CERN – EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CTF3 Note 035 (Spec.)
(Broadband Klystron)

PS/PO/Note 2001-050 (Spec.)

SPECIFICATION FOR THE SUPPLY OF A 1.5 GHZ BROADBAND KLYSTRON[1] OR OTHER RF POWER SOURCE FOR THE CLIC TEST FACILITY (CTF3)

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This Technical Specification concerns the supply of a broadband klystron or other device for operating at a centre L-band frequency of 1.5 GHz. The required bandwidth (-1 dB) of at least 150 MHz and peak output power of 0.75 MW are critical parameters for this device.

Geneva, Switzerland
30th October 2001

[1] The use of the word klystron in this document is taken to include " or other device"

INTRODUCTION

1.1 Introduction to CERN

The European Organisation for Nuclear Research (CERN) is an intergovernmental organisation with 20 Member States*. It has its seat in Geneva but straddles the Swiss-French border. Its objective is to provide for collaboration among European States in the field of high-energy particle physics research and to this end it designs, constructs and runs the necessary particle accelerators and the associated experimental areas.

At present more than 5000 physicists from research institutes worldwide use the CERN installations for their experiments.

1.2 CTF3 TEST FACILITY

A new Compact Linear Collider (CLIC) test facility, CTF3, will be constructed over a period of a few years using the present infrastructure of the LIL machine. To reduce costs CTF3 differs from the RF power source proposed for CLIC in the following ways. The frequency of the drive beam accelerator is chosen to be 3 GHz instead of 937 MHz, enabling the existing 3 GHz klystron-modulators and pulse compression units to be used for power production. These klystron-modulator systems will produce a compressed RF power pulse of 1.6 μs that is just long enough after the x10 frequency multiplication to produce the nominal CLIC RF pulse of 140 ns. Frequency multiplication is obtained through using an x2 Delay line and x5 Combiner ring. Two RF transverse deflectors in the x2 Delay line will interleave bunches in the odd and even buckets to produce a bunch spacing of 10 cm. These deflectors are powered by a 1.5 GHz klystron-modulator. This method of bunch interleaving is repeated in the x5 Combiner ring at 3 GHz, resulting in a 30 GHz acceleration system. The injector linac will use a sub-harmonic bunching system that also operates at 1.5 GHz and requires a broadband klystron for this purpose. This CTF3 test facility will be used to demonstrate the technical feasibility of the 30 GHz CLIC RF power generation scheme.

2. SCOPE OF THE TENDER

The Invitation to Tender based on this Technical Specification concerns the manufacture and testing of a broadband 1.5 GHz klystron for CERN. The klystron specification together with the mechanical details shall be agreed by CERN before any construction work is started. The klystron shall then be made and tested as specified in section 5.1. A provisional acceptance test will be made after this klystron is delivered to CERN, as specified in section 5.3.

* CERN Member States are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

3. GENERAL CONDITIONS FOR TENDERING AND CONTRACTING

Please refer to the commercial bidding documents for more complete information. A questionnaire related to the following qualification criteria is to be completed by the Bidder.

3.1 Qualification Criteria

In order to be considered as a Bidder for this Invitation to Tender, the firm shall satisfy the criteria specified below.

3.1.1 *Type of Firm.*

The Bidder must have at least 10 years successful experience in the design, development, manufacture and testing of similar high-power pulsed klystrons. The Bidder shall provide a reference to a similar tube made by themselves. CERN reserves the right to visit the user of this reference tube.

3.1.2 *Quality Assurance.*

The quality assurance plan operated by the Bidder shall conform to ISO 9000 regulations or equivalent.

3.1.3 *Testing Facilities.*

The Bidder shall specify and provide the test facilities and measuring equipment to be used for this type of klystron so that the test programme measurements in section 5 can be carried out at the Contractor’s premises according to the specification. Measuring equipment shall have full calibration traceability to an approved national standard. Should the Bidder not be able to provide all test equipment this must be stated in the offer.

3.2 Responsibility for design, components and performance

The Contractor shall be responsible for the correct performance of all items supplied, irrespective of whether they have been chosen by the Contractor or suggested by CERN. CERN's approval of the design and component choice does not release the Contractor from his responsibilities in this respect.

CERN reserves the right to make minor modifications to this Technical Specification before placing the Contract. Parameters that may change slightly are clearly indicated in the Table 1 below with the letters T.B.C. (**T**o **B**e **C**onfirmed). Unless clearly stated by the Bidder in the tender document together with a justification, these minor changes shall not affect the contractual price that shall remain fixed.

4. KLYSTRON NOMINAL PARAMETERS

There is a requirement at CERN for a microwave amplifier to provide pulsed RF power for a sub-harmonic bunching system in the CTF3 accelerator test facility as described above. Recent klystron data published by many manufacturers show that the required combination of parameters is not available for existing tubes at this operating frequency of 1.5 GHz. However, klystron amplifiers do exist at other frequencies close to the desired one, namely at 1.3 GHz. Therefore it is believed that a development of an existing klystron could be made in order to fulfil the CTF3 requirements. The following table outlines the required nominal parameters of a suitable klystron amplifier.

Alternatively, CERN would consider using three lower peak power devices (TWT's etc.) having the required bandwidth that can provide between them the total 750 kW of RF power to the three sub-harmonic bunching cavities. The Bidder must provide a full technical specification of any alternative device offered including any special high-voltage power source that may be needed. In this instance criteria relating to mechanical compatibility listed below are no longer applicable.

4.1 Parameters

Parameters	**Values**	**Units**
Centre frequency	1500	MHz
Bandwidth (at -1dB)	≥ 150	MHz
Peak output power	≥ 0.75	MW
RF pulse width	≥ 2.5	μs
Repetition frequency	5 to 50	Hz
Electronic efficiency	≥25	%
Beam voltage	≤ 90	kV
Microperveance	1.9 to 2.1	$\mu A.V^{3/2}$
Large signal gain	≥ 30	dB
Ion pump voltage	3.5 (min), 5.0 (max)	kV
Window flange L-band type	WR650 (TBC)	

Table 1. Nominal klystron parameters

The proposed klystron or alternative pulsed RF power source(s) shall be capable of operating with a beam voltage of ≤ 90 kV to integrate with an existing klystron-modulator system. The klystron gun shall be capable of operating in a mineral oil environment in a vertical position. The Bidder will provide a full mechanical specification that includes a layout drawing for the klystron or alternative device offered.

Figure 1 shows, as an example, the installation of a similar type of klystron (S-band and 35 MW) in an existing high voltage tank assembly. It is envisaged that this tank assembly type will be used for the broadband klystron to optimise the use of common components in the system. The total gun length of the klystron, inside the high voltage tank, from anode contact plate to heater connector shall not be longer than 480 mm.

A peak output power of 0.75 MW for the klystron or alternative device(s) has been given in Table 1, although if a particular design is capable of a higher peak output, without compromising other parameters, then this would also be acceptable.

Focusing of the klystron beam shall be made with an electromagnet operating at low voltage (max voltage of 30 V DC) and with coil currents not exceeding 200 A DC to use existing power supply facilities.
Lead shielding needed to screen users at a distance of 0.4 m from the klystron body, from any X-rays generated at the maximum operating voltage, shall be specified to fully comply with current European health and safety regulations.

5. TESTS

5.1 Tests to be carried out at the Contractor's premises

CERN reserves the right to witness the klystron tests carried out at the Contractor's premises. The Contractor shall give at least 10 working days notice of the proposed date of any such tests. A written factory test report, to be signed by the technical persons representing the Contractor and CERN, shall be completed for the klystron showing that the specified performance has been achieved. These tests of voltage, current and RF power measurements concerning the klystron performance shall use the test protocol from section 5.4 defined by CERN and detailed by the Contractor.

5.2 Test equipment

The contractor shall provide all necessary test and measuring equipment in order to fully test the klystron to its specification. This must include a 1.5 GHz RF drive source compatible with the klystron and capable of testing over the required bandwidth. An appropriate RF load and measuring couplers must also be provided. CERN can, if needed, supply the klystron-modulator system for these tests at the Contractors premises. This would be under terms and conditions to be agreed upon between the two parties.

5.3 Tests to be carried out at CERN

Testing shall be carried out by CERN, and with the presence of the Contractor's representative, at CERN using the klystron-modulator and CERN measuring equipment. The factory test report from section 5.1, and the specification, will be used as references in order to verify the performance after transporting the klystron from the Contractor's premises. A written acceptance test report, to be signed by the technical persons representing the Contractor and CERN, shall be completed for the klystron showing that the specified performance has been achieved.

5.4 Test protocol

The following measurements shall be made and included in the klystron's written and signed test report.

a) General Measurements:

-Filament heating: Voltage, current, power, heating time.
-Focusing: Coil voltages & currents, klystron body power dissipation.

-Vacuum Ion pump:	Voltage, current.
-Water Cooling:	Input pressure, delta pressure, input temperature.
-Gas pressure:	SF6 gas pressure at output window.
-Water Flow:	Klystron body & window, collector, focal coils, RF load.

b) Operational Pulse Measurements at 50 Hz rate:

-RF Frequency	Central frequency.
-RF bandwidth	Within the –1dB limits at the four peak output power levels given below.
-Pulse width:	Output RF pulse width.
-Rise/Fall times:	RF pulse rise and fall times (10 to 90%).
-Peak power:	Peak RF output power in kW into a calibrated water load.
-Power gain:	Input to Output saturated power gain of klystron in dB's.
-Efficiency:	Electronic efficiency under saturated conditions.
-Power transfer:	Transfer curves shall be made at 150, 300, 500 and 750 kW peak output power levels.

5.5 DOCUMENTATION

The completion schedule requires that the test report containing the klystron specification and all other performance or operational information relating to the RF power source, or detailed in section 5, shall be delivered by the Contractor with the fully tested klystron.

6. ACCEPTANCE AND GUARANTEE

Provisional acceptance of the klystron will be given by CERN only after receiving the klystron's operating manual and all documentation for the focusing solenoid and accessories, and the signed test reports for the klystron undertaken at the Contractor's premises, affirming completion within specification. Final acceptance will only be completed after the klystron has been delivered and tested at CERN.

The guarantee period is defined in the commercial bidding documents.

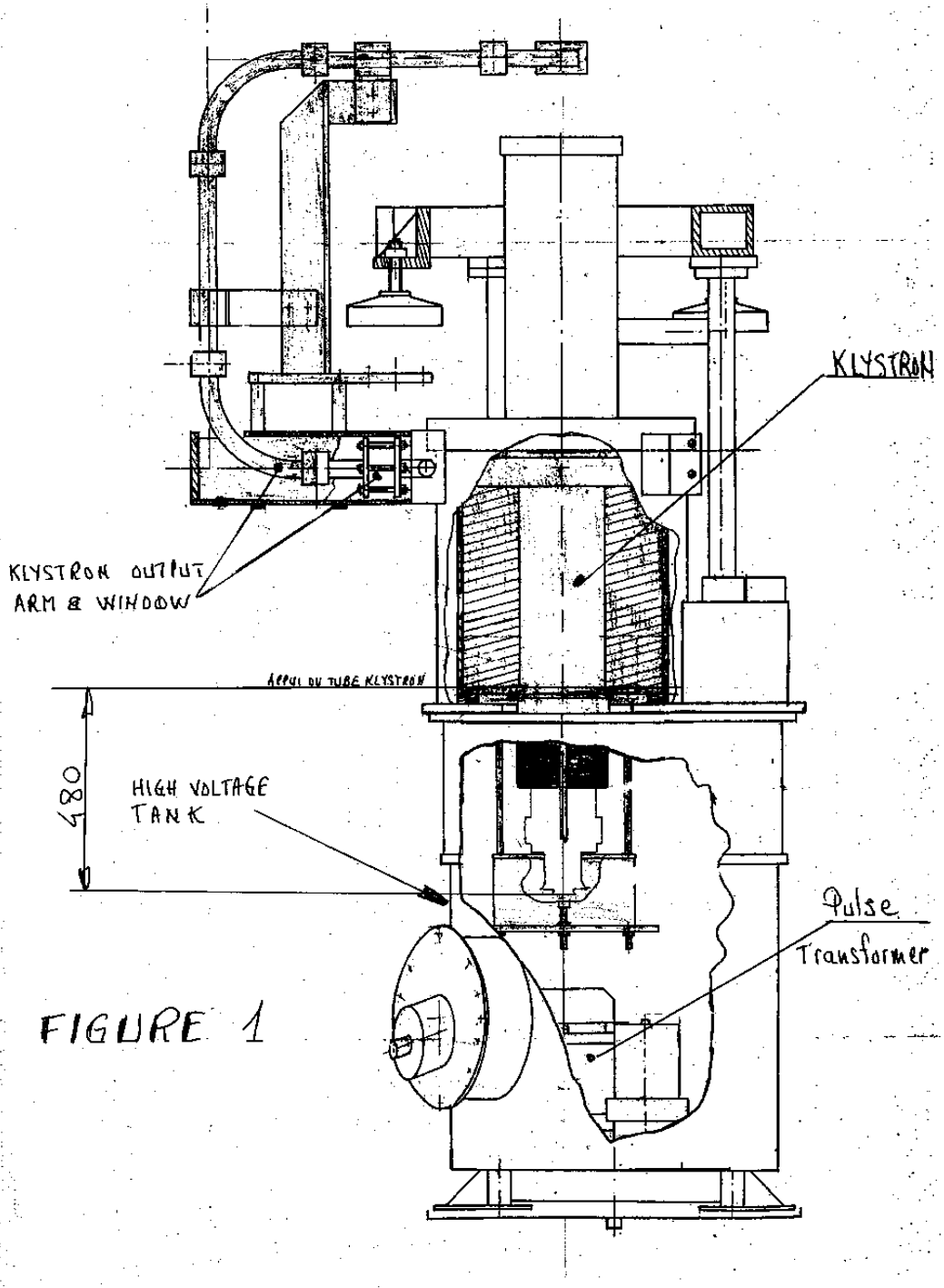
KLYSTRON
KLYSTRON OUTPUT
ARM & WINDOW
APPUI DU TUBE KLYSTRON
480
HIGH VOLTAGE
TANK
Pulse
Transformer

FIGURE 1