Distribution Amplifiers for Hydrogen Maser Frequency Standard

G. Lutes
Communications System Research Section

Distribution amplifiers have been developed for the hydrogen maser frequency standard. These amplifiers are optimized for low phase noise, high isolation between outputs, and low phase drift with temperature in order to minimize degradation of the signals.

Distribution amplifiers have been developed to distribute the various frequencies provided by the hydrogen maser frequency standard. These amplifiers are optimized for low phase noise, high isolation between outputs, and low phase drift with temperature. Optimization of these parameters minimizes degradation of the hydrogen maser frequency standard output. When one output is shorted, unloaded, or has a signal inadvertently applied to it, the effect on other outputs is minimal due to the high isolation between outputs.

The circuit consists of a four-way hybrid power splitter and four isolation amplifiers on a single printed circuit board plus the required power supply decoupling that is contained within cavities in the chassis (Fig. 1).

The four-way hybrid power splitter has > 30 dB isolation between outputs when driven from a 50-Ω source. This isolation contributes to the isolation between outputs of the distribution amplifier. Each of the four outputs from the power splitter drives one of the four isolation amplifiers.

The isolation amplifier is a two-stage unity gain amplifier consisting of a common emitter stage with collector to base feedback driving a complementary emitter follower. A complementary emitter follower is used because it is more efficient than a one-transistor emitter follower and has lower output impedance. The complementary emitter follower in itself has high inherent negative feedback, and at the same time provides a high-impedance load for the first stage, increasing its open loop voltage gain, thereby increasing the negative feedback in the first stage.

The large amount of negative feedback minimizes phase noise (which is an inverse function of negative feedback), reduces phase drift with temperature, lowers harmonic distortion, stabilizes the input and output impedance, and broadbands the amplifier.

Build-out resistors at the input and output of each amplifier provide the required impedance and low voltage standing wave ratio (VSWR).

Output-to-input isolation is maximized by this circuit configuration. A common emitter stage has the best voltage isolation and an emitter follower stage has the best current isolation. By combining a common emitter stage with an emitter follower stage, best output-to-input isolation is obtained for a two-stage amplifier.

The chassis which conforms to the standard DSN configuration contains an inner cover with cavities that match cavities in the chassis. The printed circuit board is sandwiched between the chassis and inner cover. Each amplifier section on the printed circuit board is enclosed within one pair of cavities in the chassis and inner cover. This minimizes RF leakage between isolation amplifiers.

The opposite side of the chassis contains four separate and isolated power supply decoupling lines. The power is supplied to each amplifier through a separate set of chassis channels that contain three series RFI filters. This decoupling provides > 120 dB of isolation from one power supply line to any other.

Typical test results for the 1- to 30-MHz distribution amplifiers are shown in Table 1.

A 100-MHz version of this distribution amplifier was also developed. It is basically the same as the 1- to 30-MHz version, except the first stage is a complementary common emitter stage and faster transistors are used throughout. This version is optimized for use at 100 MHz. It has capacitors in the input and output circuits to cancel the inductive reactance.

Output to output isolation in this version is typically greater than 70 dB.

Table 1. Test results for the 1- to 30-MHz distribution amplifiers

Parameter	Result
Input impedance (50 Ω nominal)	< 1.1:1 VSWR from 1 to 30 MHz
Output impedance (50 Ω nominal)	< 1.2:1 VSWR from 1 to 30 MHz
Total harmonic distortion	< 5% at +13 dBm output power
Gain flatness	±0.5 dB from 1 to 30 MHz
Drive level for full output (+13 dBm)	+19 dBm ≈ 80 mW
Isolation, output to output	> 100 dB between any two outputs from 1 to 30 MHz
Phase noise	< −140 dB below a 5-MHz carrier in a 1-Hz bandwidth 5 Hz from the carrier
Phase drift with temperature	≈ 9 m deg/°C at 5 MHz
Power supply requirements	−15 V at 134 mA

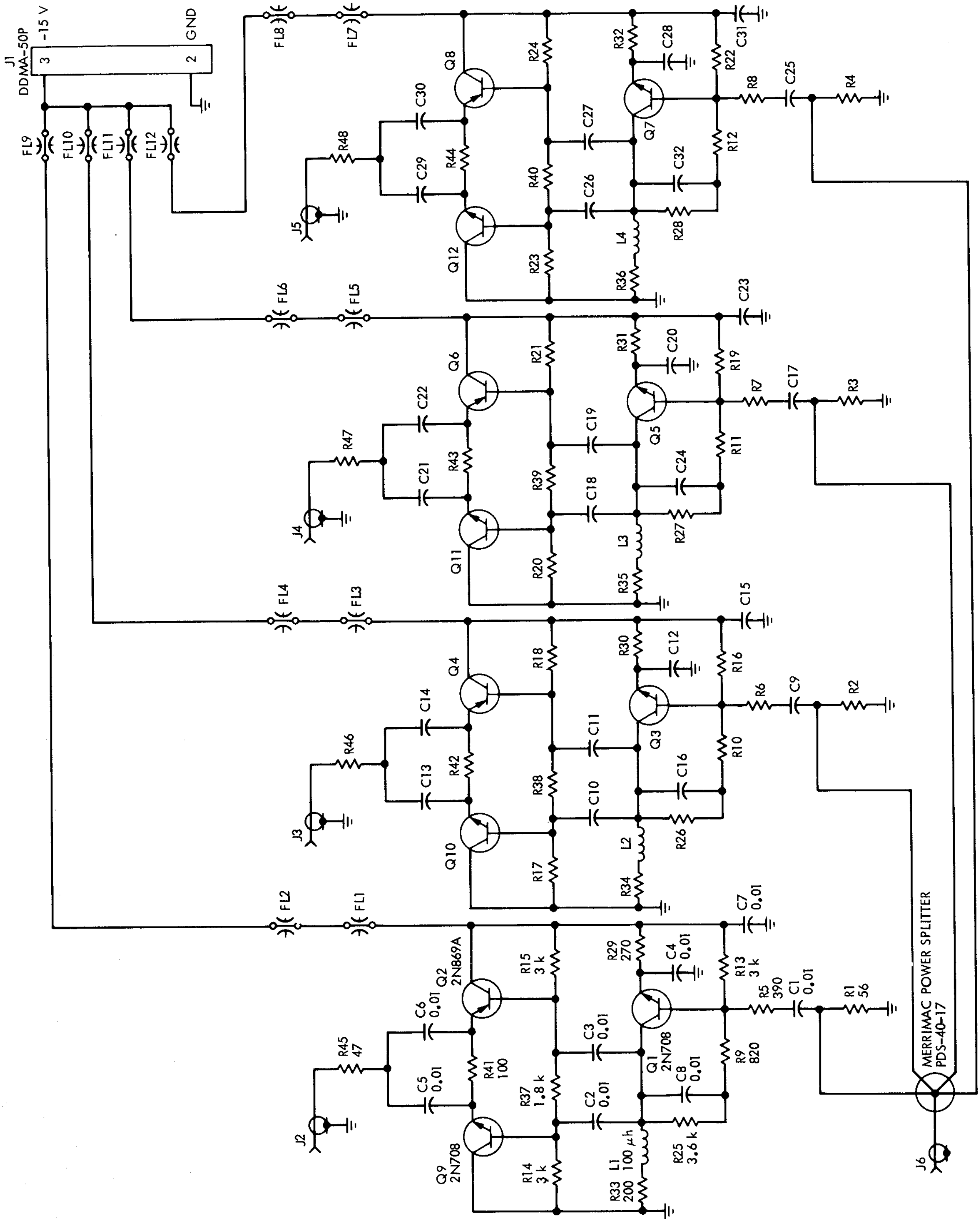

Fig. 1. Schematic, 1- to 30-MHz distribution amplifier