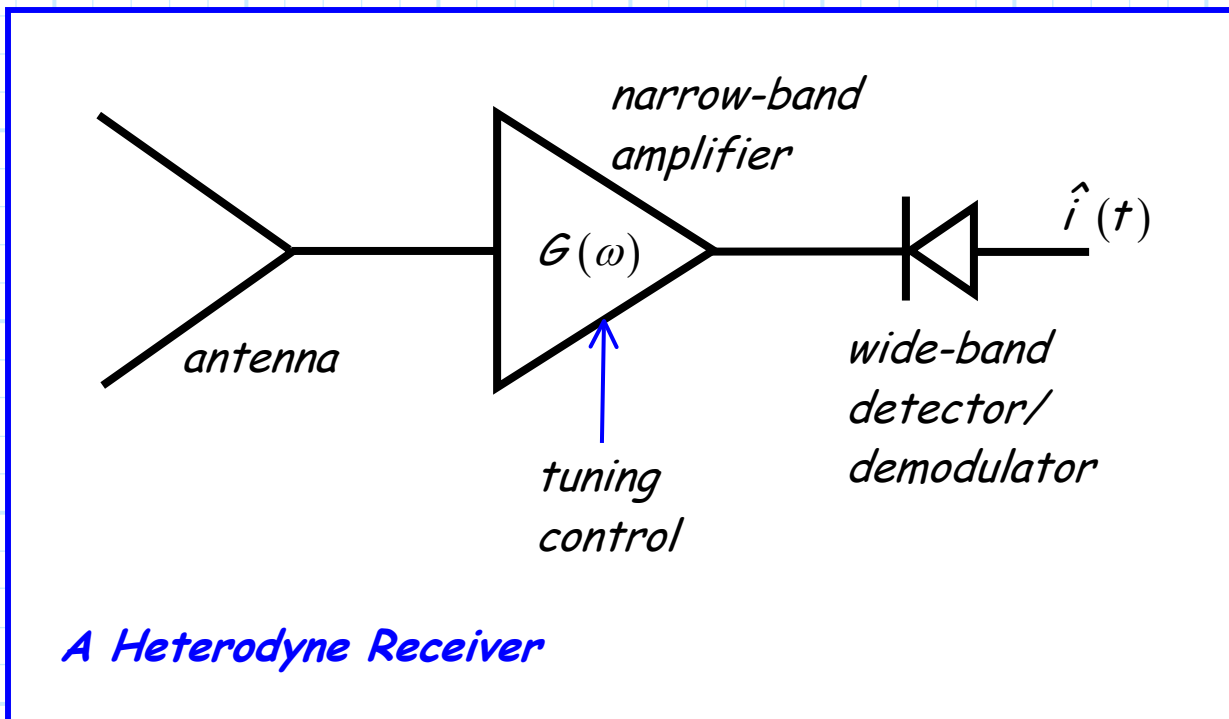


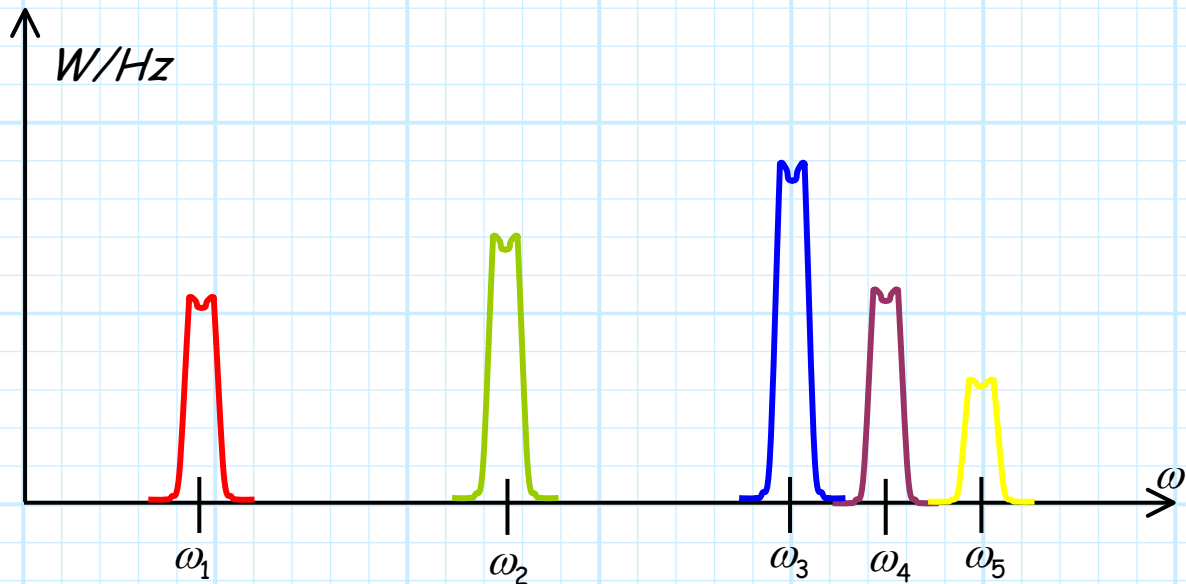
# The Heterodyne Receiver

The **original** radio receiver design was the **heterodyne** receiver.



The **desired** radio signal was selected by **tuning** a narrow-band amplifier!

For **example**, say at the output of the antenna we find the following **signal spectrum**.



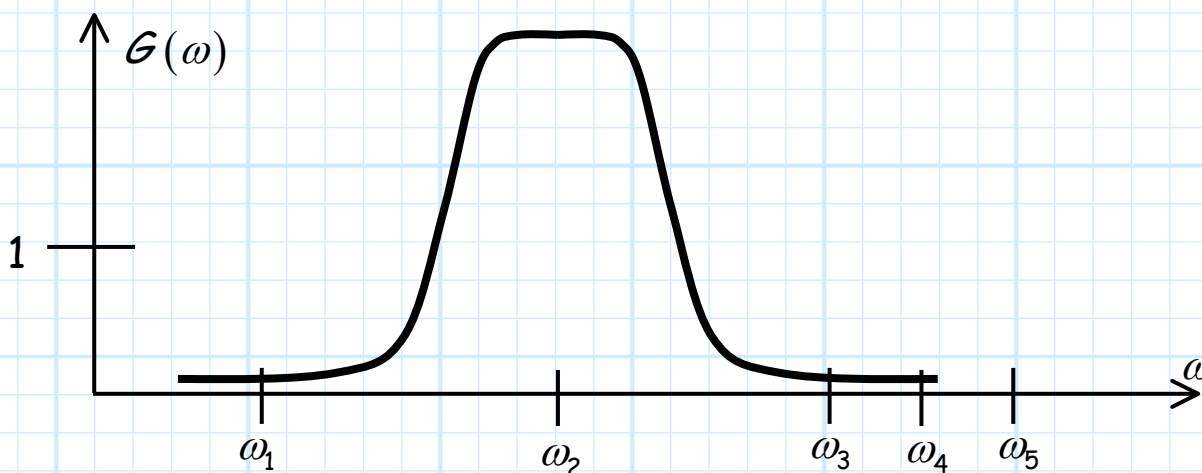
Each signal represents a **different** radio channel.

If **all** of these signals reach the detector/demodulator, the output  $\hat{i}(t)$  will be a **confused mess!**

It is the job of the receiver to select **one** signal, **amplify** it, and present that one (and **only one**) signal to the **detector/demodulator!**

Thus, the receiver must simultaneously **suppress all** of the other signals that come out of the antenna.

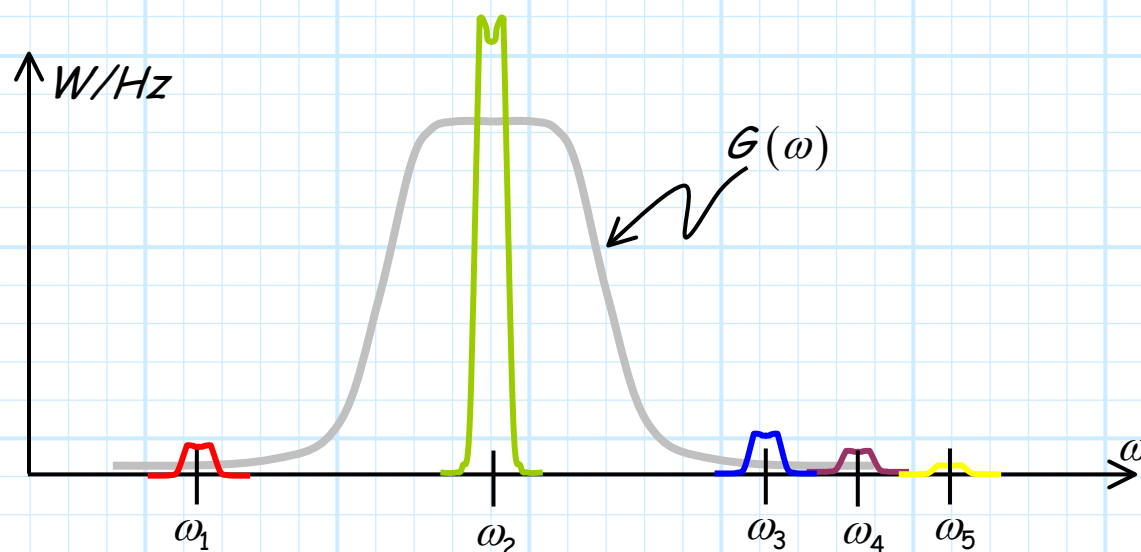
For **example**, we might tune our amplifier to frequency  $\omega_2$ :



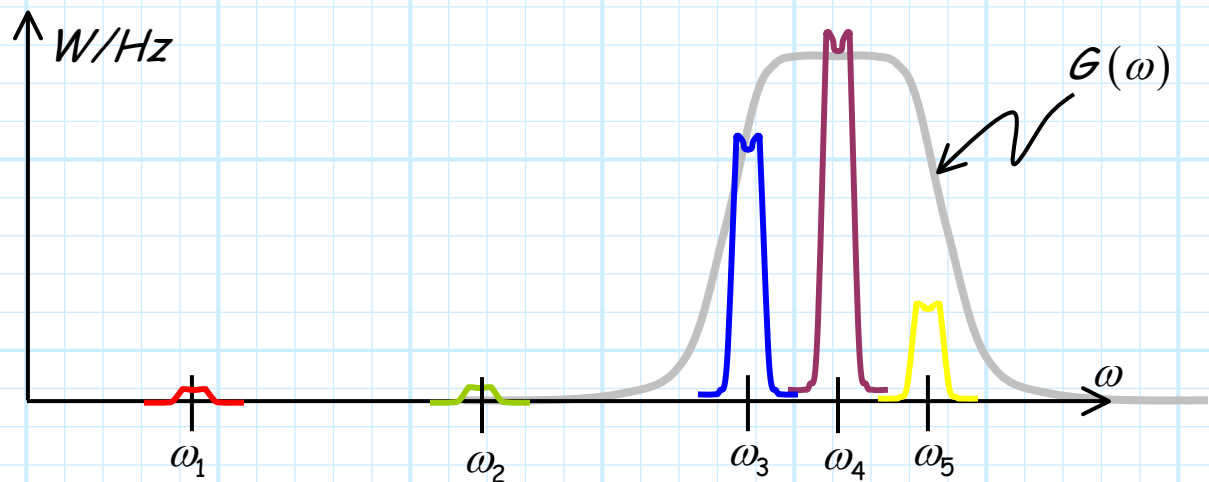
Therefore, the gain in the pass-band is **large** ( $G(\omega) \gg 1$ ), while **outside** the pass-band the gain is **small** ( $G(\omega) \ll 1$ ).

As a result, the signal at frequency  $\omega_2$  is **amplified**, while the signals at **all** other frequencies are attenuated (i.e., rejected)  
 → **only** the signal at  $\omega_2$  reaches the detector!

Thus, the signal spectrum at the **detector/demodulator** would look like this:



Now, say we **tune** the amplifier to select the signal at frequency  $\omega_4$ :

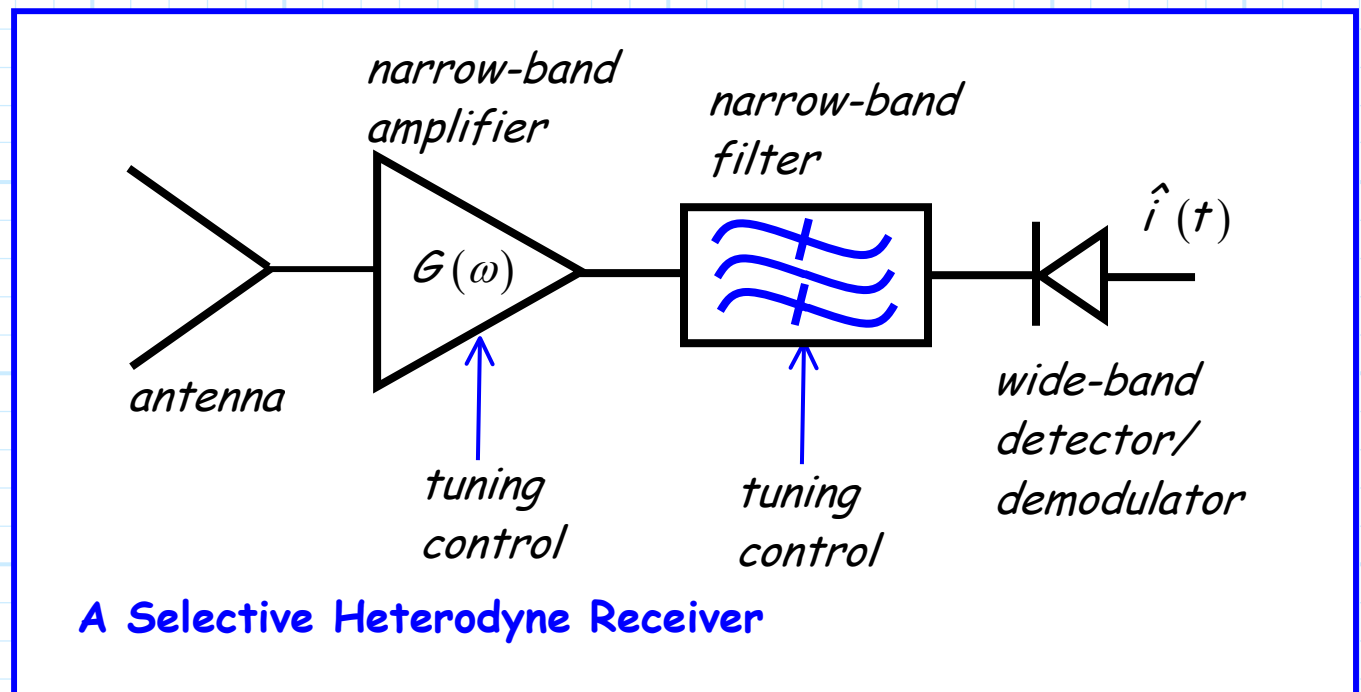


YIKES!! WE HAVE A **PROBLEM!!**

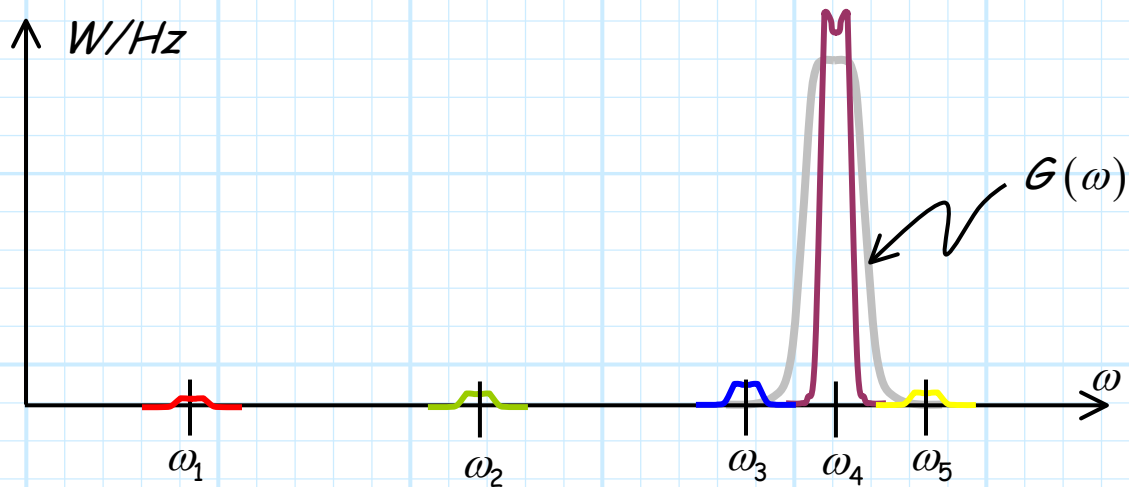
The amplifier bandwidth is **not** sufficiently narrow to **reject** completely the signal at frequency  $\omega_5$ , nor the signal at  $\omega_3$ .

We say that this receiver has poor **selectivity**  $\rightarrow$  we need to **improve** it!

Early radio engineers improved heterodyne **selectivity** by adding a **tunable, narrow, band-pass filter**:



Therefore, if we tune **both** the amplifier and filter to frequency  $\omega_4$ , we might get:



**Much better selectivity !!!**

Note that the selectivity (i.e. **bandwidth**) of the receiver should be **just** wide enough to allow the **entire** signal bandwidth to pass (undistorted!) to the detector.

Moreover, the roll-off of filter must be **steep** enough sufficiently **attenuate** radio signals in **adjacent channels**.

**Q:** *Why don't we **still** use this receiver design?*

**A:** Because a heterodyne Rx has **many problems!!!**

### Problem #1

It is very **difficult** to **tune** an amplifier and/or filter!

- \* We change the frequency **response** of an amplifier/filter by changing the **values** of the **reactive** components (i.e., inductors and capacitors).
- \* But, the center frequency and bandwidth of an amplifier/filter are related to the inductor and capacitor values in very **indirect** and **complex** ways.
- \* Additionally, a filter of high selectivity (i.e., "fast **roll-off**") will be a filter of **high order** → high order means **many** inductors and capacitors!

**Result:** Tuning a good heterodyne receiver can be very **difficult**, requiring a **precise** adjustment of **many** control knobs!

## Problem #2

The signal reaching the detector can be any one of many frequencies (e.g.,  $\omega_1, \omega_2, \omega_3, \omega_4$ ) distributed across a very wide bandwidth.

As a result, the detector must be **wideband**!

Unfortunately we find that a good wideband detector/demodulator is difficult to build. Generally speaking, a detector/demodulator will work well at some frequencies, but less well at others.

**Q:** *So how do we fix these problems??*

**A:** We can't! Instead, we use **yet another** of Edwin Howard Armstrong's inventions:

→ The **Super-Heterodyne** Receiver! ←

The incomparable Super-Heterodyne  
in a custom-built model



RADIOLA 30A  
Custom-built,  
Complete  
with Radiotrons  
\$495

—simplified socket-power operation

Radio engineers all recognize the Super-Heterodyne as the finest achievement in radio receiver design.

In response to the demand for de luxe models of the RCA Super-Heterodyne—with the convenience and efficiency of operation from the electric light socket (without batteries or liquid-containing devices)—RCA offers the new custom-built Radiola 30A. This cabinet receiver, because of its extreme selectivity, is ideally adapted for use in the congested broadcasting areas.

Each instrument (with the self-contained RCA Loud-speaker) has been hand-built and individually tested.

RADIO CORPORATION OF AMERICA  
New York Chicago San Francisco

**RCA Radiola**  
MADE BY THE MAKERS OF THE RADIOTRON

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Buy with confidence where you see this sign

*A 1920's-30's advertisement extolling the virtues of the super-heterodyne radio receiver. Note the price!*