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An L-S Band Front End Upgrade for the Compact Array and Mopra

Introduction

The following note draws together into one project, the various tasks that need to be performed on the compact array L-S front ends to eliminate beam shape problems at 13 cm band and improve the front end performance generally.

The specific tasks that mainly need to be addressed are:

(i) Replace the quad-ridged fin in the wideband 20-13cm OMT to rectify a beam shape problem at frequencies above 2.0 GHz.

(ii) Upgrade the current MESFET transistor amplifiers to HEMT units to improve the system temperature at both 20 and 13 cm bands.

Scope of the Work

(1) Quad-ridged fin replacement

This task is necessary to correct a problem of beam asymmetry at 2.3 GHz, traced to the fact that the constant cut-off (CCO) fins installed in the wideband OMT excite excessive amounts of TM_{11} in the smooth wall output waveguide of the OMT. (See ATNF files note 39.3/053 by B.M. Thomas, and RPP3794 by Cristophe Granet). This will necessitate removal of the OMT from the front end, removing the CCO quad-ridge fins and replacing them with "sin-squared" (SSQ) profile fins, or a profile which is a compromise between the CCO and SSQ profiles. (See ATNF 39.3/053, figure B1). The choice of which profile is finally used will depend on which one gives the best input VSWR and the lowest cut-off frequency with minimum TM_{11} generation.

There are two other modifications to the OMT which should be performed at the same time. These are:

(i) Modify the input coaxial line between the N type input connector and the fin gap, to incorporate a tapered inner and outer where this line changes dimensions, and also to restore this line to 50Ω characteristic impedance.

(ii) Incorporate a bifurcated backshort to terminate the quad-ridged structure at the probe end. The OMT's on the compact array currently utilise a single conical backshort placed at a compromise position to match the orthogonal probe outputs. More recent work has evolved a design which terminates each probe optimally and hence improves the overall return loss for each probe.

Once these modifications have been made to a pair of OMT's, after final VSWR tests, a careful measurement of insertion loss should be made to ensure that this is ≤0.18 db.

(2) MESFET to HEMT Amplifier Upgrade

As the OMT upgrade will necessitate a major disassembly of the front end, it would be a useful time to modify the 20 and 13 cm amplifiers up to HEMT standard. This would involve removing the first input MESFET transistor and replacing with a HEMT. The transistor most likely to be successful in this exchange will be the Fujitsu FHX13LG. The retrofitted amplifiers would then need to be tested and measured before reinstallation in the front end.

The amplifier noise temperature should thus be reduced from ~ 8 Kelvin down to ~ 3 Kelvin, giving an overall 5 Kelvin improvement in system temperature (~ 16.5%). This has been verified in practice on the Mopra L-S system (retrofitted with HEMTS for SETI) which runs a Tsys of ~ 26 Kelvin at L Band. This compares to an average Tsys of 31K at Narrabri.

Estimates of Design Machining and Retrofitting Time

(i) OMT Upgrade

Some design time is necessary here to finalise the fin profile and to make the appropriate drawings and DXF file for fin machining.

Rather than make completely new fin sets for each OMT, a more time effective method would be to modify the CCO fin shapes to a SSQ profile (or intermediate form if required) thus reducing machining times considerably. This requires checking to make sure the new fin profile can be accommodated within the old CCO profile.

Machining would then be required for the new backshort and input coaxial line.

Time estimates for these tasks in man weeks are:

Fin, design, drafting and DXF file	1 week
Backshort machining/unit	2 weeks
Coaxial line manufacture/unit	1 week
Modification to fin profile (CCO → SSQ)/unit	1 week

This would thus require machining effort of (4 x 8) = 32 man weeks for 8 20-13 cm front ends, with drafting time included this gives us 33 man weeks.

(ii) HEMT LNA Upgrade

Manpower estimates for this task would be 2 man weeks per set of LNA's, i.e. 2 x 20 cm and 2 x 13 cm. This would involve retrofitting an appropriate HEMT transistor to the input stage, cryogenic testing, and final assembly into the front end. The front end would then need to be tested before installation on the array.

Thus:

HEMT retrofit to 4 LNA's	0.5 man weeks
Cryo testing of 4 LNA's	0.5 man weeks
Assembly into front end	0.5 man weeks
Front end cryo testing	0.5 man weeks
TOTAL	2.0 man weeks/front end

Total time estimate for 8 front ends thus is:

Total = 8 x 2 = 16 man weeks

Costs

(i) OMT Upgrade

Material costs (alum. rod)	=	$500
N Type connectors (20x)	=	$200
Incidentals	=	$200

(ii) HEMT LNA Upgrade

HEMT transistors (50 off)	=	$3000
Consumables	=	$200
Total		$4100

M.W. Sinclair
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