WS No. 19 Mark III

THE IDENTIFICATION AND USE OF CRYSTAL VALVES

NOTE: This information is provisional and is supplied for guidance pending the issue of more complete instructions. All errors of a technical nature should be notified, through the usual channels, to the War Office (M.E.10).

Introduction

1. There are now ten different approved types of crystal valve, and further types will be introduced into service in due course. They are distinguished by a system of colour coding. For any one main equipment, a particular type of crystal valve is specified for normal use. This regulation details :—

(*a*) The full implications of the colour code.
(*b*) The precise type specified for use in any particular main equipment.

2. Crystal valves are used in telecommunications to fulfil two main functions :—

(*a*) Mixing (conversion of R.F. into I.F.)
(*b*) Detecting (conversion of R.F. into D.C.)

These will be dealt with in separate paragraphs. It should also be noted that, although these devices are properly designated *crystal valves* they will, in succeeding paragraphs, be referred to for simplicity as *crystals*.

MIXER CRYSTALS

Primary distinction

3. After manufacture and appropriate mechanical tests, all crystals are subjected to a test which measures the following quantities :—

(*a*) Shunt capacity at 100 Mc/s.
(*b*) Rectified current for a specified applied A.C. voltage.

The crystals passing this test are classified into three groups :—

(i) Green-spot — high performance
(ii) Yellow-spot — medium performance
(iii) Blue-spot — relatively poor performance

4. A crystal is required, if it is to be used as a mixer, to attain a certain signal/noise performance. It is found that the blue-spot crystals will not attain this figure for the higher frequency bands for which these crystals are required ; the yellow-spot crystals will attain it for the S-band but not for the X-band ; the green spot will maintain this performance up to and including the X-band. The performance is checked by a signal/noise measurement made at the appropriate frequency before final classification. Blue-spot crystals, not at present used as mixers, are dealt with in para. 8.

Secondary distinction

5. The classification into green-, yellow- and blue-spot types having been completed, a second classification within these groups is effected on the basis of resistance to burn-out by overloading. The test is carried out by applying a specified A.C. voltage for a specified time, as a result of which three sub-groups are distinguished :—

(*a*) With additional red spot—high burn-out resistance.
(*b*) With additional orange spot—medium burn-out resistance.
(*c*) With no additional spot—low burn-out resistance.

Nomenclature

6. The above classification results in the existence of six possible types of mixer crystal, which have been allocated CV numbers as follows :—

(*a*) With yellow spot only CV101
(*b*) With yellow and orange spots .. CV102
(*c*) With yellow and red spots CV103
(*d*) With green spot only CV111
(*e*) With green and orange spots .. CV112
(*f*) With green and red spots CV113

The CV111 is always *described* as green-yellow, but is *marked* with a green spot only to avoid possible confusion with the yellow-spot range (see para. 8).

Pre-plumbed mixer crystals

7. Mixers in the majority of equipments at present in service incorporate matching controls for ensuring maximum power transference into the mixer ; in such cases the precise impedance presented by the crystal is not of importance provided it lies within certain wide limits. However, in certain new equipments no such controls are provided, the mixer being said to be pre-plumbed. In these cases it may be necessary to introduce a third selection process, this time for correct impedance. Appropriate instructions will be issued in each case and special crystals will not be demanded in the absence of such instructions. Special CV numbers have not yet been allocated to such crystals, nor has the system of marking been decided. Details will be published in due course as additions to this regulation.

DETECTOR CRYSTALS

Blue-spot crystals

8. The blue-spot series (see para. 4) are not at present required for use as mixers ; they have, however, considerable utility as detectors, their main application being as the detecting device in resonant-cavity wavemeters. The characteristics required for detection are not precisely the same as those for mixing. A further process of selection is therefore necessary, but since all blue-spot crystals undergo this process no additional marking is necessary. As before, there is a possible three-fold division into sub-classes based on resistance to burn-out, viz., blue-red, blue-orange, or blue. Of these, the first two are not at present approved for service use, but the third (low burn-out resistance) is approved, and has been allocated the number CV241. As with the corresponding member of the green-spot series, this type is described as blue-yellow, but in this case the crystal is physically marked with both blue and yellow spots. It is therefore important to note that *a crystal bearing both blue and yellow spots is not a member of the yellow-spot range, and must not be used as an S-band mixer crystal.*

Other detector crystals

9. For special applications, selection from the yellow- or green-spot ranges may be carried out to obtain high-grade crystals for use as detectors. Two such special crystals are approved :—

(*a*) CV246 .. .. selected from CV111
(*b*) CV247 .. .. selected from CV112

The system of marking such crystals is not yet decided.

CRYSTALS FOR OTHER PURPOSES

10. One other special crystal is in use. This is the CV226, distinguished by a black band. This crystal is required for specific purposes other than as mixers or detectors and is unlikely to be encountered.

~~END~~

CRYSTAL MIXERS

Measuring the quality of the crystal

11. In the equivalent schematic circuit diagram of a crystal mixer a condenser can be shown in parallel with the crystal. This condenser represents the capacity across the rectifying layer of the crystal and affects the operation of the crystal.

12. If the capacity is large, it by-passes the crystal contact at R.F. frequencies, with a consequent loss in signal strength.

13. This indicates that the examination of the characteristic of the crystal on an oscilloscope, or the examination of the ratio of front-to-back resistance, is an inadequate measure of the quality as a mixer.

14. However, measurement of the D.C. resistance is a useful field test, as nearly always a decrease in the efficiency as a mixer is accompanied by an appreciable drop in backward resistance, although there seems to be no relation between the magnitudes of the changes. The only satisfactory field test of a crystal is the measurement of the overall signal-to-noise ratio performance of the receiver by means of the appropriate R.F. signal generator, and the resistance check is of value only if the necessary measuring equipment is not available.

Crystals as noise generators

15. Crystals also generate noise, a bad crystal generating more than a good one. Manufacturing experience has shown that crystals having a backward resistance of less than 5,000ohms will, in general, be noisier in operation than those of a higher resistance.

16. Both the conversion loss and the output noise are functions of the rectified crystal current which in turn is determined by the local oscillator power injected.

17. The conversion loss improves as the crystal current increases, but the noise produced also increases. Consequently a compromise has to be used.

18. The minimum receiver noise figure varies from crystal to crystal but is usually found in the region from 0.3mA to 0.7mA of rectified current.

Resistance measurement

19. It should be emphasized that crystal instability characterized by a fall in backward resistance is usually due to come fault developing in the associated circuits which should be investigated before a new crystal is inserted. Crystals should not be repeatedly changed if the equipment performance deteriorates, until all other possible reasons for deterioration have been eliminated.

20. Reasonable figures for the rejection of a crystal are a backward resistance of less than 2,000ohms or a forward resistance of greater than 270ohms, as measured on the 100,000ohms range of an Avometer, model 7. In connection with this test, it is important that the condition of the Avometer battery be checked immediately before the test is carried out, otherwise entirely misleading readings will be obtained.

21. The values of crystal resistance will depend on the magnitude of the voltage applied by the measuring instrument, and will vary according to the instrument and range used. The 100,000ohms range of the Avometer, model 7 limits the forward

crystal current when testing to about 2mA, which is not sufficient to injure the crystal. Use of a lower range or some other meter often has the effect of making the overall noise factor worse by several db. and may give a misleading result.

Handling of crystals

22. Crystals may be damaged in various ways, of which the following are the most common:-

(a) By static charge accumulated either by the person handling the crystal or by the crystal holder in the equipment.
(b) By exposure to an R.F. field while being carried from place to place, or while in workshops.
(c) By mechanical shock.
(d) By exposure to large R.F. currents while in the equipment.

NOTES: (i) When working in R.F. fields, the body acts as an aerial, also in dry weather the body becomes charged with respect to earth. Hence, if in either case the crystal is allowed to complete the circuit to earth, a current will flow through it large enough to damage it.

(ii) Crystals must at all times be treated in the same manner as delicate valves, and rough handling or usage is to be avoided.

23. The following precautions should, therefore, be taken:-

(a) When inserting crystals into equipments, hold the crystal between the thumb and first finger of the right hand. Allow the remaining fingers of the hand to make direct contact with the crystal holder or mixer framework before inserting the crystal.
(b) Spare crystals should always be kept in a metal box padded with cotton wool. When it is necessary for the crystal to be carried about, it should be either in its original metal container or wrapped in metallic foil. At no time should a crystal be left without adequate screening. Crystals are now being issued in sealed lead containers. They should not be removed until actually required for service.

END

The word END will be deleted from page 1