

Norcal 30
High Performance/Low power
30m Transceiver

Dan Tayloe, N7VE

Norcal 30 Novel Features

- High performance Quadrature DC Detector
 - *High Rcvr Sensitivity/Excellent large signal performance*
- Single sided reception with phasing receiver
- 3v low power receiver
- Switching supply minimizes current drain

Norcal 30 Specification Summary

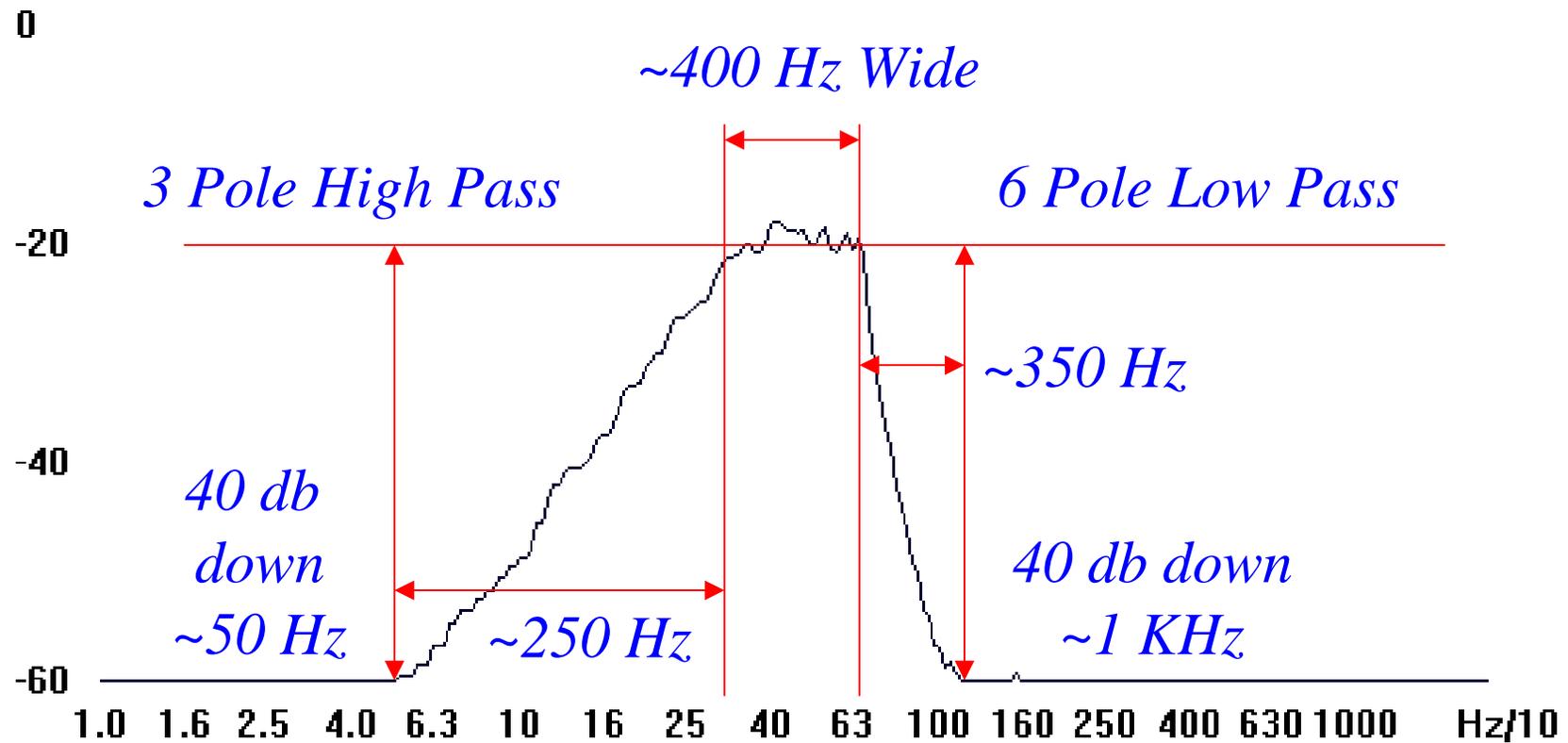
- Receiver Type: Direct Conversion with Phasing
- > 45 db opposite sideband suppression
- Tuning range: 25 KHz, 10.1 – 10.125 MHz
- Receiver sensitivity: -136.5 dbm (0.1 uV), 3 db S+N/N
- Blocking: $> +2$ dbm
- Blocking Dynamic Range: > 138 db
- Third order intercept: $> +25$ IP3
- IM Dynamic Range: > 107 db
- No Spurious SW Broadcast AM Detection
- *Rcvr Blocking/IP3 better than practically useful*

Norcal 30 Specification, Cont.

- Transmit: Variable power, **5w max**
- Operating voltage: 12v nominal
- Current drain
 - Receive with moderate signal: **13.5 ma at 12v.**
 - 10.5 ma at 16v,
 - 18 ma at 9v
 - Transmit, 5w output: xxx ma at 12v.
- Simple RIT provided (0 to ~800 Hz offset)
- Tick keyer
- SSS Audio Frequency Annunciator

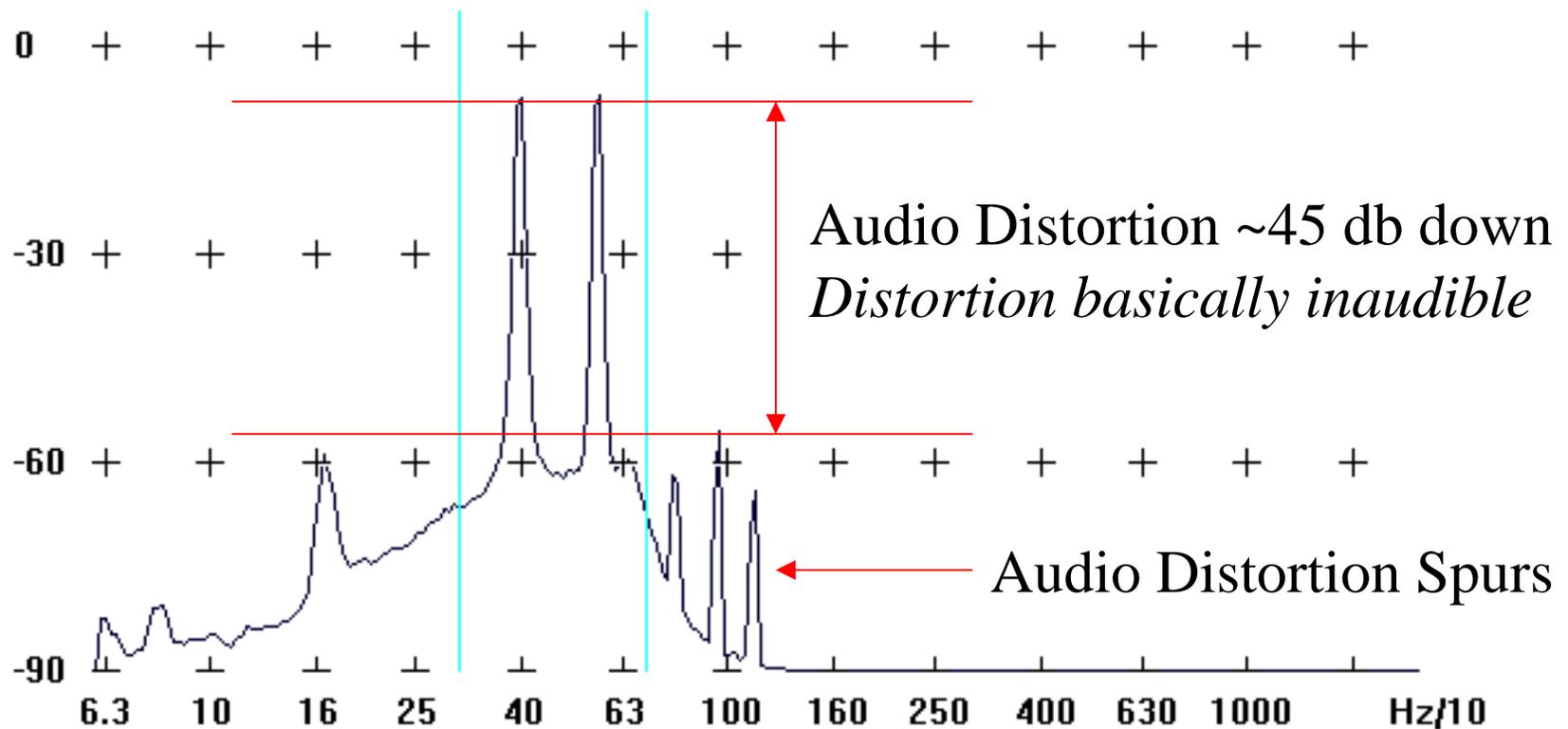
Receiver Audio Response

Measured Using 30m Band Noise



Two Tone Audio IM Response

Test demonstrates linearity/clarity of the audio chain



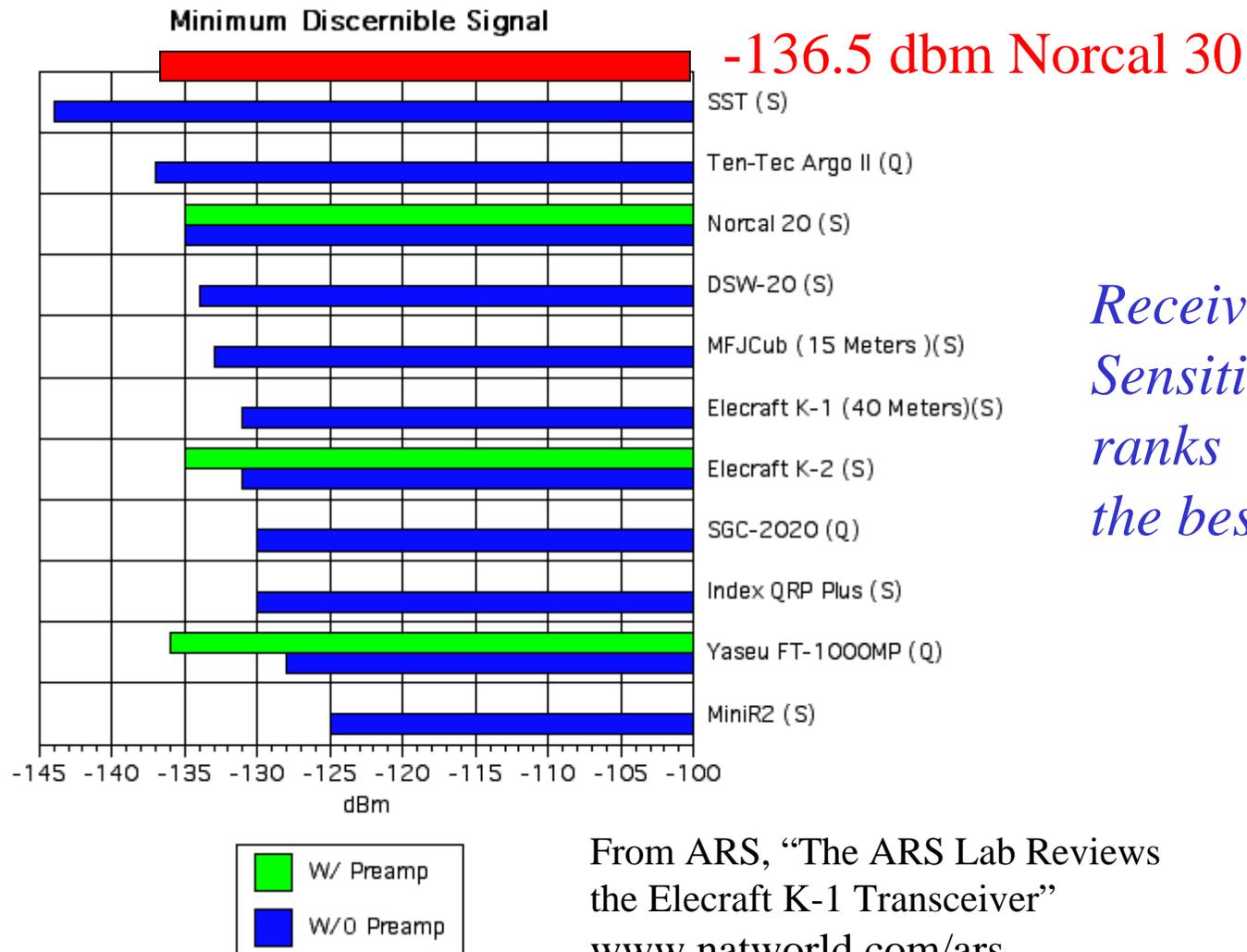
Comparison: FT1000MP @ -31 db, K2 @ -35 db, K1 @ -65 db

Rig Comparisons

- Rig performance data taken from Adventure Radio Society web site.
- The ARS contains a wealth of information comparing the performance of various QRP radios with full size rigs.

www.natworld.com/ars

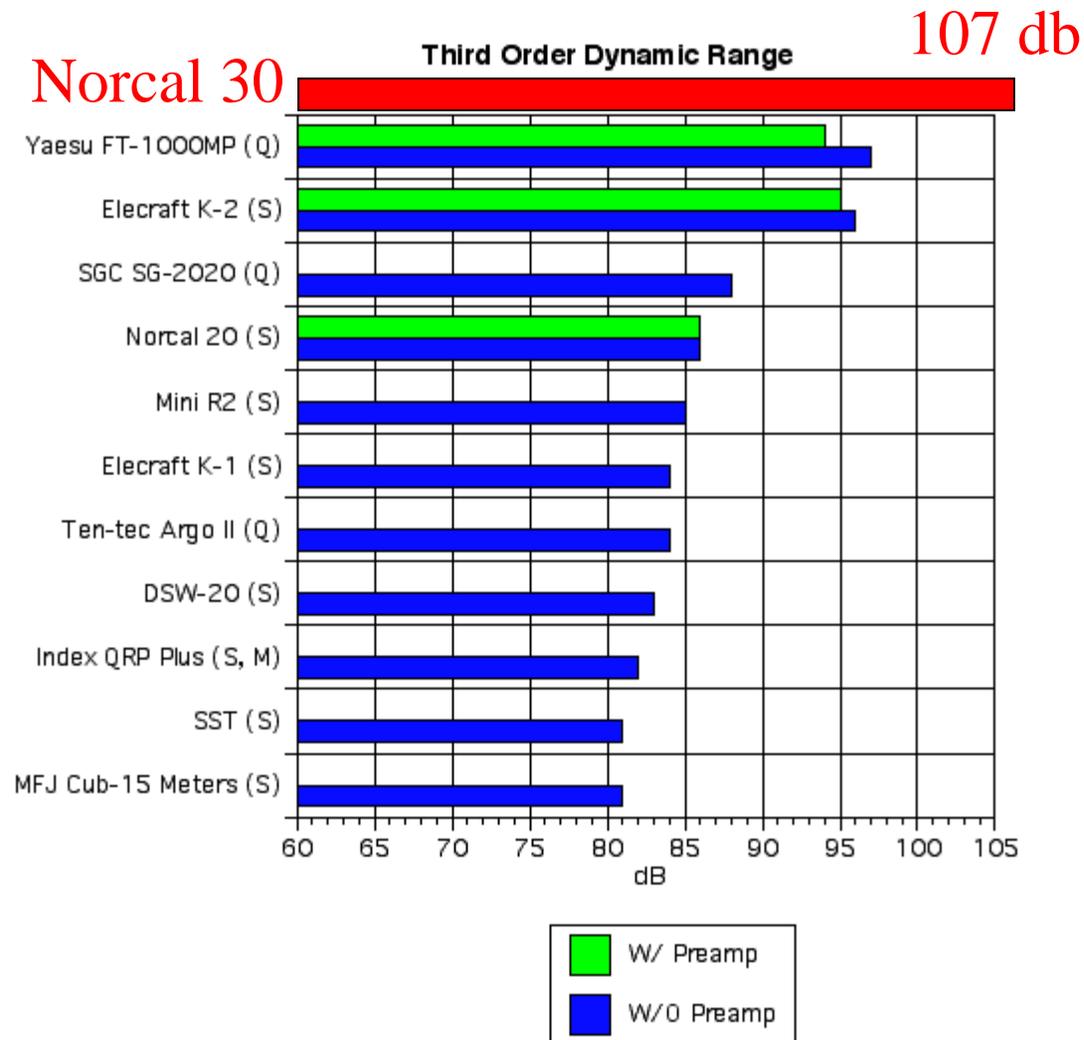
Receiver Sensitivity



Receiver Sensitivity ranks among the best.

From ARS, "The ARS Lab Reviews the Elecraft K-1 Transceiver"
www.natworld.com/ars

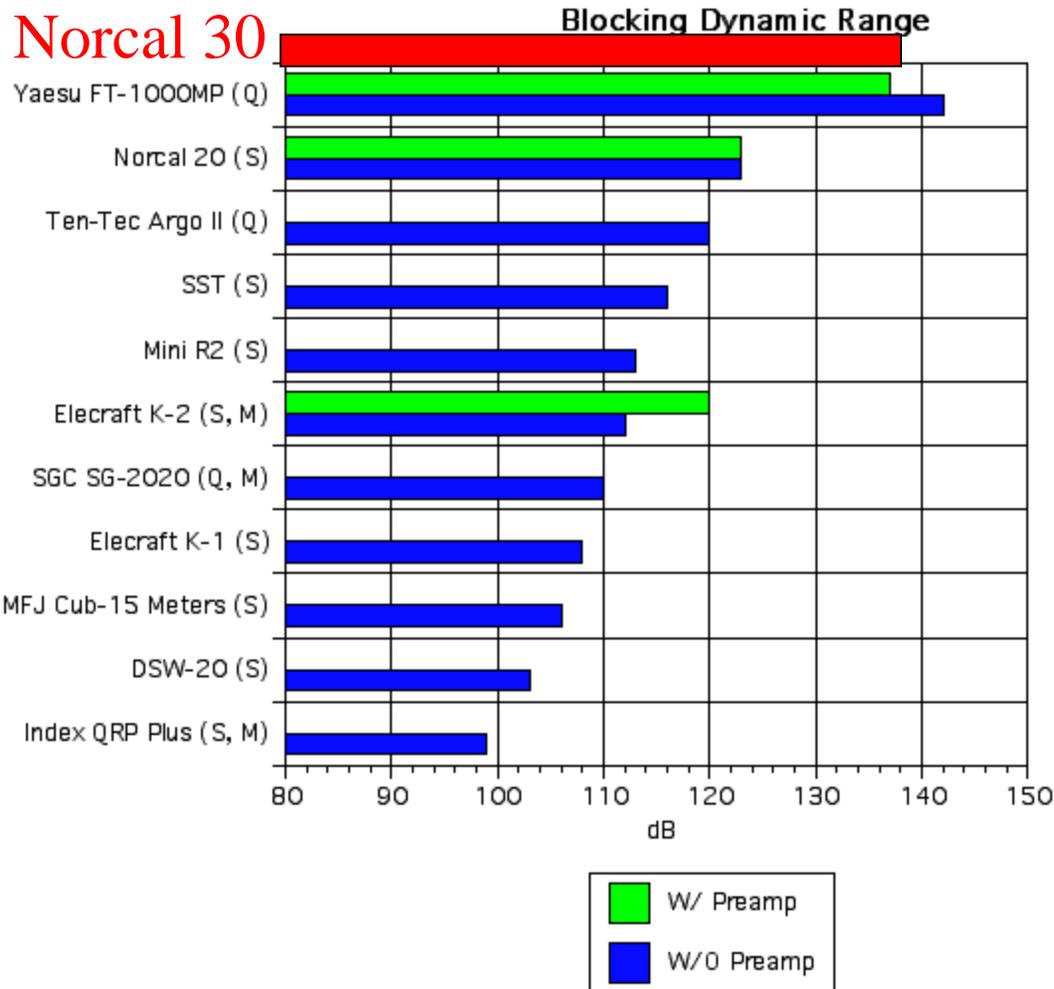
Third Order Dynamic Range



*Norcal 30 excels
in third order
dynamic range.*

From ARS, "The ARS Lab Reviews
the Elecraft K-1 Transceiver"
www.natworld.com/ars

Blocking Dynamic Range



138 db

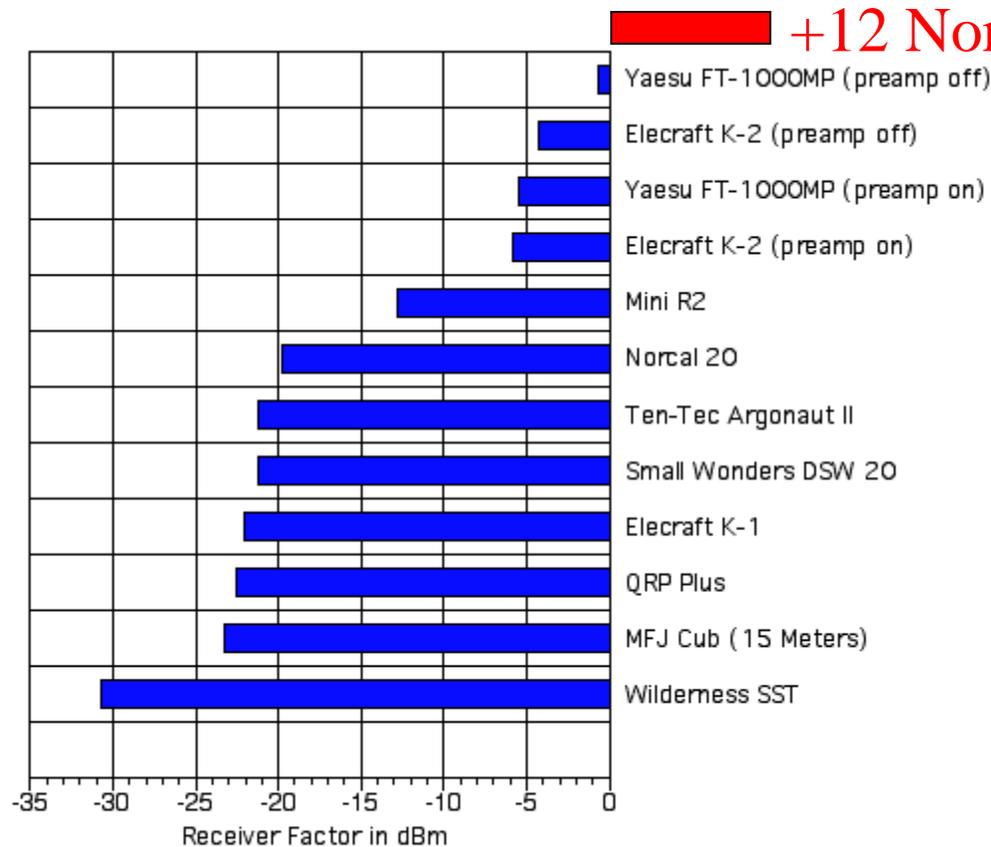
Blocking Dynamic range is bested only by the FT-1000MP

From ARS, "The ARS Lab Reviews the Elecraft K-1 Transceiver"

www.natworld.com/ars

ARS – Receiver Factor

Sensitivity vs. IP3 Tradeoff



The receiver factor measures the tradeoff between high level signal performance and high sensitivity.

Think of this as the ability to receive weak stations in the midst of high power signals.

From ARS, “The ARS Lab
Introduces the Receiver Factor”
www.natworld.com/ars

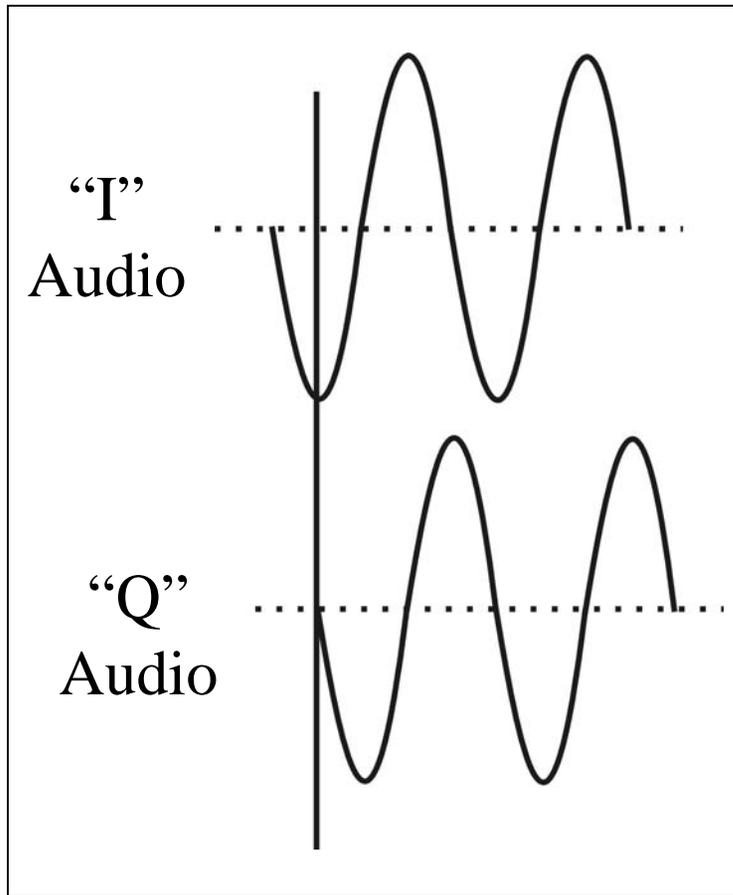
$$\text{Rcvr Factor} = \text{IP3} - \text{NF}$$

How Does Phasing Work?

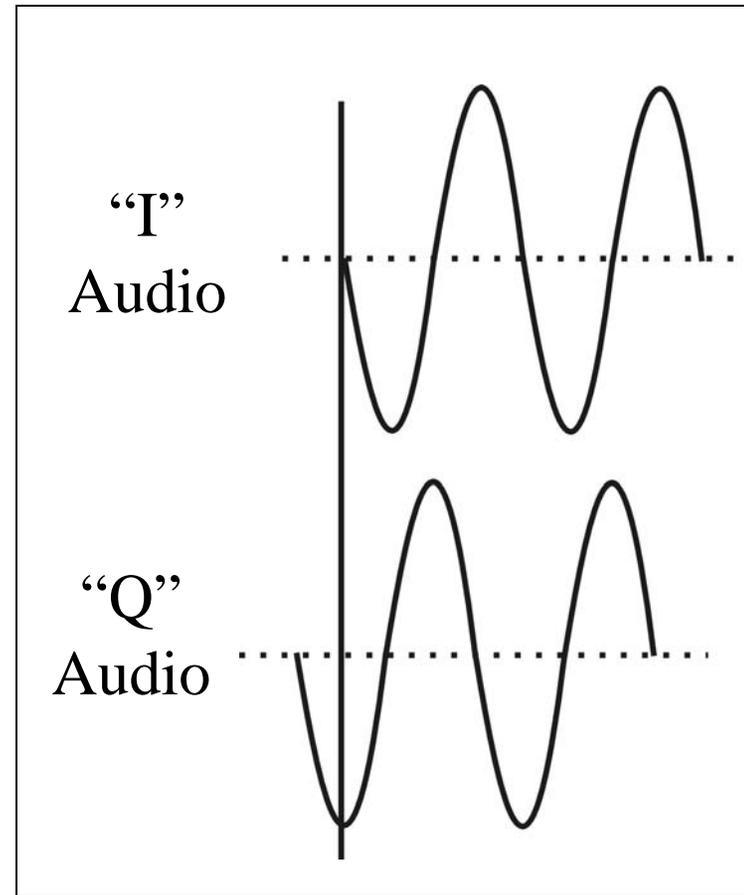
- Requires quadrature (I & Q) signals as input
 - *Taken from High Performance Quadrature Detector*
- For Norcal 30 USB Signals:
 - I leads Q by 90 degrees
- For Norcal 30 LSB Signals:
 - Q leads I by 90 degrees

Picture of Two Sidebands

USB – I leads Q



LSB – Q leads I



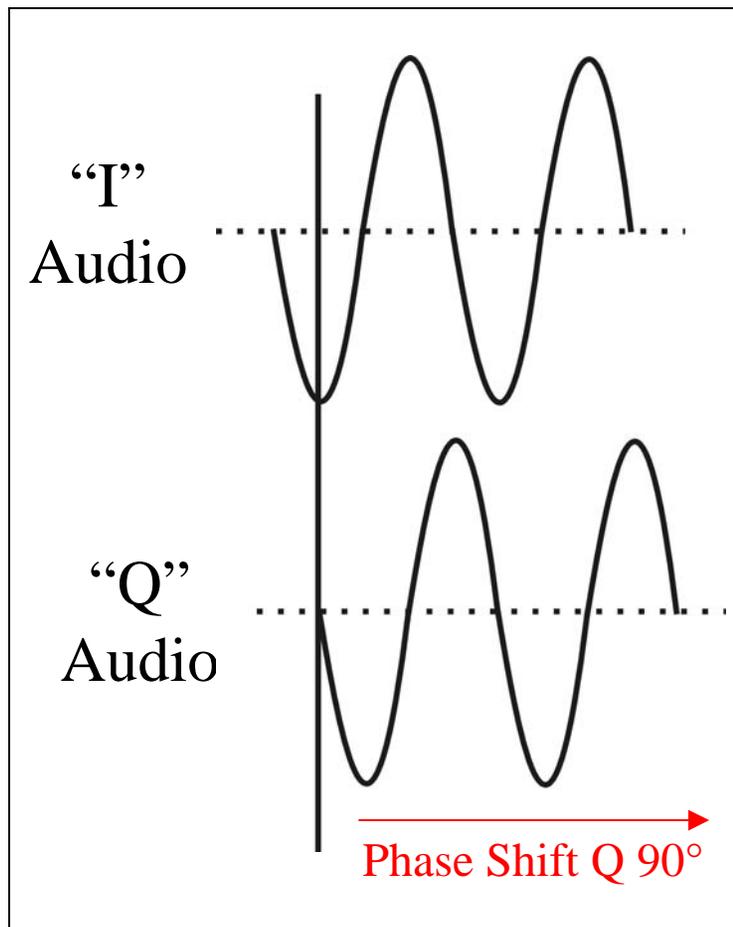
Amplify "As Is" to get a "Binaural" Receiver

Additional 90° Phase Delay Trick

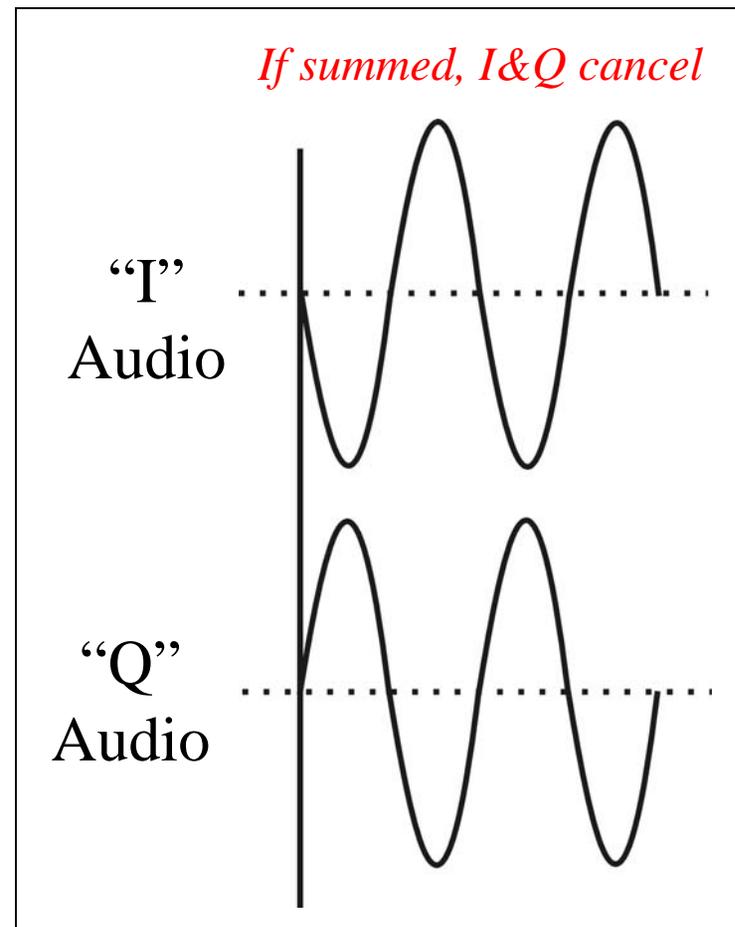
- Trick: Use Phase delay network to add an *additional 90° shift* between I and Q
- Now **LSB** I & Q are **in phase**
- While **USB** I & Q are **180° out of phase**
 - *After phase shift, LSB signals add while USB signals cancel.*

Before and After - USB

USB – Before Phase Shift

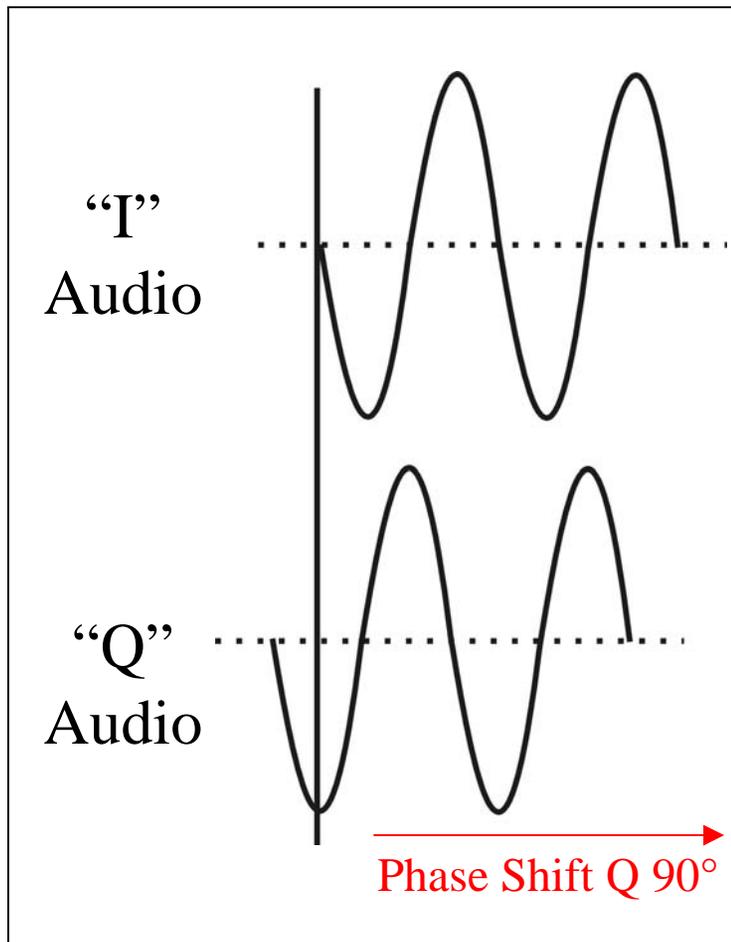


USB – After Phase Shift

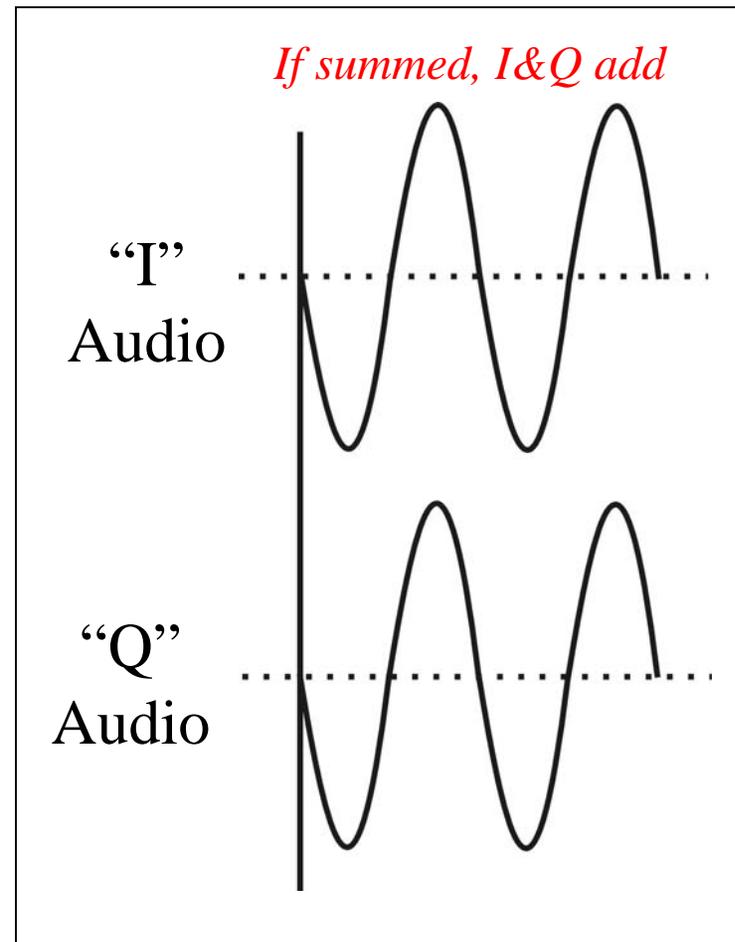


Before and After - LSB

LSB – Before Phase Shift



LSB – After Phase Shift



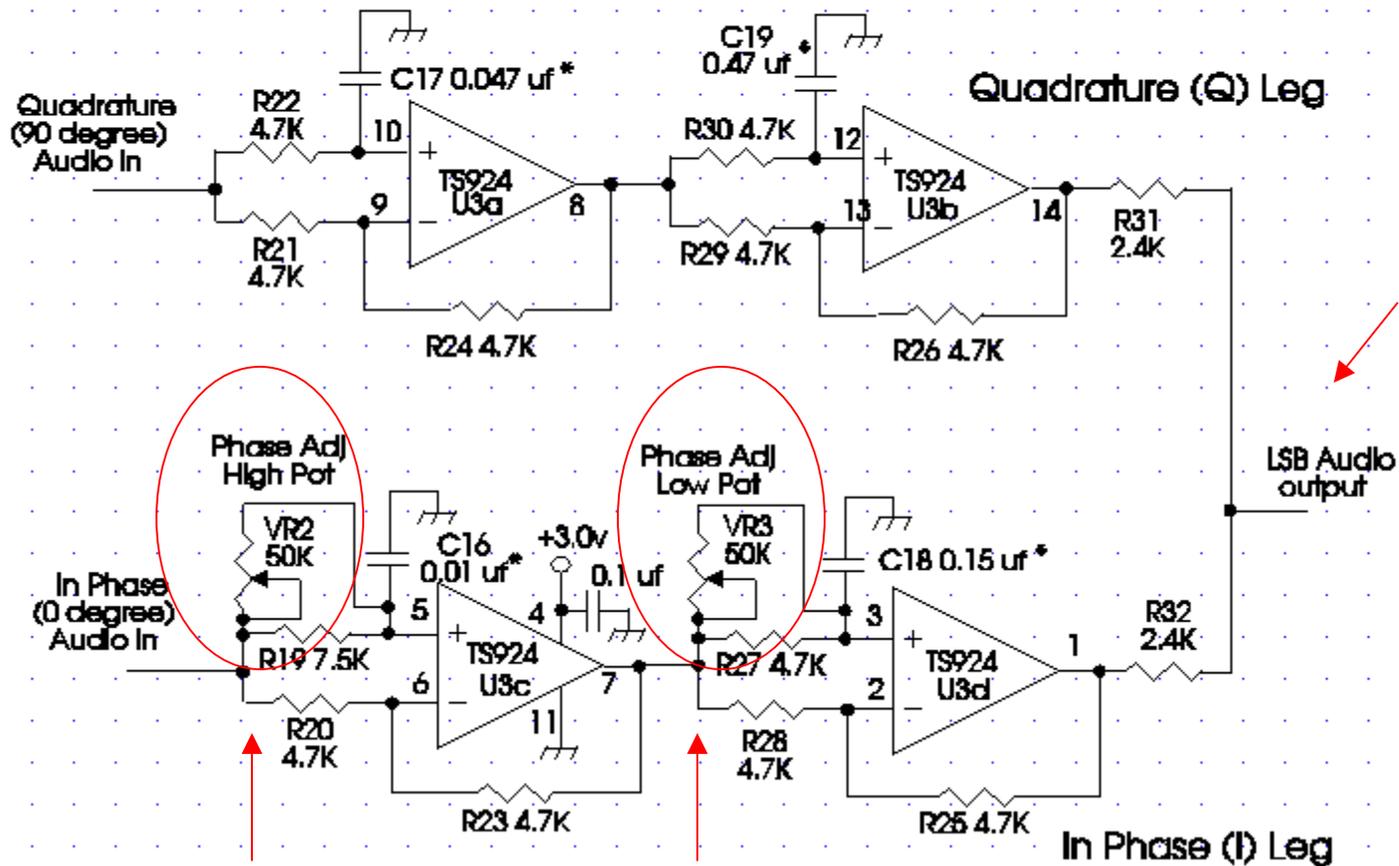
Norcal 30 Phasing Network

- When I/Q audio is applied to the phasing network, the USB sideband cancels out
- Component tolerances non-critical
- Opposite sideband rejection **> 45 db**
- Sideband rejection set using 3 trim pots
 - Balance / Low frequency / High frequency
- **Several passes through all three trimmers easily sets opposite sideband rejection**

Norcal 30 Phasing Network

90 Degree Phase Delay Network

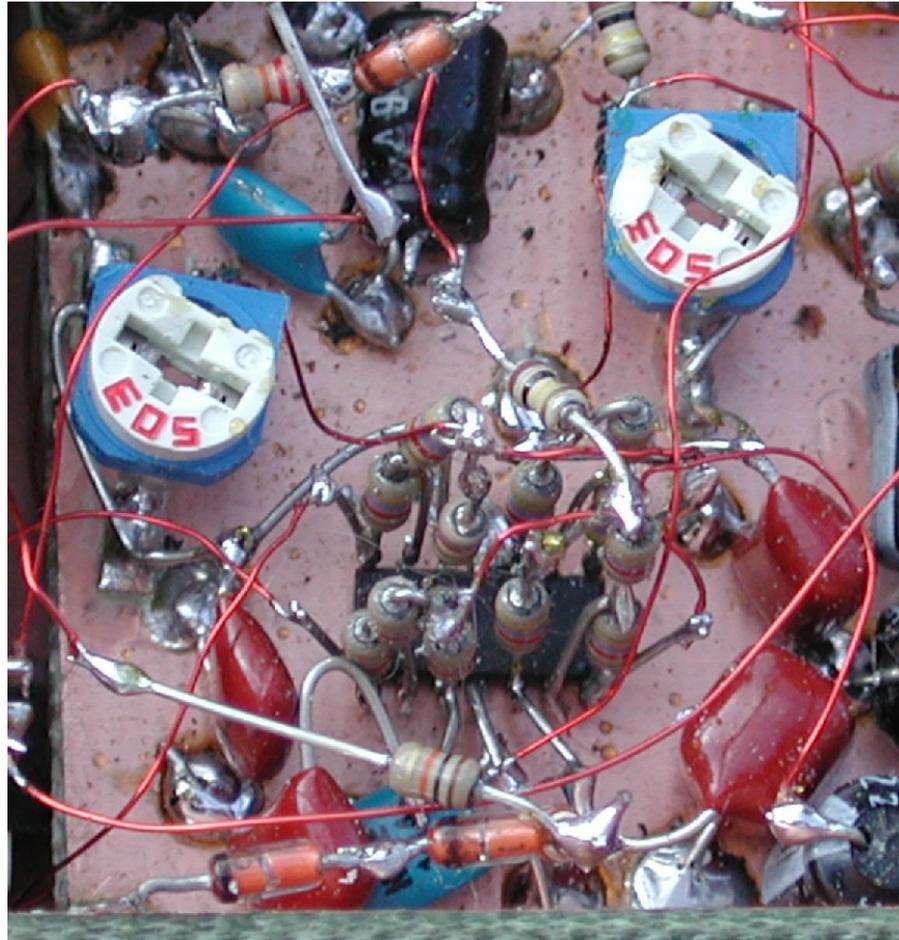
Caps with * are miniature 5% stacked metalized caps such as the Panasonic V series



*Audio
Summed
Here*

Phase adjustment pots

HB Phasing Strip



Why use a 3v Receiver?

- Goal is to deliver audio signal to the ear.
- Normal headphone listening level is only **100 to 200 mV pk-pk**.
- Small, efficient headphones typically rated ~ 40 mW max at 16 ohms.
- 40 mW / 16 ohms is 3.2v pk-pk
 - *But who wants to smoke their headphones?*
- 3v is more than enough for headphones.
- **12v wastes over 9v of battery energy!**

Why Use a Switching Supply?

**To waste less power
when using 12v!**

Rough Guidelines

(3 ma at 3v) = (1 ma at 12v)

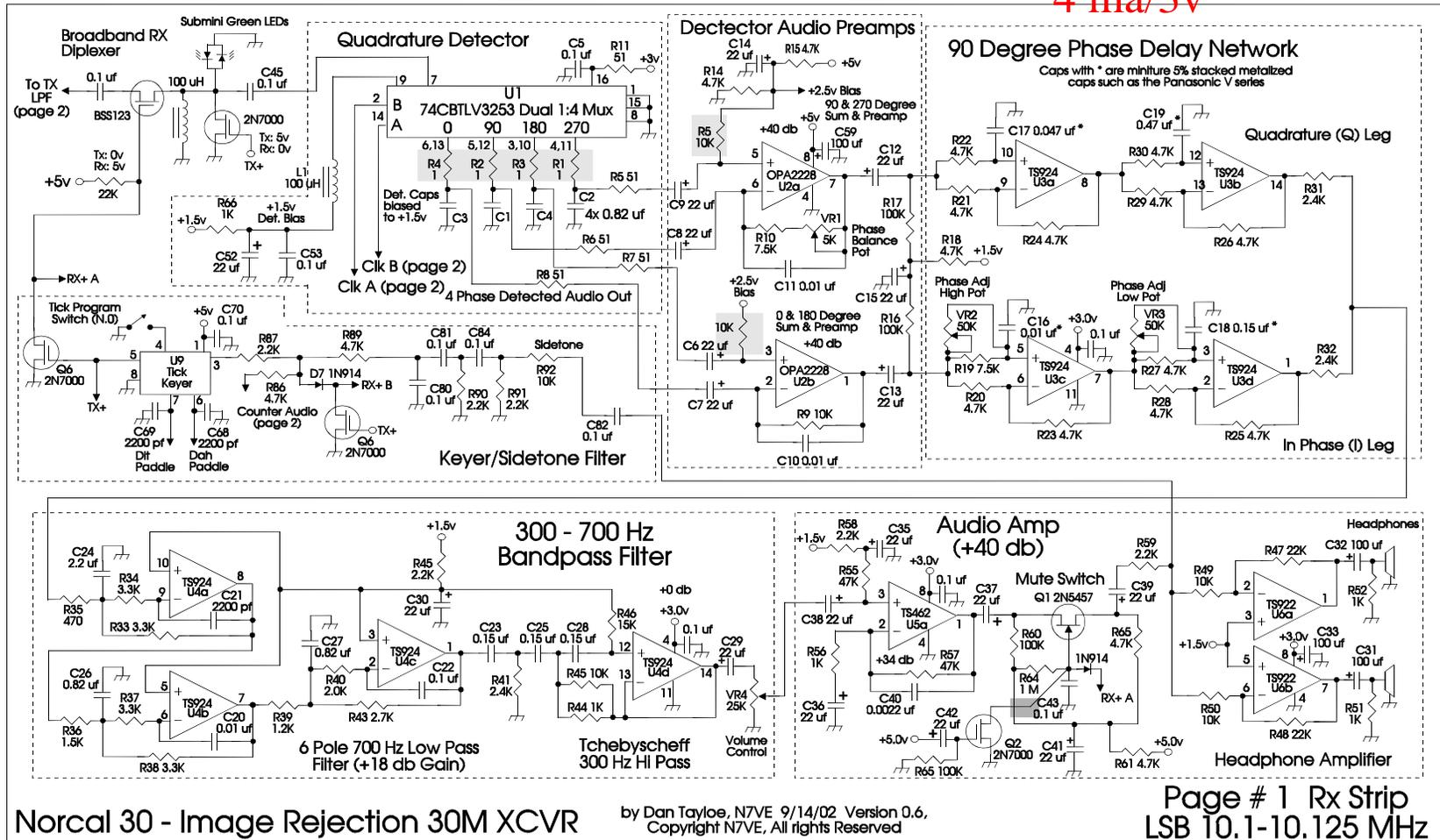
(2 ma at 5v) = (1 ma at 12v)

Receiver Current Drain

Detector:
3 ma/3v

Preamps:
7 ma/5v

Phasing:
4 ma/3v



AF Filter:
4 ma/3v

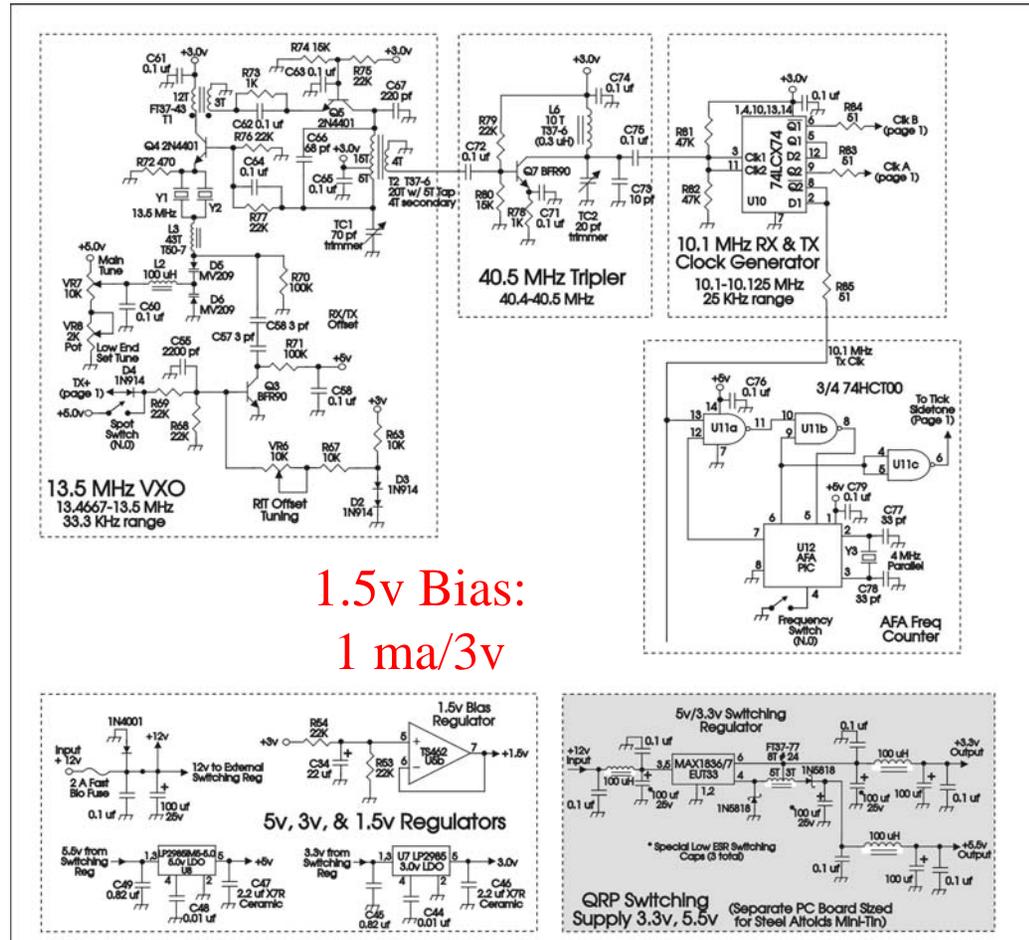
Audio Amp:
1 ma/3v

Audio Drivers:
2 ma/3v

Tripler:
1 ma/3v

VXO:
3 ma/3v

Detector
Clock Gen:
4 ma/3v



1.5v Bias:
1 ma/3v

Misc.:
2 ma/3v

Norcal 30 - Image Rejection 30M XCVR by Dan Tayloe, N7VE 9/14/02, Version 0.6, Copyright N7VE, All rights Reserved

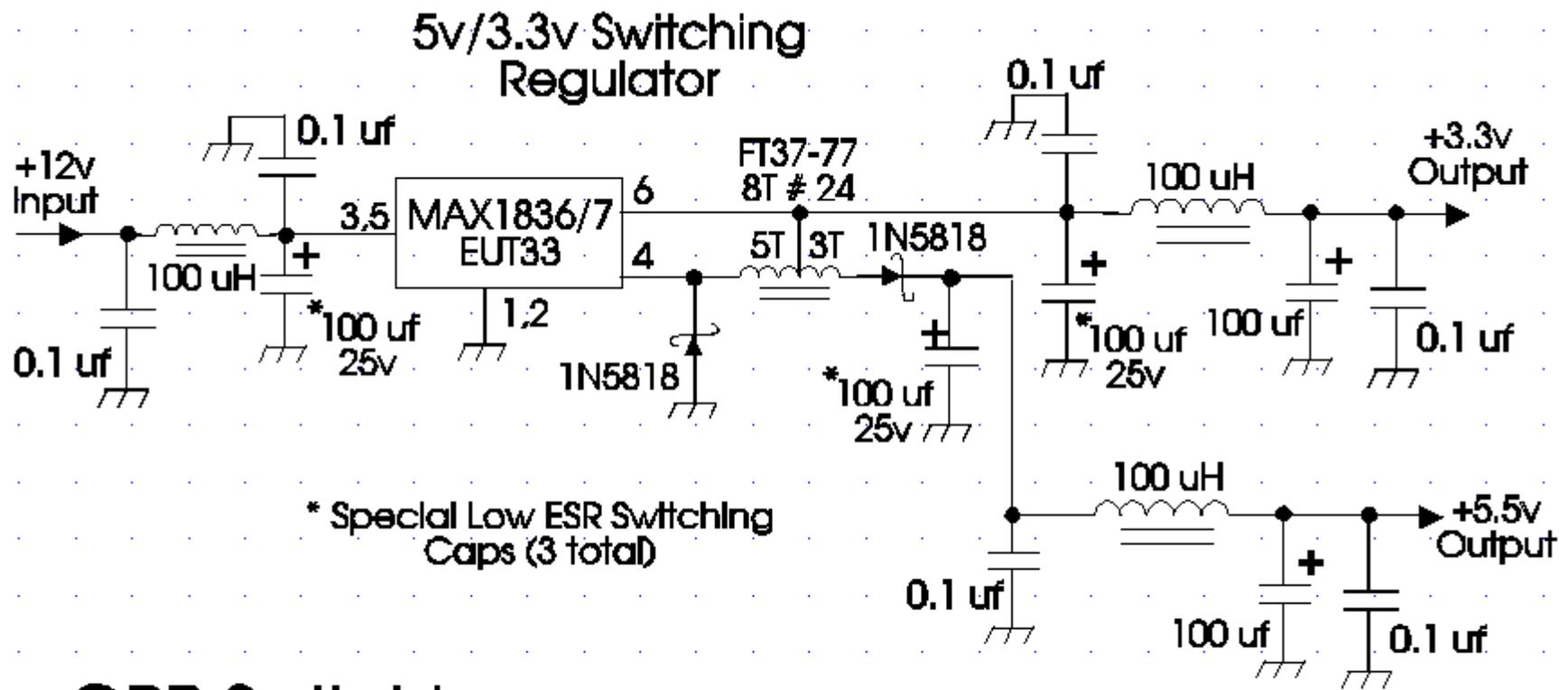
Grand total: 25 ma, 3v and 7 ma, 5v; ~110 mW

Switching Supply Savings:

32 ma vs. 13 ma

- Total: 25 ma, 3v and 7 ma, 5v; ~110 mW
- Linear LDO Regulators provide clean 3v, 5v
 - With 3.3v/5.5v in, LDO regulators burn 10%, 11 mW
- Switching Supply output: 3.3v, 5.5v
 - Switcher circuit is about 75% efficient at 12v
- Switcher: 161 mW in, 121 mW out
- Switcher input, ~13.4 ma at 12v
- **If no switching supply: 32 ma**
- *Switcher saved ~19 ma at 12v.*

QRP Switching Power Supply



QRP Switching
Supply 3.3v, 5.5v

HB QRP Switching Supply



Altoids mini-tin magnetic shielding

Summary: Norcal 30 Design

- High performance Quadrature DC Detector
 - *Unmatched Overall Receiver Performance*
 - *High Rcvr Sensitivity/Excellent large signal performance*
- Single sided reception with phasing receiver
 - *> 45 db of USB suppression*
- Low power receiver
 - *3v, 110 mW*
- Switching supply minimizes current drain
 - *Only 13.5 ma at 12v*