x 20.2mm ("24-pin") ii. 42.9mm x 19.6mm ("32-pin") iii. 54.3mm x 28.9mm ("40-pin")
Substrate Adhesive) Acoustic absorber)	Dow Corning 738 RTV silicone rubber compound.
Interconnections	Thermocompression bonding using gold tape.

Appendix 1 Examples of forms

1. Travel Card: Quartz Growth

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

Appendix 1 Examples of forms

2. Travel Card: Stone to Wafer

SAW FILTERS FOR SPACE QUALIFICATION

Travel Card: STONE TO WAFER

THIS CARD TO ACCOMPANY QUARTZ PIECE PARTS. IT MUST BE FILED BY THE ENGINEER ON COMPLETION OF THE DESCRIBED ACTIVITIES.

Operator: Date Started: Stone No:

Blue Book No. for Cutting and Grinding: Slurry Saw Sheet No:

Qualification Samples QDA-SP-226	Operator	FTIR Sample 15x5x stone thickness (Z) Polished Date:	Chemical Analysis Sample (15x5x7)(2 off) Ground Date:	X – Ray Topography Sample Full Slice, ground & etched (1.5 thick) Date: All Dims are mm

Wafer No	As Sawn Orientation (2Θ) QDA-SP-196 Z	X	As Sawn Centre Thickness QDA-SP-188	Post Grinding Orientation (2Θ) QDA-SP-196 Z	X	Post Grinding Centre Thickness QDA-SP-188	Diameter QDA-SP-186	Comments	Completion Date

QDA-FF-021 Issue a DEC 89 CN 333

Appendix 1 Examples of forms

3. Travel Card: Polishing

SAW FILTERS FOR SPACE QUALIFICATION

Travel Card: POLISHING

THIS CARD TO ACCOMPANY QUARTZ PIECE PARTS. IT MUST BE FILED BY THE ENGINEER ON COMPLETION OF THE DESCRIBED ACTIVITIES.

Operator: Date Started: Stone No:

Blue Book No. for Polishing:

Wafer No	Thickness prior to polishing QDA-SP-183	Thickness after lapping QDA-SP-183	Thickness After Regipol polishing QDA-SP-183	Thickness after Syton polishing QDA-SP-183	Visual Inspection PASS/FAIL QDA-VI-225	Comments	Despatch Date

QDA-FF-022 Issue a DEC 89 CN 334

Appendix 1 Examples of forms

4. Travel Card: Metallisation

SAW FILTERS FOR SPACE QUALIFICATION

Travel Card: METALLISATION

THIS CARD TO ACCOMPANY QUARTZ PIECE PARTS. IT MUST BE FILED BY THE ENGINEER ON COMPLETION OF THE DESCRIBED ACTIVITIES.

Operator: Date Started: Stone No:

Wafer No	Programmed Chromium Thickness QDA-SP-182	Programmed Chromium Rate QDA-SP-182	Deposited Chromium Thickness QDA-SP-182	Programmed Aluminium Thickness QDA-SP-182	Programmed Aluminium Rate QDA-SP-182	Deposited Aluminium Thickness QDA-SP-182	Visual Inspection Pass/Fail QDA-VI-223

ODA-FF-023 Issue b Apr 90 CN 90.100

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

Appendix 1 Examples of forms

5. Travel Card: Wafer to Substrate by Direct Write

Appendix 1 Examples of forms

6. Travel Card: Design and Manufacture of Spiral Inductors

Appendix 1 Examples of forms

7. Travel Card: Final Assembly/Test

SURFACE ACOUSTIC WAVE FILTERS FOR ESA/SCCG QUALIFICATION APPROVAL PROCESS IDENTIFICATION DOCUMENT

Appendix 1 Examples of forms

8. Travel Card: Lot Acceptance Test

EXHIBIT No. 3 (CTD.)

RESTRICTED
COMMERCIAL IN CONFIDENCE

F.S. McClemont

MARCONI SPACE AND DEFENCE SYSTEMS LTD.,
THE GROVE, WARREN LANE,
STANMORE, MIDDX.

79481/PBH/BB/S08
DATE: JANUARY 1982
COPY NO: 14.

Production Devices
M/L 83 Level B

DEMONSTRATOR PROGRAMME
REQUIREMENT SPECIFICATION
BANDPASS FILTER ASSEMBLY

Prepared by: P.B. Hutchinson
Approved by: M.R. Winstone

Issue 2 8th January, 1982

RESTRICTED
COMMERCIAL IN CONFIDENCE

INTRODUCTION

This specification describes the requirement for a bandpass filter assembly for a Demonstrator Programme. It also outlines the requirement for further developments of the filter assembly into an item suitable for quantity production and for use in a military environment.

It is intended that the same electrical specification of the filter will apply to both the Demonstrator and the production hardware.

This specification document forms the basis of a development sub-contract.

GENERAL DESCRIPTION

The filter is to form part of an IF receiver incorporated in an airborne guided weapon. The filter determines the system bandwidth.

Because of the non-critical effect of input and output impedance matching on the filter's performance, the filters are to be supplied without any matching networks. It is intended that the filters be presented with a 50 ohm impedance on both the input and the output. MSDS will design the circuitry at each end of the filter accordingly.

BUILD STANDARDS AND QUANTITIES

There are currently two timescales associated with the project:-

(a) Technology Demonstration Programme, starting immediately, to be completed by June 1982.

(b) Full Scale Project Definition and Development Programme, leading to an in-service date of 1985/86. This programme will involve the production of both A and B models.

The hardware built on the Demonstration Programme is to be suitable for air carriage. This does not necessarily mean the use of military standard components but it does require a rugged form of construction and adequate temperature stability. An environmental specification for the demonstration hardware is given in Annex 1.

The in-service production hardware will need to be manufactured to full military standards. An environmental specification for the production hardware is given in Annex 2.

Quantities

Demonstration Programme	8 off by the end of March 1982
	further 4 off by mid May 1982
	further 4 off by the end of June 1982 to second design iteration*
	TOTAL 16 off
A Models & B Models	TBD
Production Programme	Approximately 4000 off, commencing late 1985/early 1986, extending over a period of 3 years.

* It is anticipated that a second design iteration will be required in order to achieve the desired performance.

Packaging of Demonstration Hardware

Each filter is to be supplied in a hermetically sealed metal dual-in line package of a size as small as is practicable. The package size is to be agreed with MSDS at the earliest opportunity. The filters are to be tested and supplied ready for use.

EXHIBIT No. 3 (CTD.)

Packaging of Production Hardware

The filters are required to be compact, fully ruggedised and Q.A. approved to meet military requirements. It is not possible to give dimensions at this stage.

Test and Documentation Requirements

The filters are to be tested against the 'Electrical Parameters' requirements given in this specification. It is realised that owing to the short timescale of the Demonstration Programme the devices may not fully meet the requirements specification, for the March 1982 delivery. A set of test results is to be supplied with each filter, together with a description of the test methods employed.

A document outlining the design and summarising the results obtained, but which need not include processing details for the SAW substrate, is to be supplied to MSDS. It is understood that the processing details will be supplied to MEDL, Lincoln, if and when required.

ELECTRICAL PARAMETERS

Source Impedance	50 ohms ± 3 ohms		
Load Impedance	50 ohms ± 3 ohms		
Noise Input Level	~~-88~~ -94 dBW		
Maximum Input Signal Level	~~-8~~ -14 dBW		
Cross Talk (between like filters in adjacent channels)	< -50 dB		
		Absolute Tolerance	Matching Tolerance
Centre Frequency	120 MHz	±5 MHz	±0.5 MHz
Bandwidth (-3 dB)	10 MHz	±0.5 MHz	±0.5 MHz
Insertion Loss	21 dB	±3 dB	±0.25 dB
Attenuation at 110 and 130 MHz	20 dB min.	relative to pass band	
Peak Side Lobe Levels	-50 dB max.	relative to pass band	
Final Attenuation & Spurious Outputs	50 dB min.	relative to pass band	
Pass Band Shape/Ripple	Flat to within ±1.5 dB throughout pass band		
Group Delay	Absolute delay is not important		
Group Delay Matching*	Devices to be matched to ±2.5 nS of nominal delay		
Group Delay Dispersion	< ± 1nS		

* It is recognised that the group delay matching of ±2.5 nS may not be achievable within the timescales of the Demonstrator Programme, if at all. The requirements of the system dictate however that this figure remains as a design aim. It is expected that a figure of better than ±5nS will be achieved for the Demonstrator Programme.

EXHIBIT No. 3 (CTD.)

ANNEX 1

ENVIRONMENTAL SPECIFICATION FOR DEMONSTRATOR HARDWARE 25.11.81

(Ambient ground temperature range has been assumed at -0°C to +35°C).

Temperature in Pod:	-35°C to +70°C (min. 0°C with heater)
Stress limits: (non-operational)	10 G down) 2½ G forward) concurrent 2 G lateral)
Vibration:	.03g²/Herz from 20 Hz to 100 Hz
	.01g²/Herz from 100 Hz to 2 kHz
	Swept sine-wave test at 2G (peak) from 10 Hz to 200 Hz
Relative humidity:	95%

57

ANNEX 2

ENVIRONMENTAL SPECIFICATION FOR PRODUCTION HARDWARE

to be added.

DISTRIBUTION

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EXHIBIT No. 3 (CTD.)

Appendix 2

GEC RESEARCH LABORATORIES
HIRST RESEARCH CENTRE
WEMBLEY MIDDX

30 AUGUST 1983

DRAFT BUILD SCHEDULE

Operation of Electrotech CL680 Electron Beam Coater

A J Byrne

The machine runs continuously, but to conserve water and liquid nitrogen, they are turned on and off at the beginning and end of the day.

Outside the Clean Room

1. Ensure that the Dewar (50 litre Edwards) contains liquid nitrogen. The 'C' Nut secures the filling tube to the Dewar; on removal of nut and tube the Dewar can be wheeled away to be re-filled. The Dewar is filled early in the morning by Despatch Dept. personnel, so must be put out in corridor the previous evening with a pink (internal) requisition form.
   The Dewar contains sufficient LN_2 for approximately 3 days. When replacing the fill tube and 'C' nut ensure that the 'O' ring is in position, and only tighten the nut by hand.

2. Plug the solenoid connector (which hangs down between the rotary pump and the main body of the machine) on to the solenoid attached to the fill tube at the Dewar end of the fill tube.

3. Turn on the red water tap (for the chamber and gun cooling water) which is between the rotary pump and the machine main body; also turn on the brass water tap (for the high voltage valve cooling) nearby. DO NOT alter the water regulator valve adjacent to the brass water tap.

4. Turn on the water pump by pressing the green button on the white starter box. This box is attached to the main Clean Room wall, above the 60 amp power board.

5. Turn on the "H.V.BREAKER" switch which is located on the bottom right-hand corner of the right-hand side of the main power cabinet.

Inside the Clean Room

6. Vent the chamber. Ensure the chamber door latch is up. Turn the pumping "SYSTEM CONTROL" knob to "VENT". When the chamber door opens a hissing will be heard (5 - 10 mins) turn the "SYSTEM CONTROL" knob to "STANDBY" in the "AUTOMATIC" section.
7. Load the samples to be coated on to suitable carousel plates. A selection of ready-drilled plates are available; special plates are easily made.
8. Load the carousel plates into the carousel. Hold the plates with gloved hands.
9. Inspect the electron beam gun to ensure that there is sufficient melt in the crucible(s) to be used. The crucible must be more than a quarter full, but the level of the melt MUST NOT come above the top of the crucible. The shutter may be moved by switching the gun "POWER" control switch to "MANUAL" (situated below the "BEAM ALIGNMENT" potentiometers) and switching the "SHUTTER" control to "OPEN". When putting new melt in the crucible, take out the old material, place the new material in the bottom of the crucible and replace the old. An attempt should be made to rotate the melt by 90° after each use, particularly in the case of silver and chromium.
Also inspect the gun area for any pieces of evaporated metal that have pealed off the shutter etc. These should be vacuumed up periodically.
10. Close the chamber door and rotate the handle through 180° so that it clamps the door shut.
11. Turn the "SYSTEM CONTROL" to "PUMP".
The coater will automatically cycle. Roughing out takes about 12 mins. then there is a short pause (1 min) and the high vacuum valve will open.

Ensure that the "ION GAUGE" switch is in the "READ" position. The gauge will come on automatically when the high vacuum valve has been open for a short period; however, this should be checked after 15 mins. into the pumping cycle. If the gauge has not come on, the switch should be moved to "OFF" and back to "READ".

12. Switch on the "ROTATION". The speed control is set and does not need adjusting,

13. Switch on the heater (if required). Set the temperature on the thumb-wheel switch which is calibrated in degrees Celsius. The heater will not come on until the pre-set base pressure has been reached. Also the chamber cannot be vented if the temperature of the carousel is above 100℃. The heater takes between 20 and 40 mins. to reach temperature, and the gauge shows the difference between the set point and actual carousel temperature in ℃.

14. Switch on the glow discharge (if required) and press the "CYCLE" button. The time and current controls are set to suitable values.
The glow discharge will be started when the base pressure reaches the pre-set value. The base pressure will be regained after the glow discharge and then the heating cycle will start.

15. Set up the Electron Beam Gun controls.

 a) Adjust the longitudinal "SWEEP AMPLITUDE" and lateral "SWEEP AMPLITUDE" as follows:-

Material to be evaporated	Longitudinal	Lateral
Aluminium	4	0
Titanium	4	0
Chromium	10	6
Silver	10	6

This must be done to ensure the correct beam spot size for the particular material being evaporated.

b) Select the required crucible, using the "CRUCIBLE POSITION" control.

CR1	Aluminium
CR2	Titanium
CR3	Chromium
CR4	Silver

The red LED glows continuously when the crucible has been located.

16. Set up the film thickness monitor - it is the lowest instrument in the control rack. This has an independent on/off switch and MUST be left on all the time.

a) Set film thickness.

Find the "FILM LIST" page: Press "EDIT" to find the menu page; press "ITEM " to move the cursor down the page to "FILM LIST"; press "ACCEPT" - the "FILM LIST" will appear.

The "FILM NUMBER" and "FILM TYPE" number correspond to the crucible number, and hence material type.

Move the cursor until it is adjacent to the "OVERRIDE THICKNESS" of relevant film type. Enter the required thickness in Angstroms (Å). Press "ACCEPT" and the "OVERRIDE THICKNESS" will change to the desired value.

Film Number	Film Type	Override Thickness
1 (Aluminium)	1	1000
2 (Titanium)	2	200
3 (Chromium)	3	50
4 (Silver)	4	2000
5		
6		
7		

EXHIBIT No. 8 (CTD.)

b) Set up the "STATUS" ~~or~~ OR "RUN" page.

Press "EDIT" and the "STATUS" or "RUN" page will appear. Move the cursor to "FILM NUMBER". Type in the required number corresponding to the type of metal to be deposited, and press "ACCEPT" - the film number will be entered.

The thickness monitor is now prepared to run.

17. Ensure that the five red interlock lights marked:-

"CABINET"

"CHAMBER"

"VACUUM"

"WATER"

"READY"

are on. If they are not on, check that all previous steps have been carried out then, when they are correct and the interlock lights are still out call for help!!

Press "H.V. ON" - the high voltage will come on as indicated by the LED and the meter. If it cuts out call for help!!

Move the switch marked "POWER" to "AUTO", after a short pause the LED will come on.

18. The evaporation can now proceed.

Press "RUN" on the thickness monitor. The monitor will automatically control the gun in the following sequence:-

a) Ramp up to low power, hold for a short period (approx. 1 min).

b) Ramp up until the material is just evaporating and hold (approx.1min).

c) Open shutter and power up gun until desired deposition ~~rote~~ rate is reached and hold. usually about 1-5 mins.

d) Close shutter when required film thickness is reached.

e) Ramp down power rapidly to low level (10 sec).

f) Ramp down power to zero (1 min).

g) Idle for 10 minutes.

h) Start next film.

When the power has gone to zero in the "IDLE 2" stage, the gun <u>MUST</u> be turned off by pressing "HOLD" once and "RESET" twice on the thickness monitor.

When "RUN" is pressed the thickness monitor zeros automatically, and clears the fault page. If a fault occurs during a run, press "ALARM ACCEPT" and ignore the problem, but if the run stops - call for help!!

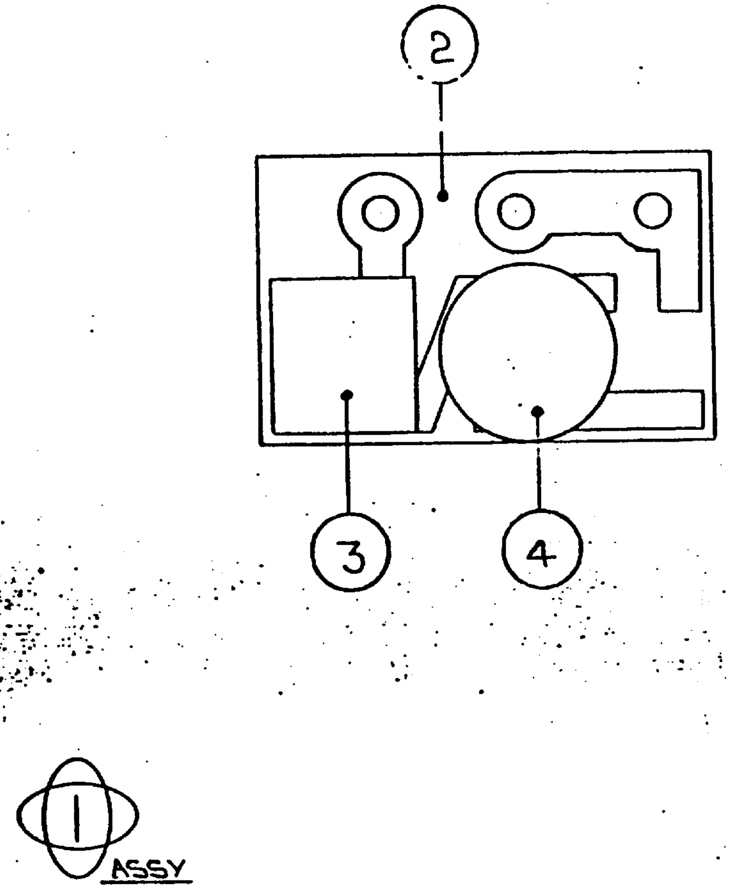
19. Turn the "POWER" switch to "OFF".
20. Press "H.V. OFF".
21. Wait for two minutes.
22. If another film is to be deposited, repeat 15 to 21.
23. Switch heat off.
24. Switch glow discharge off.
25. Switch rotation off.
26. Rotate "SYSTEM CONTROL" to "VENT" - when chamber opens, turn to "STAND-BY".
27. Unload samples using gloves to hold carousel plates.
28. Close chamber door and set "SYSTEM CONTROL" to "PUMP".
29. When leaving the machine overnight, or at week-ends, reverse instructions 1 to 5. However, if substrates are to be left in vacuum overnight, also turn the "SYSTEM CONTROL" to "STAND-BY".

EXHIBIT No. 3 (CTD.)

Quick Check List

1. & 2.	Liquid nitrogen on.
3. & 4.	Water on.
5.	High voltage breaker on.
6, 7, 8 & 9.	Vent chamber, load sample, check melt and gun.
10. & 11.	Pump down.
12, 13 & 14.	Rotation, glow discharge and heater on.
15.	Set gun controls - spot size and crucible.
16.	Set monitor - film thickness and film type.
17.	Start H.V. and power (interlocks on?).
18.	Run.
10, 20, & 21	Power off, H.V. off, wait.
22.	Back to 15 for another film.
23, 24 & 25.	Rotation, glow discharge, heat off.
26 & 27	Vent and unload.
28.	Pump down.
29.	Switch off LN_2, water and H.V. overnight.

DRG. Nº 15365/A3 | ©1982 | MEDL



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ISSUED · 0 JUN 1993
PLEASE DESTROY ALL PRINTS BEARING A PREVIOUS DATE.

EXHIBIT No. 3 (CTD.)

QTY	PT	DESCRIPTION	MATL/DRG Nº
1	4	THIN TRIM CERAMIC CAPACITOR	15373/A4-2
1	3	CHIP INDUCTOR	15622/A4-1
1	2	THICK FILM SUBSTRATE	15374/A4-1
A	1	ASSEMBLY	

REVISIONS
1 — APP'D. [signature] JO — DATE 31-3-83
PART 3 WAS 13854/A4-82
APP'D.
DATE

67

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.
UNLESS OTHERWISE STATED THE FOLLOWING TOLERANCES APPLY TO ALL DIMENSIONS
UP TO 299·9 ± 0·4
300 TO 999·9 ± 1·0
ABOVE 1000 ± 1·5
DRAWN TO B.S. 308

ISSUED BY M.E.D.L — D.O.
DRAWN [signature] 7-5-82
CHECKED [signature] 24/5/82
ISSUE TO

11¾ × 16½ A3.
THIRD ANGLE PROJECTION.

MARCONI ELECTRONIC DEVICES LIMITED
LINCOLN ENGLAND

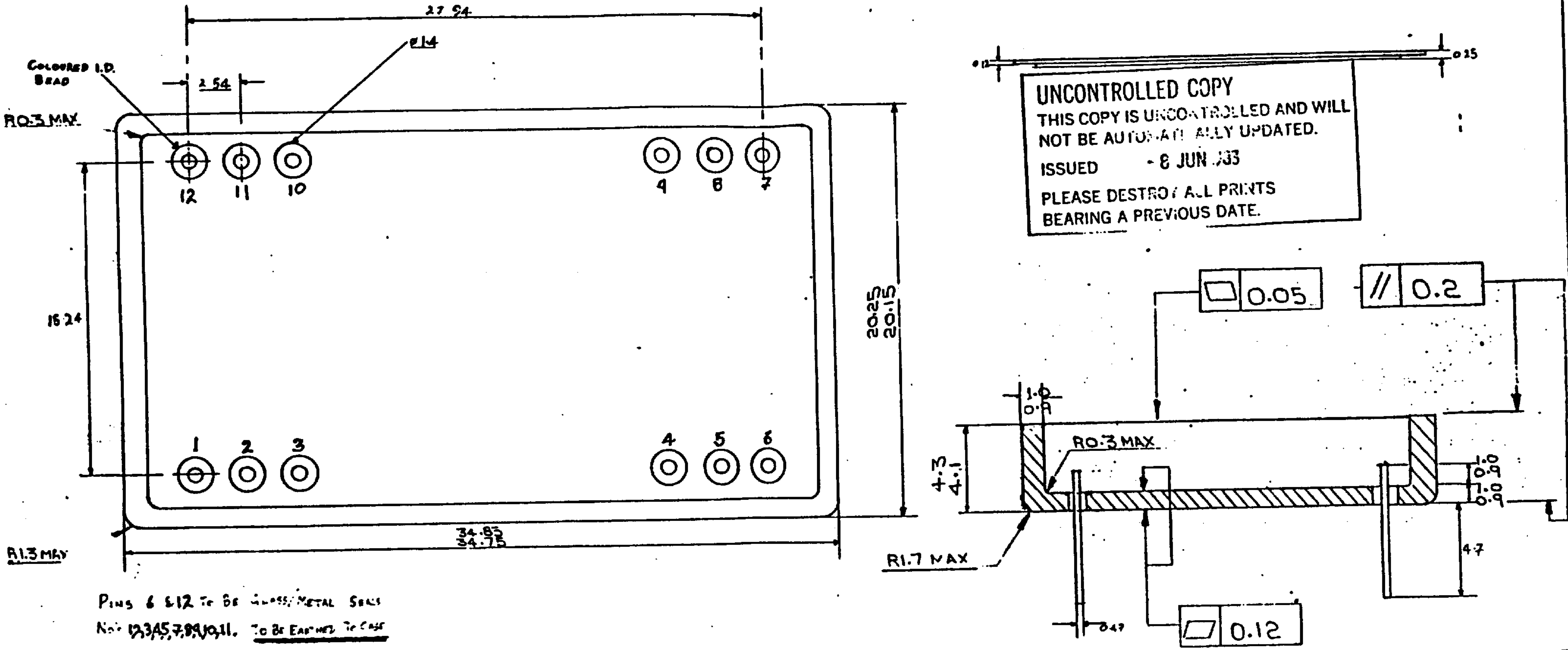
ASSEMBLY OF THICK FILM SUBSTRATE FOR S.A.W FILTER NB4

DEVICE OR MACHINE: DA 9200
SCALE 10/1
PLANT Nº
DRG. Nº 15365/A3

ADMEL P

DRG. No 14632/A3 | ©1981 | MEDL

THE PINS MAY BE SITUATED ± 0.12 FROM THEIR THEORETICAL POSITION



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ISSUED - 8 JUN .83
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Pins 6 & 12 To Be Glass/Metal Seals
No's 1,2,3,4,5,7,8,9,10,11. To Be Earthed To Case

PINS GOLD PLATED 1.5µM

PACKAGE MATL. :- KOVAR / NICKEL FLASH / GOLD PLATED 1.5µm. LID MATL. :- NICKEL PLATED KOVAR

REVISIONS 1	APPD. Jo / DATE 15.5.82	MODIFIED SEPT. 82402 SOLID SIDEWALL PACKAGE
	E REMOVED	
2	APPD. [signature] Jo / DATE 29.3.83	
	PINS WERE NICKEL FINISH	

68

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

UNLESS OTHERWISE STATED THE FOLLOWING TOLERANCES APPLY TO ALL DIMENSIONS
UP TO 299.9 ± 0.4
300 TO 999.9 ± 1.0
ABOVE 1000 ± 1.5

DRAWN TO B.S. 308

QTY	PT	DESCRIPTION	MATL/DRG No

ISSUED BY		D.O.
DRAWN	PA DURRANT	
CHECKED		
ISSUE TO		

MARCONI ELECTRONIC DEVICES LIMITED
LINCOLN ENGLAND

S.A.W. 200 MHz FILTER
SOLID SIDEWALL
NARROWBAND PACKAGE

DEVICE OR MACHINE.

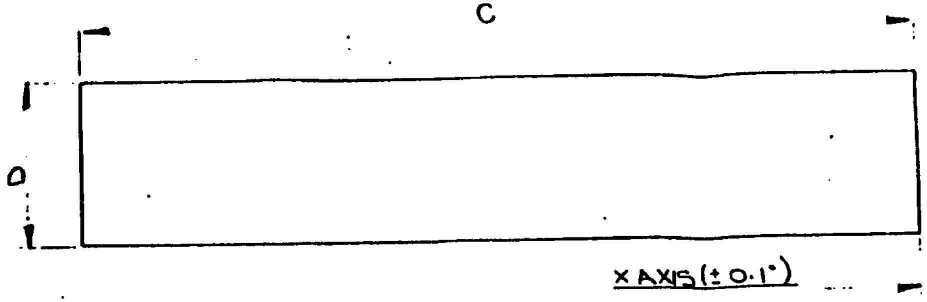
11¾ x 16½ A3.	THIRD ANGLE PROJECTION.	SCALE	PLANT No	DRG. No 1463?/A3

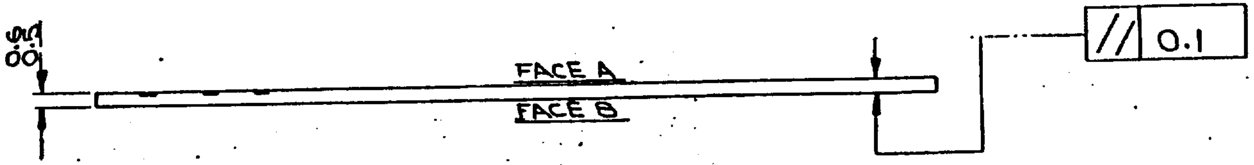
ADMEL P.4

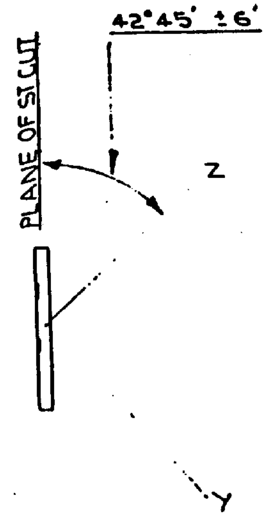
EXHIBIT No. 3 (CTD.)

SHEET 1

DRG. Nº 15368/A3	©1982	MEDL







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PLEASE DESTROY ...
BEARING A PREVIOUS ...

PN	DIM. C	DIM. D	DEVICE	CODE
2	25.1 24.9	20.1 19.9	DA9201	S215
1	32 31	6.1 5.9	DA9200	S214

MATL:
HYDROTHERMALLY CULTURED (SYNTHETIC) QUARTZ

FINISH:
FACE A FINE LAPPED, FACE B SYTON POLISHED TO BE FREE FROM VISIBLE DEFECTS EG. SCRATCHES OR CHIPS ETC. EDGES TO BE FINE LAPPED. ALL SHARP EDGES TO BE CHAMFERED.

QTY	PT	DESCRIPTION	MATL/DRG Nº

REVISIONS — APP'D. / DATE — APP'D. / DATE

69

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

UNLESS OTHERWISE STATED THE FOLLOWING TOLERANCES APPLY TO ALL DIMENSIONS
UP TO 299·9± [redacted]
300 TO 999·9 ± 1·0
ABOVE 1000 ± 1·5

DRAWN TO B.S. 308

		D.O.
ISSUED BY	N.E. O.L.	
DRAWN	[signature]	5.5.82
CHECKED	[signature]	12/5/82

ISSUE TO

MARCONI ELECTRONIC DEVICES LIMITED
LINCOLN ENGLAND

ST CUT QUARTZ SUBSTRATE FOR 200 MHz S.A.W

DEVICE OR MACHINE: DA 9201 DA 9200

11¾ x 16½ A3. | THIRD ANGLE PROJECTION. | SCALE 5/1 | PLANT Nº | DRG. Nº 15368/A3

SHEET 1

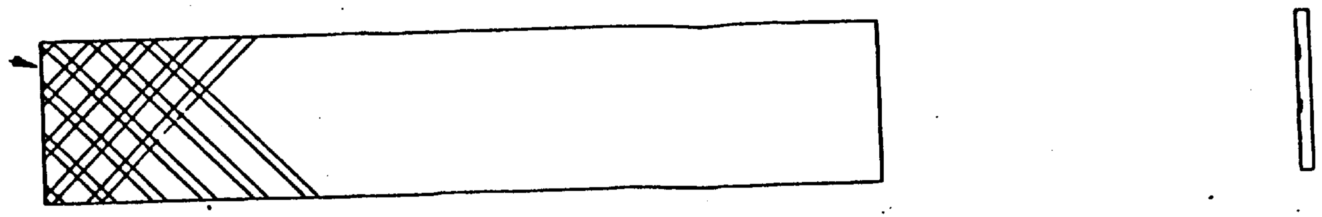
ADM. 8 417

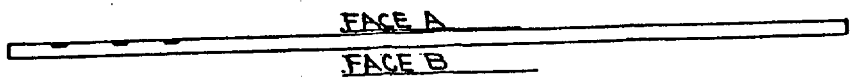
EXHIBIT No. 3 (CTD.)

SHEET 2

DRG. Nº 15368/A3 | ©1982 | MEDL

TWO ORTHOGONAL SETS OF SAWCUTS TO EXTEND OVER THE WHOLE OF THE UNPOLISHED FACE A, EACH AT 45°±30′ TO LONG AXIS OF SUBSTRATE, 0.254 ±0.076 WIDE X 0.127 ± 0.05 DEEP ON 1.016 ±0.127 PITCH





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ISSUED - -8 JUN 1983
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NOTE:

ENSURE FACE B (POLISHED FACE) IS PROTECTED AT ALL TIMES FROM DAMAGE ie SCRATCHES, CHIPS ETC.

QTY	PT	DESCRIPTION	MATL/DRG Nº

REVISIONS — APP'D / DATE — APP'D / DATE

70

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

UNLESS OTHERWISE STATED THE FOLLOWING TOLERANCES APPLY TO ALL DIMENSIONS

UP TO 299·9 ± 0·4

300 TO 999·9 ± 1·0

ABOVE 1000 ± 1·5

DRAWN TO B.S. 308

ISSUED BY	M.E.D.L	D.O.
DRAWN	[signature]	5-5-82
CHECKED	[illegible]	[illegible]
ISSUE TO		

11¾ × 16½ A3. | THIRD ANGLE PROJECTION.

MARCONI ELECTRONIC DEVICES LIMITED
LINCOLN ENGLAND

ST CUT QUARTZ SUBSTRATE FOR 200 MHz S.A.W

DEVICE OR MACHINE: DA9201, DA9200

SCALE 5/1 | PLANT Nº | DRG. Nº 15368/A3

SHEET 2

ADMEL P

British Standards Institution

BS 9000 : GENERAL REQUIREMENTS FOR ELECTRONIC COMPONENTS OF ASSESSED QUALITY

CAPABILITY APPROVAL CERTIFICATE

Certificate no.	CA/065
Issue no.	1
Date	17 November 1981

ABSTRACT OF DESCRIPTION OF CAPABILITY AS PUBLISHED IN PD 9002

Basic technology: Thin film using Rayleigh mod theory.
Substrate: Quartz or Lithium Niobate.
Pattern formation: Photolithography and etching.
Conductors: Interdigitated transducers, aluminium.
Assembly: SAW element flexibly fitted in metal enclosure with a suitable adhesive. Add-on components such as printed circuit boards and inductors included in box where required by design.
Encapsulation: Lidded box, welded (hermetic) or epoxy gasket.
Package: Precision metal enclosure (either screwed or gasket sealed) or standard transistor package (welded).

Ratings:

Maximum dissipation	10 mW
Maximum operating temperature range	- 20 °C to + 80 °C (quartz)
Operating temperature	+ 40 °C ± 1 °C (lithium niobate)
	- 40 °C + 85 °C

Inspection and tests
Screening: Reference 1.2.9 or BS 9450
Environmental: Tests, inspection levels and AQLs as for full assessment level in Table 1.3.3/1 of BS 9450.

BS 9450 Reference	Test	Test Condition
1.2.6.13	Rapid change of temperature	- 26°C to + 80°C
1.2.6.5	Damp heat cycle	6 cycles
1.2.6.9	Acceleration, steady state	196 m/s²
1.2.6.8.1	Vibration, swept frequency	55 to 2000 Hz, 98 m/s²
1.2.6.6	Shock	490 m/s², 11 ms
1.2.6.14	Sealing	As BS 2011, Test QK
Endurance 1.2.7	Inspection levels as for full assessment level in Table 1.3.3/1 of BS 9450	+ 85 °C (non-operating)

Typical performance: Fast cut-off SAW bandpass filter up to 70 MHz and 5 μs delay and DCPSK demodulator with reference frequency up to 60 MHz.

Level or stage of customer participation in design: Any by agreement.

Guidance to customer document: To be published.

This approval may be withdrawn in accordance with the provisions of BS 9000

Approved on behalf of BRITISH STANDARDS INSTITUTION

[signature]
Senior Certification Officer

Maylands Avenue
Hemel Hempstead
Herts
HP2 4SQ

THIS COPY TO CONSIGNEE WITH THE GOODS

APPROVED CERTIFICATE, CERTIFICATE OF CONFORMITY OR RELEASE NOTE

Issued under

Clause 1 MOD (PE) DCL Registration No. 281M02 (DEF. STAN 05-21)
Clause 2 B.S.I. Approval No. 1016/M
Clause 3 CECCRegistration No. M/0011/CECC/UK-1016/M
Clause 4 Private Sale

Nº 12178 D

MARCONI ELECTRONIC DEVICES LIMITED
DODDINGTON ROAD, LINCOLN LN6 0LF, ENGLAND

To Messrs. HIRST RESEARCH CENTRE,
East Lane,
Wembley,
Middlesex HA9 7PP
The Attention of Mr J. PATRICK, Q.A. Manager

Contract No.

Sub Contract or Order No. Advice Note No 821751581 001

MEDL Order No. GRN No 126845

Item	DESCRIPTION (with Part Number/Serial Number)	Qty.	Specn. and/or Drg. No. or Reference	Batch No.
1	ST- QUARTZ S/S	9		

REMARKS

Free Issue

Clause 1 Certified that the whole of the supplies detailed hereon have been inspected, tested and unless otherwise stated above, conform in all respect to the requirements of the contract or order.
Clause 2 Certified that the components detailed hereon have been manufactured, inspected and tested in conformity with the specification quoted, and are released with my authority under BSI Approval No. 1016/M.
Clause 3 The Component(s) in this package have undergone quality assessment in accordance with the procedures given in document BS 9000 RP7 under the supervision of Electrical Assurance Directorate M.O.D., acting on behalf of BSI a full member of ECQAC according to the above numbered harmonised specification. These component(s) are therefore released under the CECC system.
Clause 4 Certified that the whole of the supplies detailed hereon conform in all respect to the requirements of the contract or order.

Clause(s) applicable

INITIAL AS APPROPRIATE							
1	T.E.J.	2		3		4	

INSPECTOR'S

108 239

Signed .... Date 13-9-83

CHIEF INSPECTOR/QUALITY MANAGER/AUTHORISED REPRESENTATIVE
for and on behalf of Marconi Electronic Devices Ltd.

BUILD STANDARDS AND QUANTITIES

There are currently two timescales associated with the project:-

(a) Technology Demonstration Programme, starting immediately, to be completed by June 1982.

(b) Full Scale Project Definition and Development Programme, leading to an in-service date of 1985/86. This programme will involve the production of both A and B models.

The hardware built on the Demonstration Programme is to be suitable for air carriage. This does not necessarily mean the use of military standard components but it does require a rugged form of construction and adequate temperature stability. An environmental specification for the demonstration hardware is given in Annex 1.

The in-service production hardware will need to be manufactured to full military standards. An environmental specification for the production hardware is given in Annex 2.

Quantities

Demonstration Programme	8 off by the end of March 1982
	further 4 off by mid May 1982
	further 4 off by the end of June 1982 to second design iteration*
	TOTAL 16 off
A Models & B Models	TBD
Production Programme	Approximately 4000 off, commencing late 1985/early 1986, extending over a period of 3 years.

* It is anticipated that a second design iteration will be required in order to achieve the desired performance.

Packaging of Demonstration Hardware

Each filter is to be supplied in a hermetically sealed metal dual-in line package of a size as small as is practicable. The package size is to be agreed with MSDS at the earliest opportunity. The filters are to be tested and supplied ready for use.

EXHIBIT No. 3 (CTD.)

Packaging of Production Hardware

The filters are required to be compact, fully ruggedised and Q.A. approved to meet military requirements. It is not possible to give dimensions at this stage.

Test and Documentation Requirements

The filters are to be tested against the 'Electrical Parameters' requirements given in this specification. It is realised that owing to the short timescale of the Demonstration Programme the devices may not fully meet the requirements specification, for the March 1982 delivery. A set of test results is to be supplied with each filter, together with a description of the test methods employed.

A document outlining the design and summarising the results obtained, but which need not include processing details for the SAW substrate, is to be supplied to MSDS. It is understood that the processing details will be supplied to MEDL, Lincoln, if and when required.

ELECTRICAL PARAMETERS

		Absolute Tolerance	Matching Tolerance
Source Impedance	50 ohms ± 3 ohms		
Load Impedance	50 ohms ± 3 ohms		
Noise Input Level	-94 ~~-88~~ dBW		
Maximum Input Signal Level	-14 ~~-8~~ dBW		
Cross Talk (between like filters in adjacent channels)	< -50 dB		
Centre Frequency	120 MHz	±5 MHz	±0.5 MHz
Bandwidth (-3 dB)	10 MHz	±0.5 MHz	±0.5 MHz
Insertion Loss	21 dB	±3 dB	±0.25 dB
Attenuation at 110 and 130 MHz	20 dB min.	relative to pass band	
Peak Side Lobe Levels	-50 dB max.	relative to pass band	
Final Attenuation & Spurious Outputs	50 dB min.	relative to pass band	
Pass Band Shape/Ripple	Flat to within ±1.5 dB throughout pass band		
Group Delay	Absolute delay is not important		
Group Delay Matching*	Devices to be matched to ±2.5 nS of nominal delay		
Group Delay Dispersion	< ± 1nS		

* It is recognised that the group delay matching of ±2.5 nS may not be achievable within the timescales of the Demonstrator Programme, if at all. The requirements of the system dictate however that this figure remains as a design aim. It is expected that a figure of better than ±5nS will be achieved for the Demonstrator Programme.

EXHIBIT No. 3 (STD.)

ANNEX 1

ENVIRONMENTAL SPECIFICATION FOR DEMONSTRATOR HARDWARE 25.11.81

(Ambient ground temperature range has been assumed at $-0^{\circ}C$ to $+35^{\circ}C$).

Temperature in Pod:	$-35^{\circ}C$ to $+70^{\circ}C$ (min. $0^{\circ}C$ with heater)
Stress limits: (non-operational)	10 G down) 2½ G forward) concurrent 2 G lateral)
Vibration:	$.03g^2$/Herz from 20 Hz to 100 Hz $.01g^2$/Herz from 100 Hz to 2 kHz Swept sine-wave test at 2G (peak) from 10 Hz to 200 Hz
Relative humidity:	95%

76

5/11/MS.
11th Dec 1978
Quartz

ELECTRIC COMPANY LIMITED

CH CENTRE

DLESEX

EXHIBIT No. 3 (CTD.)

MATERIALS SCIENCE DIVISION

MATERIALS CHARACTERISATION DEPARTMENT

port No. 15/11/MS

th December 1978

D.A.S.

C. Dineen

Approved by:
B.J. Isherwood

Orientation Measurements on large ST-Cut α-Quartz plates for Surface Acoustic Wave Device Application

1. Introduction

A requirement has arisen for a facility to be established which will permit orientation measurements to be made on large single crystal plates of ST-cut α-quartz. The plates, which are 2.5mm thick and 15mm wide have a 7.6° bevel at each end (trapezium shaped) and a maximum length of 205mm.

These measurements are required for quality assurance purposes in connection with the manufacture of Surface Acoustic Wave Dispersive Delay Lines. The orientation specifications for these plates are as shown in the figure.

The standard procedures which would normally be employed to determine the orientation of large blocks of single crystal material cannot be applied directly in this instance because of the size and shape of the crystal plates. A modification to the basic procedure has therefore been devised to facilitate the determination of the ST-cut, whilst a new specimen-mounting jig has been designed and manufactured to permit measurement of the position of the x-axis.

This report describes the revised measurement procedures and illustrates the methods employed with results obtained on a large ST-cut α-quartz plate (Z140SK413254, Serial No. 145).

2. Equipment

The equipment used to make the orientation measurements was a Hilger and Watts Y130 quartz crystal orienter, calibrated to read to one minute of arc. The ST-cut determination was made using a standard specimen-mounting stage whilst to facilitate the determination of the angular position of the x-axis a new specimen stage was designed and manufactured. The new specimen stage supports the crystal in a horizontal position and allows the crystal to be rotated about an axis parallel to the long edge of the crystal. Measurements carried out by the Inspection and Calibration Service

/at

EXHIBIT No. 3 (CTD.)

at H.R.C. indicate that the angular errors introduced into the orientation determination by a rotation of the plate through 180° are less than 0.3' (minutes) of arc.

3. Orientation Determination

3.1 General Considerations

A number of problems exist with the manufacture and preparation of large single crystal plates. Amongst the more important, from the point of view of the orientation specification are those associated with the distortion of the plate which occurs during the manufacturing process. The effect of this distortion may be illustrated by the consideration of the two extremes which may occur in practice. These are

1. The crystal lattice is undistorted, but the reference surface and edges of the plate do not conform to the flatness specifications.

2. The surface and edge flatness specifications are satisfied, but the crystal lattice is distorted.

The nature of the distortion may vary from a simple uniform deviation of the surface from the desired orientation to a uniform curvature of the crystal lattice or reference surface and edge. The possibility that both forms of distortion may be present must also be considered. The effect of these distortions range in complexity from a simple misorientation angle, which is characteristic of the whole plate,to an angular orientation function which describes the local relationship of adjacent parts of the crystal lattice to the reference surfaces.

This latter measurement is, since it necessitates a detailed study of the entire surface of the crystal, a lengthy procedure. In the context of the present requirement is is proposed that the orientation determination be confined to measurement of the misorientation of the crystal lattice with respect to the reference surface at each end of the plate. Local variations in the orientation of the plate will not be observed, however this procedure should detect excessive curvature or twist, the most likely problems to occur in practice. It should be noted that the orientation error associated with the maximum permissible deviation from flatness specified for these plates would be of the order of 0.5' (minutes) of arc.

In view of the size of these plates and the requirements listed in item 2.1 (1) of the quality assurance specifications it is strongly recommended that an X-ray topographical or other such technique, capable of revealing twinning and other lattice defects, be used to examine these crystals.

3.2 Proposed Experimental Procedure

It will be assumed in the sections which follow that the basic orientation of the plate is correct i.e. that the sense of rotation of the cut is correct and that the angle of rotation is approximately correct. The Laue X-ray diffraction technique may be used to establish the basic orientation of the plate.

/The

The proposed procedure is illustrated in the sections which follow by a description of an orientation determination made on crystal No. Z140SM413254 Serial No. 145.

3.2.1. Determination of the ST-cut orientation

The basic calibration of the crystal orienter, equipped with the standard specimen stage was first established with the aid of a reference block of α-quartz with a known orientation. The orientation of the ST-cut in the plate was then determined using both the $01\bar{1}1$ (Bragg angle 13° 19' - CuKα and the $02\bar{2}3$ (Bragg angle 34° 4' - CuKα) reflections as described below.

1. The plate was mounted vertically with the polished surface in contact with the reference surface on the specimen stage.

2. The X-ray detector was then positioned to receive the diffracted beam and the orientation of the plate adjusted until a diffracted beam was detected.

3. The angular position of the crystal was then noted and used to calculate the orientation of the polished surface.

4. Steps 1-3 were then repeated at the other end of the rod.

The measurements made were as shown below.

End (See figure)	Orientation of Plate $01\bar{1}1$	$02\bar{2}3$	Misorientation w.r.t. the reflector $01\bar{1}1$	$02\bar{2}3$
A	8° 35'	40° 58'	+ 4° 44'	-6° 54'
B	18° 6'	27° 19	+ 4° 47'	-6° 45'

The theoretically calculated angles between the $01\bar{1}1$ and $02\bar{2}3$ planes and the ST-cut are 4° 32' and 7° 0' respectively. The $01\bar{1}1$ and $02\bar{2}3$ planes are effectively rotated Y cuts in which the angles of rotation are - 38° 13' and 49° 45' respectively. The angle of the cut at each end of the rod is therefore

End A 42° 57' $(01\bar{1}1)$ & 42° 51' $(02\bar{2}3)$

End B 43° 0' $(01\bar{1}1)$ & 43° 0' $(02\bar{2}3)$.

The accuracy of each determination is estimated to be $\pm$ 3'. The difference in the orientation of the cut at each end of the rod (mean at A 42° 54' $\pm$ 3', mean at B 43° 0' $\pm$ 3') is therefore not significant so that we may calculate on average for the four results of 42° 57' $\pm$ 3'.

3.2.2. Orientation of the x-axis

The new crystal mounting stage was fitted to the goniometer and the basic calibration again established using a block of α-quartz of known orientation. The orientation of the x-axis was then determined in the plane of the plate and at right angles to it, at both ends of the plate as indicated below.

/1

1. The crystal was mounted in the plate holder with the polished surface uppermost and horizontal.

2. The position of the detector was adjusted to receive the 1010 reflection and the orientation of the plate adjusted until a reflection was observed.

3. The crystal was then rotated in 90° steps and at each step the orientation of the crystal at which a reflection occurred noted.

4. The crystal was then remounted with the other end of the rod in a position to diffract and the measurements repeated. The results obtained are shown below.

	Position 1	Position 2	Position 3	Position 4
End A	17° 50'	18° 18.5'	18° 45'	18° 15'
End B	17° 50.5'	18° 18'	18° 44'	18° 15'

The means of the values at positions 1 & 3 and 2 & 4 give the Bragg angle for the reflection employed.

	Positions 1 & 3	Positions 2 & 4
End A	18° 17.5'	18° 16.8'
End B	18° 17.3'	18° 16.5'

Since there is no significant difference between this group of angles, we may calculate a mean value from the set as 18° 17' ± 0.2'. The theoretical value is 18° 17'.

The differences in the results obtained at positions 1 & 3 and 2 & 4 give an angle which is twice the orientation error of the x-axis with respect to the major edges of the plate. At end A the axis lies in the plane of the plate to within 2' however in the plane it makes an angle of 27.5' with the major edge. Essentially the same result is obtained at end B. The accuracy of the determination is estimated to be ± 2' of arc.

4. Summary and Conclusions

Procedures have been devised and equipment developed to facilitate orientation measurements on large single crystal, ST-cut plates of α-quartz. The procedures and equipment have been employed to determine the orientation of a typical crystal plate (No. Z140SK413254 Serial No. 145).

The orientation of the ST-cut was found to be 42° 57' ± 4' just within the specification of 42° 45' ± 15'. The x-axis was found to lie in the plane of the plate to within 2' ± 2', but to subtend an angle of 27.5' ± 2' with the long edge of the crystal. The orientation of the x-axis is therefore outside the specification of ± 15'.

/Reference

Reference

1. Substrate for S.A.W.

Marconi Drawing No. Y331298.

H.J. Cluley

Circulation:

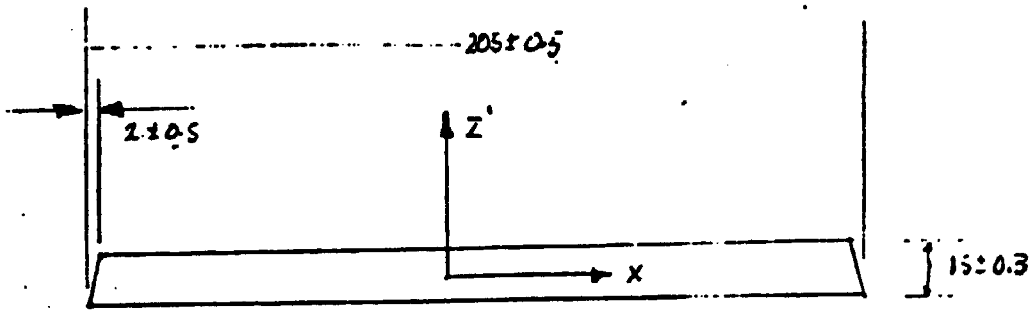
Mr. A. Prince
Dr. H.J. Cluley
Dr. B.J. Isherwood
Miss B.R. Brown
Mr. C. Dineen
Mr. B. Murray
Dr. E. Read
Quality Assurance - H.R.C.
Correspondence
Quality Assurance - Marconi
S. Radcliffe "

OC

EXHIBIT No. 3 (CTD.)

FIGURE

Orientation Requirements



thickness 2.5 ± 0.3

Orientation of the Polished Face.

ST-cut axis Y' rotated + 42° 45' ± 15' from Y
Each long edge ∥ with axis ± 15'

All dimensions in millimetres.