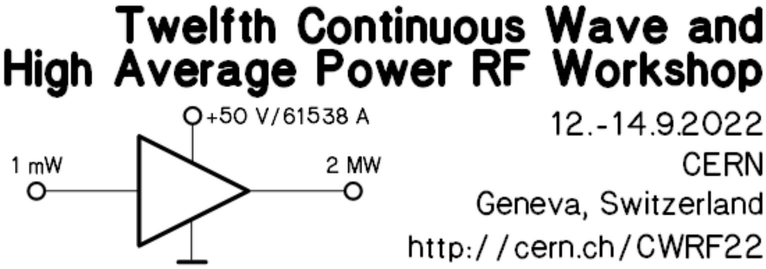

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Type: **Oral presentation 25' + 5'**

Overview of high power ferrite devices and key considerations for the design, operation and high-power testing of ferrite circulators

Tuesday 13 September 2022 11:40 (35 minutes)

With a heritage of more than 50 years AFT is a leading designer and manufacturer of high-performance ferrite-based microwave components and subsystems. The high-power product range includes microwave ferrites, circulators, isolators, loads, fast ferrite tuners and power variators for scientific particle accelerators, medical and industrial LINACs as well as for radar systems.

Isolators provide key contributions in high-power RF systems such as reliable protection and stable operation of RF tubes and SSPAs, improvement of the life time of tubes, high efficiency by low insertion loss, continuous and failure-free system operation, high system availability and long system operating life.

This workshop contribution introduces basic design aspects for circulators operated under high peak and cw power. It specifies important power handling requirements regarding capabilities to cope with the max. possible power dissipation (heating) as well as to withstand electrical break down under worst case conditions. Key topics are low insertion loss by careful selection of ferrite materials and proper setting of the magnetic bias for the ferrite, sophisticated thermal management by cooling, thermal drift compensation (TCU) and an elaborated design of the ferrite section with regard to electrical breakdown.

The considerations of circulator power capability cover worst case conditions as given by operation into a 100% reflective load at the circulator output, including all phase conditions. In a high-power test these conditions are usually represented by a sliding short circuit or multiple discrete short circuits of different electrical offset length, forming a moveable standing wave between the short circuit and the circulator. Focus is on two critical phase conditions of the standing wave: (1) Max. magnetic field strength (min. electrical field) in the circulator: criterion for max. power dissipation and heating in the circulator. (2) Max. electrical field strength (min. magnetic field) in the circulator: criterion for high peak power capability. Based on calculations of the standing wave pattern, a method is presented for finding a minimum number of phase positions or offset lengths, in order to adequately cover the above critical phases in a high power test.

The presentation provides technical comments on the expression "isolation"and introduces basic calculations for the effective port 1 input return loss of a circulator, operated into a short circuit at port 2 and terminated with a dummy load at port 3, by taking into account all possible signal contributions.

Attention is also dedicated to the requirements on directional couplers and harmonic filters to accurately measure forward and reverse power. An analysis investigates the coupler directivity and its sensitive impact on reverse power measurements.

The presentation discusses an essential high-power test set-up, test equipment, measurement categories (such as forward and reverse power, return loss, insertion loss, calorimetric power loss, body temperature…), test procedures, high-power circulator-TCU calibration, arc protection, safety interlocks and common safety rules for hot testing.

High-power test results for recent state-of-the-art circulators illustrate the above topics and complete the workshop contribution.

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