Designing Vacuum Tube Amplifier Negative Feedback Circuitry

Objective: Design a hi-fi amplifier that provides roughly 12 Watts RMS, using EL84 power vacuum tubes in Push-Pull output

- EL84 datasheet specifies that plate and screen voltage can be set to 300V and max plate power dissipation is 12 Watts.
- When plate E is 300V an output transformer for push-pull operation, with reactive load of 8K Ω provides each vacuum tube with a load of 4K Ω when operating in Class A.
- By setting the plate bias current to 28mA, we obtain the load line depicted by the red line









Ken Seymour, KA7OSM 3dB Communications, LLC Western Oregon Radio Club (WORC) Oregon Amateur Radio Club (OARC) January 18, 2025



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Metro LPFM's Owned by Ham Radio Clubs





Club ¹	Western Oregon Radio Club	Oregon Amateur Radio Club		
Frequency MHz	95.1 Portland Eastside	100.7 Tigard/L.O./Sherwood		
		96.7 Beaverton to Forest Grove ²		
Club Status	Active VHF/UHF Repeater System w/ many members	FM operation only promotes ham radio with news		
Club Website	WORC.INFO	N/A		
Station Website	Goodguyradio.com	KQRZ.ORG		
Station ERP	2 watts	100.7 = 100 watts; 96.7 = 4 watts		
On-Air Date	May 1, 2015	July 22, 2012		

¹ Each club has separate ownership and board members

² 96.7 KICN-LP is owned by Vector Communications w/ Simulcast Agreement with OARC

What is LPFM?

- Original concept is analogous to the Cellular Telephone service
 - Multiple stations in a community can squeeze-in and reuse radio channels
- "Frequency Reuse" concept, A station could operate on 95.1 MHz in Hillsboro and also on 95.1 MHz in East Portland without causing interference to each others service area...due to restricted power
- The FCC L100 LPFM class is where Tx power limited to 100 watts ERP
 - This is when the Tx antenna HAAT ≤ 30 meters (~ 100 feet)
- FCC allows on paper, the 1 millivolt per meter (mV/m) contour (60 dBu contour) to be 5.6 km (3.5 miles)

FCC Contours of KISN Sister Station KQRZ (KICN) @ 96.7 MHz



HAAT - Height Above Average Terrain

- HAAT is determined by taking 50 evenly spaced elevation points along 8 radials separated by 45°, from the transmitter site (GEL + Antenna Height C_L)
- The 50 points are sampled in the segment between 3 to 16 km (~2 to 10 miles) along each radial
- The elevation points along each radial are averaged, then the radial averages are averaged to provide the final FCC HAAT value



GEL = Ground Elevation

FCC ERP: Transmit Power Rules

- If the resulting HAAT of the transmit antenna is > 30 meters, then the ERP must be lowered to ensure that the 60 dBu contour remains at 5.6 km
- KISN's HAAT (*Mt Scott*) = 280 meters (918 feet)
- Therefore, the ERP must drop below 100 watts
 > KISN's ERP = 2 watts to maintain the 5.6 km 60 dBu radius
- KQRZ's antenna HAAT (*Tigard*) is < 30 meters
 KQRZ's ERP = 100 watts

Effective Radiated Power - ERP

• ERP is the Tx power (watts) radiated from an antenna, taking into account the gain of the antenna (relative to a standard dipole) and taking all system losses into account



- ERP is assigned by the FCC to meet 5.6 km distance contour
- ERP = TPO * PG
- PG = Power Gain = antilog₁₀ (dB_L/10)
- *Example*: *dB*_{*L*} = −9.86 *dB*; *: PG* = .103
- *If TPO* = 50 *watts ∴*
- ERP = 50 * 0.103 = 5.15 watts

FCC LPFM Separation Distances

- Per FCC Rules 73.807
- Co-Channel separation between two LPFM's must be ≥ 24 km (15 miles)
- First adjacent' s must be spaced 14 km (8.7 miles)
- Some cities may be able to support two LPFM's on the same frequency
 - Depending on Tx location

Station class protected by LP100	Co-chan minimumsepar	nel ation (km)	First-adjacent channelminimum separation (km)		
	LP100	24	24	14	
D	24	24	13	13	
А	67	92	56	56	
B1	87	119	74	74	
в	112	143	97	97	
СЗ	78	119	67	67	
C2	91	143	80	84	
C1	111	178	100	111	
со	122	193	111	130	
с	130	203	120	142	



Channel Spacing

- The channels next to each other are referred to as: Adjacent Channels
- FCC rules at the time of early LPFM, required stations to be separated by at least 2 Adjacent channels
- Subsequently, the rules have been relaxed to 1 Adjacent channel separation
- This opened up more potential channels for LPFM to use. Example below, how KQRZ-LP got squeezed in

ž	100.1	100.3	100.5	100.7	100.9	101.1	101.3
		KKRZ		KQRZ		KXL	

The FM Radio Channel (Review)



- Channels are 200 kHz wide, including two 25 kHz guard bands
- 100% Modulation is achieved when the carrier frequency deviation is +/- 75 kHz from the Carrier
 - The amount of frequency deviation determines the degree of modulation
- Total frequency swing is 150 kHz
- In FM, the amplitude of the modulating signal is the primary factor in determining the BW

LPFM Is Inherently Subject to Interference

- FCC considers LPFM as a "secondary service"
- LPFM stations are prone to interference especially outside of their 60 dBu contours
- Co-Channel and First Adjacent channels effect reception the most
 - KISN has numerous co-channels: KSND in Monmouth, KITI Winlock (north of Longview), KZAS-LP Hood River
- Adjacent digital IBOC stations also degrade signal reception for LPFM and FM DX'ing in general

The IBOC Signal

- In-Band on-Channel (IBOC) is a hybrid method of transmitting digital and analog radio signals simultaneously on the same frequency
- Simply put, the HD IBOC signal spatters across multiple FM channels as allowed by FCC
- Notice the "Mask" (orange color) extends way beyond the standard 200 kHz FM channel into adjacent channels



How the Spectrum Looks



- HD IBOC signal extends +/- 600 kHz from the carrier @ -75 dBc
- Swamps the LPFM signal in marginal areas
- Only receivers with good selectivity can discriminate LPFM signals

IBOC Side Band Power Levels

200 KHz



- Most HD FM stations are operating @ 20 dBc SB power
 FCC rules
 - may allow -10 dBc soon

The KISN-LP 95.1 Transmitter Site



KISN-LP History

- The WORC was first licensed on February 7, 2009 with an "STA" (Special Temporary Authority) to run KQSO-LP in Newberg which operated for nearly 5 years
- WORC decided to apply for an LPFM in the FCC's 2014 licensing window for a new location on Mt Scott
- FCC issued the CP and KISN was launched May 1, 2015
- Since the FCC rules allow only one entity to own one LPFM, the club turned in the KQSO-LP license and call sign. The station was shut down on December 25, 2014



PORTLAND/VANCOUVER METRO	AREA*:
Population	956,600
Households	328,100
Total Retail Sales \$1,838,	794,000

KISN 0.5 MILLIVOLT AREA:

Population	1	,077,792
Households		352,217
Total Retail	Sales \$2,214	,800,000

*SOURCE Sales Management Survey of Buying Power 6/10/69





Ten Northwest Tenth Telephone 226-7191 Portland Dial 91

1001 Main Street Ph.: (206) 694-4541 Vancouver, Washington



olv NOR MAR LIT Z 5 S COLUMB Cape Fa VANCOUVER WASHING TH-BOLD MAA PORTLAND MT HOOD-YAMH ATIONAL MC MINNVILLE ATTONAL A C Fik A S Perrydala

FCC Calculated KISN Contours



The "local", "distant" and "fringe" lines on the map corresponds to the predicted 60, 50, and 40 dBu field strength contours respectively.

Computer Model - Metro Coverage KISN-LP







CP Antenna Data Sheet

Shively Labs®

Model 6812B Circularly-Polarized FM Antenna

Full-Wave-Spaced

Z Matching

Network



No. of Bays	G	Gain				
	Power	dß	ω			
1	0.46	-3.4	1000			
2	0.99	-0.04	1500			
3	1.52	1.83	1500			

KISN-LP Tower/Antenna

Possible ice build-up requires a Radome surrounding antenna to prevent detuning > & high VSWR



Inside Original KISN-LP Tx Building





KISN Studio

"Dirty" Dave (programming)

Scott Young (production)

COND ALBUM

The KQRZ-LP 100.7 Transmitter Site



Computer Model - Coverage KQRZ-LP 100.7



The KICN-LP 96.7 Transmitter Site



Computer Model - Coverage KICN-LP 96.7



WORC (KISN-LP Licensee)

WORC Board Members President: Ron Polluconi - KJ7IY Secretary: Kris Schatz - KR7IS Treasurer: Mike Hemel - KB7WUK

Technical Advisor Ken Seymour – KA7OSM

Radio network consists of 24 VHF & UHF repeaters throughout NW Oregon

System Overview Map









Barlow Road Simulcast System



Barlow Road Simulcast System Coverage



Calendar of Nets on the WORC System

PM	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
6:05	NW Traffic & Training	NW Traffic & Training	NW Traffic & Training	NW Traffic & Training	NW Traffic & Training	NW Traffic & Training	NW Traffic & Training
7:00			Oak Lodge CERT ¹	WORC Users			
7:30	Clackamas East County ARES						
8:00					PNW Fishing		
9:00							
10:00	New Hams Discussion						

WORC Owned & Operated Repeaters

Site ID	Band	Name	Repeater Input (MHz)	Repeater Output (MHz)	Offset +/-	Offset Frequency	Tone Mode	Tone Hz	General Service Area
W01	70 cm	Aloha	447.5250	442.5250	Plus	5.0 MHz	Tone	107.2	PDX Westside to Cornelius
W02	70 cm	Sherwood	448.4250	443.4250	Plus	5.0 MHz	Tone	107.2	Newberg, Sherwood, Scholls
W03	10 M	Sherwood	29.5800	29.6800	Minus	100 KHz	Tone	162.2	Newberg, Sherwood, Scholls
W04	6 M	Sherwood	51.1300	52.8300	Minus	1.7 MHz	Tone	107.2	Newberg, Sherwood, Scholls
W05	2 M	Sherwood	144.8700	145.4700	Minus	600 KHz	TSQL	107.2	Newberg, Sherwood, Scholls
W06	1.25 M	Sherwood	222.4600	224.0600	Minus	1.6 MHz	Tone	107.2	Newberg, Sherwood, Scholls
W07	23 cm	Sherwood	1272.0000	1292.0000	Minus	20 MHz	Tone	107.2	SE Port, Vancouv, E County
W08	23 cm	Sherwood	1228.7500	1248.7500	Minus	21 MHz	Tone	108.2	SE Port, Vancouv, E County
W09	70 cm	Forest Heights	448.0250	443.0250	Plus	5.0 MHz	Tone	107.2	Portland, Vancouver, Bvtn
W10	70 cm	Clackamas	448.1500	443.1500	Plus	5.0 MHz	Tone	107.2	SE Port, Vancouv, E County
W11	2 M	Colton	144.8300	145.4300	Minus	600 KHz	Tone	107.2	Clackamas County
W12	70 cm	Colton	448.8750	442.8750	Plus	5.0 MHz	Tone	107.2	Clackamas County
W13	6 M	Mt Hood	51.2700	52.9700	Minus	1.7 MHz	Tone	107.2	Clackamas, Hood River County
W14	70 cm	Mt Hood	447.9250	442.9250	Plus	5.0 MHz	Tone	107.2	Clackamas, Hood River County
W15	6 M	Timber	51.1500	52.8500	Minus	1.7 MHz	Tone	107.2	West Washington Cnty, NW OR
W16	2 M	Timber	144.6700	145.2700	Minus	600 KHz	Tone	107.2	West Washington Cnty, NW OR
W17	70 cm	Timber	446.8250	441.8250	Plus	5.0 MHz	Tone	107.2	West Washington Cnty, NW OR
W18	70 cm	Newberg	447.2750	442.2750	Plus	5.0 MHz	Tone	107.2	Newberg, Sherwood, Tualatin
W19	2 M	Manning	149.8500	145.4500	Minus	600 KHz	Tone	107.2	Banks, West Washington Cnty
W20	70 cm	Manning	447.4000	442.4000	Plus	5.0 MHz	Tone	107.2	Banks, West Washington Cnty
W21	33 cm	Forest Grove	902.1125	927.1125	Minus	25 MHz	Tone	108.2	West Washington Cnty
W22	70 cm	Ripplebrook	448.8500	443.8500	Plus	5.0 MHz	Tone	107.2	East Clackamas County
W23	2 M	Barlow Road	146.2000	146.8000	Minus	600 MHz	TSQL	107.2	System Wide Simulcast
W24	FM	KISN-LP	-	95.1000	-	-	-	-	Portland Eastside

WORC Emergency & Disaster Recovery Capabilities

100% of the WORC Repeaters are backed up by batteries and AC generators. In case of a disaster or public utility power outage, generators supplies power to the repeater until the disaster or outage is resolved. Hardened sites designed to withstand Magnitude 8-9 earthquake





Typical WORC Site

Questions?

