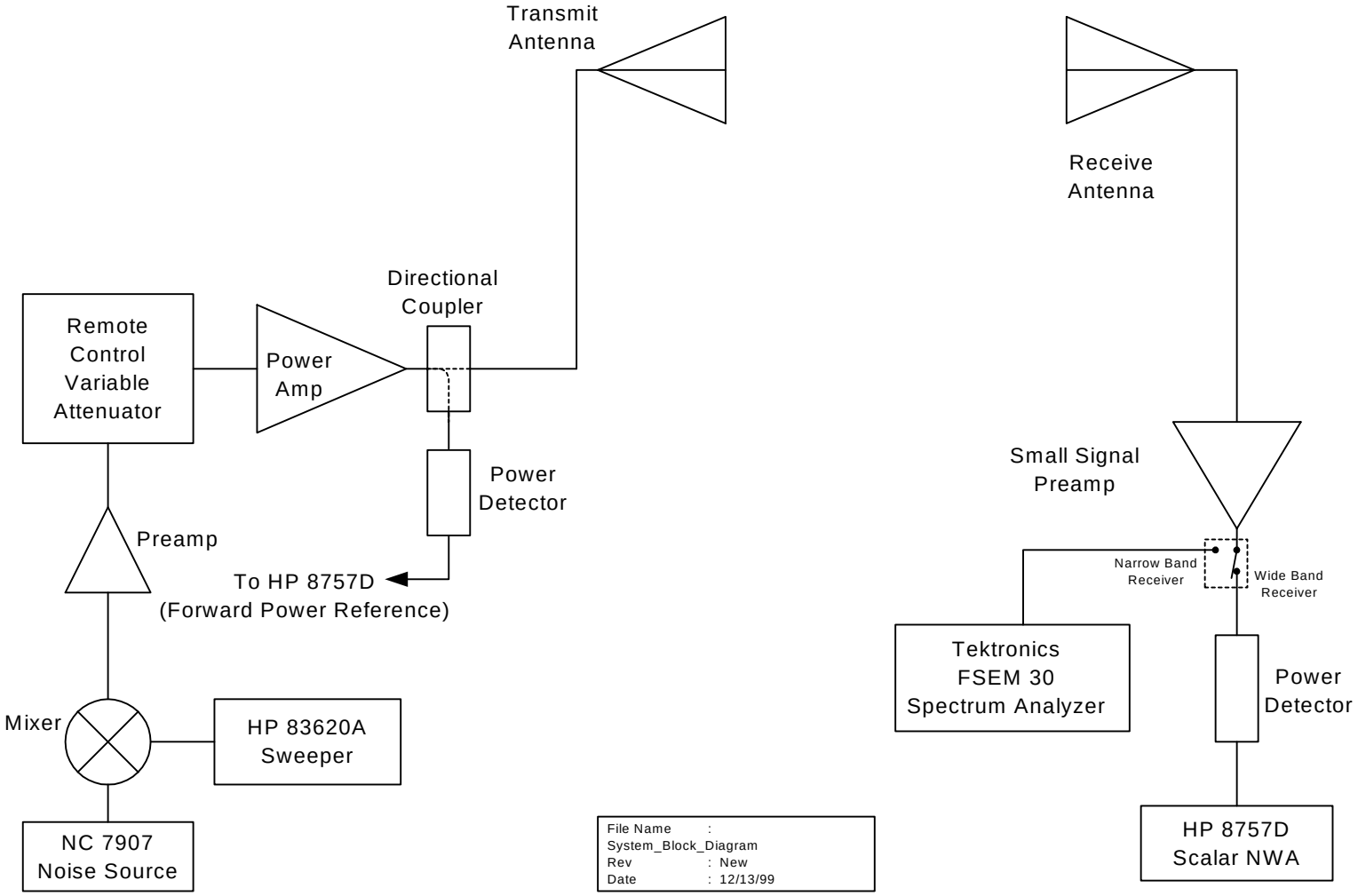

System Block Diagram

Transmit Instrumentation

NoiseCom Noise Generator

The NoiseCom UFX 7907 is a programmable, broadband white noise generator. The UFX 7000 series instruments contain an amplified noise source that is tuned to provide the best flatness at the instrument output. The amplifier is optimized to deliver an unsaturated output level of +30 dBm over the full bandwidth (250 kHz to 100 MHz) with a Gaussian amplitude distribution (see Tables 3-1 and 3-2). The power spectral density of white noise is constant over frequency; therefore, noise power is proportional to bandwidth. The noise output power level can be attenuated from 0 to 127 dB in 1 dB steps. A block diagram and photo of the noise generator is shown in Figures 3-12 and 3-13. Note that the signal input attenuator and combiner are options that were not purchased.

The output level in dBm for various noise bandwidths can be calculated as follows:

$$NoiseGeneratorOutput = 30dBm - 10 * \log_{10} \frac{100MHz}{NoiseBandwidth(MHz)}$$

For example, when the full bandwidth (100 MHz) of the output signal is reduced to 25 MHz, the noise generator output level is reduced from +30 dBm to +24 dBm (factor of four reduction in power). Since we want the output level of the noise generator to match the ideal input level for the IF port on the mixer (+4 dBm), we add 20 dB of noise attenuation (NA).

The output state is controlled by an RF switch. In the standby state, the noise is terminated into an RF load and in the on-state it is directed to the output connector.

The generator incorporates a switched, low pass filter bank with filter corner frequencies of 1, 2, 5, 10. and 25MHz (see Table 3-3).

There is a connector on the front panel for an optional signal-plus-noise combiner: this option was not required or ordered.

NoiseCom UFX 7907 General Specifications

Output	
Attenuator	0-127 dB in 1 dB steps
Attenuator switching time	5 ms typical
Delay time resolution	0.1s
Impedance	50 ohms
Typical VSWR	1.5:1
Output Connector	SMA Female

NoiseCom UFX 7907 Low Pass Filters

Filter Number	Low Pass Filter Bandwidth	Noise Bandwidth
1	No filter – through line	100^{+} MHz
2	No filter	Terminates output in 50Ω
3	1 MHz	2 MHz
4	2 MHz	4 MHz
5	5 MHz	10 MHz
6	10 MHz	20 MHz
7	25 MHz	50 MHz

HP 83620A RF Source

The HP83620A performance synthesized signal generator (10 MHz to 20 GHz) used for all measurements (CW and noise). It features excellent frequency resolution, level control, signal purity, and modulation capabilities. The modulation capability is not discussed below because it is not used during testing.

The specifications of interest are as follows:

RF Output:	+13 dBm to –20 dBm, resolution = 0.02 dB.
Frequency Resolution:	1 Hz (purchased option 008)
Time Base:	Internal 10 MHz time base. Aging rate: less than $5x10^{-10}$/day, $1x10^{-7}$/year after 30-day warm-up.
RF Output Connector:	3.5 mm
Spectral Purity:	
Harmonics and Subharmonics	< -50 dBc
Non-harmonically related Spurious:	< -60 dBc

Mixers

An RF mixer is used to modulate a CW signal (LO port) with the band limited, white Gaussian noise (IF port) to produce the desired noise signal (RF port). The mixers are used in an up-converter application providing double sideband, suppressed carrier modulation. **Two double balanced mixers are used to cover the test bandwidth: Mini-Circuits ZFM2000 from 100 MHz to 1 GHz, and M/A COM DM1-18A from 1 to 18 GHz.**

The mixers are driven with an LO drive level of +7 dBm, and an IF drive level of +4 dBm. These optimum values were determined by considering mixer specifications and empirically determining the settings which gave the desired carrier suppression, flattest response, and sharpest skirts.

Mini Circuits ZFM 2000 Double Balanced Mixer

RF Frequency Range:	100 MHz – 2 GHz
L-R Isolation:	20 dB min, 37 dB typical
L-I Isolation:	20 dB min, 30 dB typical
3 dB IF Bandwidth:	dc - 0.6 GHz
LO:	+7 dBm
RF:	Up to +1 dBm
Conversion Loss:	7.5 dB typical, 9.5 dB max
Maximum RF Power:	+17 dBm max (50 mW)
Operating Temperature	-55° C to 100° C

M/A-COM DM1-18A Double Balanced Mixer

RF Frequency Range:	1.0 – 18.0 GHz
L-R Isolation:	22 dB
L-I Isolation:	18 dB
3 dB IF Bandwidth:	dc - 0.5 GHz
LO Range:	+7 dBm min / +11 dBm max
Conversion Loss:	6.0 dB typical, 9.5 dB max
IF Input 1 dB Compression Point:	+3 dBm
Noise Figure SSB:	10 dB max
Operating Temperature	-55° C to 85° C

HP 8449B Preamp

The HP8449B preamp is used in conjunction with two programmable attenuators to drive the inputs to the power amplifiers at the optimal drive levels. The HP8449B is a high gain, low noise preamplifier which operates over the frequency range of 1 to 26.5 GHz. The specifications for the preamp are shown in Table 3-4.

HP 8449B Preamplifier Specifications

Preamp Specifications	HP 8449B Preamplifier
Frequency Range:	1.0 to 26.5 GHz
Gain:	>= 26 dB
Gain Flatness across full frequency range:	+/- 4.5 dB (worst case)
Noise Figure:	<=12.5 dB (worst case)
Output Power for 1 dB gain compression	<=+7 dBm
Harmonic distortion	-30 dB for 0 dBm output
VSWR: Input and Output	2:0:1 max
Reverse Isolation:	>75 dB

HP 8494H and 8495H Programmable Attenuators

Two programmable, coaxial step attenuators are used to adjust the input level to the power amplifier(s). The HP 8494H is a four section attenuator, with a minimum selectable step of 1 dB and a maximum attenuation of 11 dB. The HP 8495H is a three section attenuator, with a minimum selectable step of 10 dB and a maximum attenuation of 110 dB. The specifications for the attenuators are shown in Table 3-5.

HP 8494H and 8495H Programmable Attenuator Specifications

Frequency Range (GHz)	**DC - 8**	**8 – 12.4**	**12.4 - 18**
HP 8494H VSWR (Max)	1.5	1.6	1.9
HP 8495H VSWR (Max)	1.35	1.5	1.7
HP 8495H Maximum Residual Attenuation : 0.6 dB + 0.09 dB/GHz			
HP 8495H Maximum Residual Attenuation : 0.4 dB + 0.7 dB/GHz			
Typical Attenuation Repeatability: 0.03 dB, Typical after 1 million steps			
Electrical **RF Power Handling Capability:** All Modes: 1 watt average, 100 watts peak with maximum pulse width of 10 mS **Solenoid Drive:** 20 to 30 Vdc with approximately 110 mA at 24 Vdc.			

3.2.6 Power Amplifiers

A total of five power amplifiers are used to cover the frequency spectrum and power requirements for the radiated test transmitted power:

Amplifier	Frequency Band	Output Power	Gain
Kalmus 520	30 MHz – 400 MHz	20 W	42 dB
Kalmus 720	400 MHz – 1 GHz	25 W	40 dB
Logimetrics PA345/LS	1 – 4 GHz	50 W	54 dB
Hughes 8920H02	4 – 8 GHz	20 W	39 dB

The Kalmus 520FC, Kalmus 720FC and the LogiMetrics PA351/LS are Class AB linear amplifiers. The Hughes 8920H02 is a TWT based mcrowave amplifier.

3.2.7 Directional Couplers

Four directional couplers are required to cover the frequency range and power requirements:

- MCL HC-12-30
- HP 778D

Model	Frequency Range	Coupling	Isolation	Insertion Loss	VSWR (Max)	Power (CW)
MCL	1-11 GHz	30 dB+/-1.5 dB	15 dB	0.2 dB	1.3:1	600W
HP	0.1-2 GHz	20 dB+/-1.5 dB	Not specified	Not specified	1.1:1	50W

Transmit Antennas

200 MHz – 1 GHz

A log periodic EMCO 3146 antenna is used for this frequency range

Specifications	**EMCO 3146**
Frequency Range	200 MHz to 1 GHz
Power Input (max CW)	1kW
VSWR (average)	<1.5:1
Max Gain	6.5 dBi @ 990 MHz
Beamwidth	~87° @ 500 MHz
Height	6.4 cm
Width	33.7 cm
Length	73.7 cm
Weight	4.5 pounds

200 MHz – 18 GHz

A double ridged waveguide EMCO 3115 horn is used for this frequency range: This broadband antennas offer excellent gain, pattern, and VSWR characteristics over it's operating frequency range. Considering the horn dimensions and the "$2d^2/\lambda$" rule-of-thumb, the furthest boundary between the near and far field is six or seven meters away from the aperture of the horn.

Specifications	**EMCO 3115**
Frequency Range	1 to 18 GHz
Power Input (max CW)	300 W
VSWR (average)	<1.5:1
Max Gain (1-18 GHz)	16.5 dBi @ 15.5 GHz
Max Gain (1-6 GHz)	11.2 dBi @ 6.0 GHz
Beamwidth	~30° horizontal ~50° vertical
Aperture Height	15.9 cm
Aperture Width	24.4 cm
Depth	27.9 cm
Weight	4 pounds

Transmission Lines

The following types of coax and waveguide are used in the test system:

UT 141 Semi-rigid Coax
RG 142 Double Shielded Coax
RG 214 Double Shielded Coax
LDF1-50 Heliax
HST1-50 Heliax
FSJ1-50 Heliax (no longer used)

RG214 and RG142 are used for lower frequency testing (<1 GHz), where there loss is acceptable and the convenience of a flexible cable is desired. UT141 semi-rigid coax is used for internal rack plumbing of (mostly) high frequency runs. The specifications for these three cable types are shown in Table 3-11. Above 1 GHz, all of the cable used is either semi-rigid or heliax.

Heliax cable is in most respects superior to braided cable for high frequency applications. The solid copper corrugated outer conductor results in low loss, high power handling, and improved EMI shielding. We have experience with three types of 1/4" Andrews heliax:

- FSJ1-50A Superflexible Foam Dielectric
- LDF 1-50 Foam Dielectric
- HST1-50 Superflexible Star Dielectric

Comparison of Coaxial Cable Specifications

	RG214	RG142	UT 141
ELECTRICAL			
Max Frequency	11 GHz	8 GHz	34 GHz
Velocity, %	66 %	69.5 %	70% (PTFE)
Max attenuation @ 400 MHz (dB/100'):	5.5 dB	9.0	6.5 dB
C (pF/m)	101	96.5	95.1
L (μH/m)	0.201	0.245	0.238
Attenuation Constants*	k1=0.161 k2=0.00126	k1=0.368 k2=0.0012	N/A
MECHANICAL			
Diameter over jacket (mm)	10.8	5.0 mm	3.6 mm

*The 'typical' or 'nominal' attenuation may be estimated using the following equation:

$$Attenuation(dB/100') = k1x\sqrt{F(MHz)} + k2xF(MHz)$$

Comparison of Heliax Cable Specifications

	HST1-50	LDF1-50	FSJ1-50
ELECTRICAL			
Max Frequency	18 GHz	15.8 GHz	20.4 GHz
Velocity, %	82 %	86 %	84 %
DC Resistance (ohms/1000m)			
Inner	6.71	5.15	9.8
Outer	6.5	3.33	6.5
C (pF/m)	82.4	76.8	79.4
L (μH/m)	0.201	0.19	0.20
MECHANICAL			
Diameter over jacket (mm)	7.4	8.8 mm	7.4 mm
Min Bend Radius	25 mm	76 mm	25 mm
# of bends, min(typ)	15 (20)	15 (30)	15 (20)

RF Switches

Eight RF switches are used to route various RF connections. The switch numbers are labeled on the RF Switching schematic.

Switches #1 and #2: Narda Microwave SEM133 Switch

A DC – 18 GHz single-pole, three-throw, normally open RF coaxial switch (see Table 3-13).

Actuation Data:

- Voltage: 28 VDC
- Switching time: 15 ms (typical)
- Actuating Current: 140 mA (Max) @ 28 VDC & 25^{o} C.

Switches #3, #4, and #5: Loral 023-A2-D2D-3C0 Switch

A DC – 12.4 GHz single pole, double throw, "break before make" RF coaxial switch (see Table 3-14). Operating Mode: Failsafe.

Actuation Data:

- Voltage: 28 VDC
- Switching time: 15 mS (Max)

- Actuating Current: 200 mA (Max) @ 28 VDC & 72^{o} F.
-

Switches #6, #7, and #8: Loral 062-DA2-A2D-5C1 Switch

A DC – 18 GHz single pole, six throw, "break before make" RF coaxial switch (see Table 3-15). Operating mode: Normally Open/Failsafe to Position1.

Actuation Data :

- Voltage : 28 VDC
- Switching time : 15 mS (Max)
- Actuating Current : 350 mA (Max) @ 28 VDC & 75^{o} F.

Narda Microwave SEM133 Switch

Actuating Current mA @ 28 Vdc & 25^{o} C	Frequency Range DC – 18 GHz	Insertion Loss dB (Max)	VSWR (Max)	Isolation dB (Min)
140	DC – 3	0.2	1.2:1	80
140	3 – 8	0.3	1.3:1	70
140	8 – 12.4	0.4	1.4:1	60
140	12.4 - 18	0.5	1.5:1	60

Loral 023-A2-D2D-3C0 Switch

Frequency Range (GHz)	**DC - 3**	**3 - 8**	**8 – 12.4**
VSWR (Max)	1.2:1	1.3:1	1.4:1
Insertion Loss (Max dB)	0.2	0.3	0.4
Isolation (Min dB)	80	70	60
Impedance : 50 Ohms Nominal			
Operating Ambient: -55°C to +85°C			

Loral 062-DA2-A2D-5C1 Switch

Frequency Range (GHz)	**DC - 3**	**3 - 8**	**8 – 12.4**	**12.4 - 18**	**18 – 18.5**
VSWR (Max)	1.2:1	1.3:1	1.4:1	1.5:1	1.5:1
Insertion Loss (Max dB)	0.2	0.3	0.4	0.5	0.55
Isolation (Min dB)	80	70	60	60	55
Impedance : 50 Ohms Normal					
Operating Ambient: -55°C to +85°C					

Attenuators and Loads

One medium power attenuator and one high power load are used instead of a transmitting antenna for closed loop system testing, amplifier testing, etc. A 50 W attenuator (Narda 776B, see Table 3-16) is available for use up to 4 GHz, and a 500 W termination (Narda 368BNF, see Table 3-17) is used above 4 GHz, where the amplifier power increases to 200W.