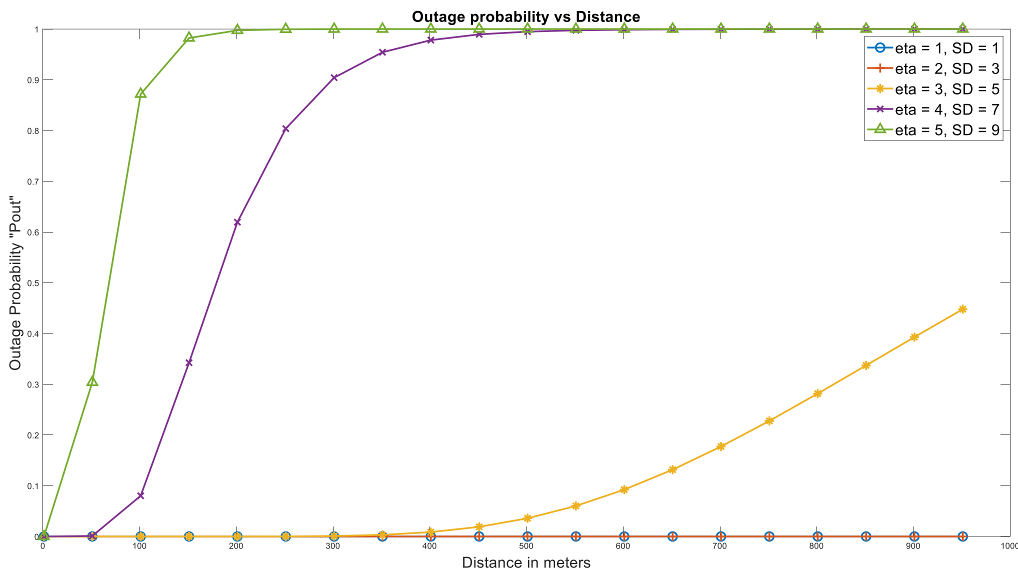
EE 597, Fall 2020

Homework -2

Anu Nair

Shahid Mohammed Shaikbepari

Problem 1:



Comment:

1. Outage probability: The probability with which there is a failure in receiving the signal or signal is lost
2. We can clearly infer from the above graph that with the increase in the distance the outage probability is increase, which is very intuitive as the distance increase the SNR drops and probability of outage increases
3. With the increase in path loss exponent and standard deviation, the curves are shifting upwards which indicates that outage probability is rapidly increasing. We can infer that higher the path loss exponent and standard deviation the received power is decreased therefor SNR is decreased.

Problem 3:

Problem-3

$$T_1 \xleftrightarrow{\;2\;} R_2 \xleftrightarrow{\;1\;} T_2 \xleftrightarrow{\;x\;} R_1$$

$\theta = 1$

$$g_{11} = \frac{1}{d^2} = \frac{1}{(3+x)^2}$$

$$g_{22} = 1$$

w.r.t,

$$g_{11} \cdot g_{22} \geq \theta^2 \cdot g_{12} \cdot g_{21}$$

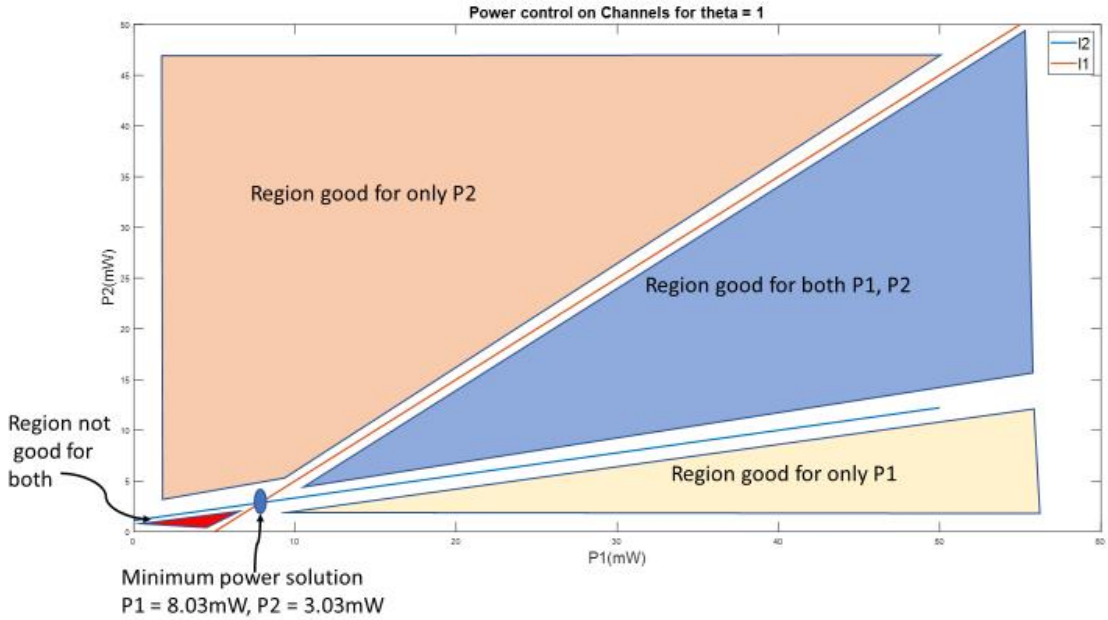
$$\frac{1}{(3+x)^2} \geq 1 \cdot \frac{1}{4} \cdot \frac{1}{x^2}$$

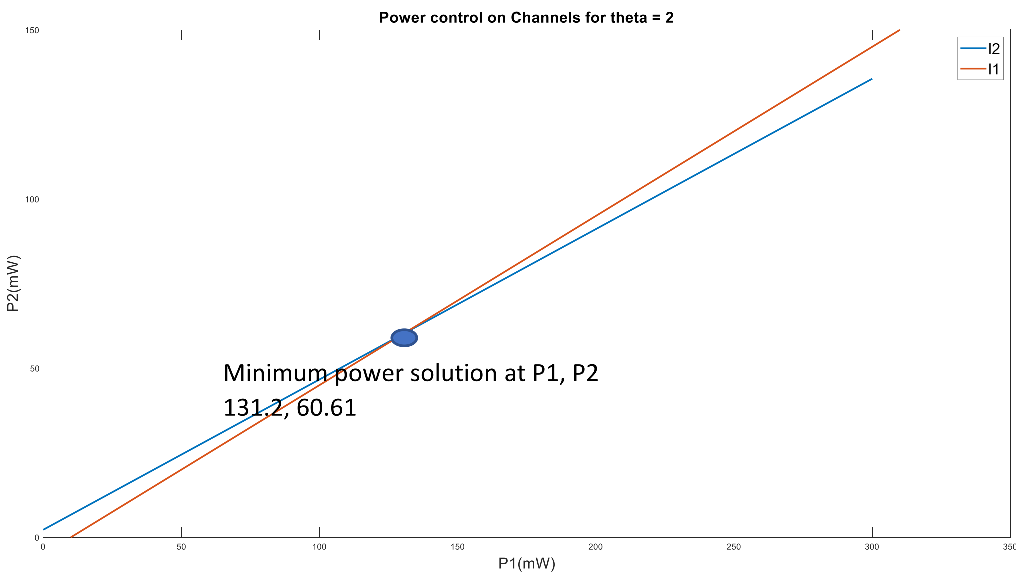
$$3x^2 - 9x + 3x - 9 \geq 0$$

$$x \geq 3, \; (x \leq -1) \times$$

If 'x' is greather than or equl to 3 we can satisfy the both links simultaneosly.

Problem 4:



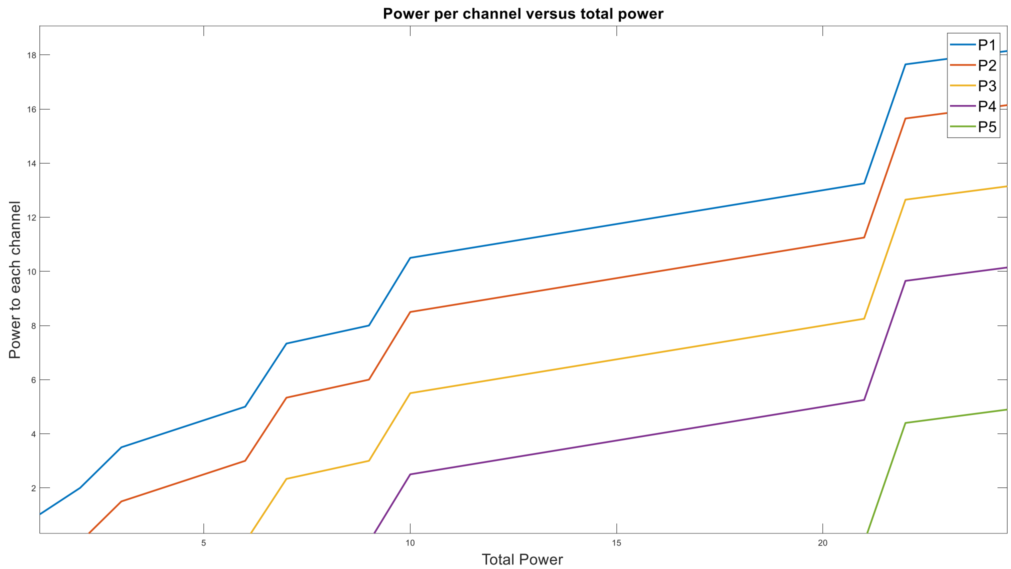


Comments:

1. It is possible for both the links to operate simultaneously for both theta = 1, 2
2. The operating region is the region in between the two lines after the intersect in both cases, we have clearly pointed in the above figure for theta =1, similar is the case for theta = 2
3. The region between the two lines before the intersect is not a suitable region for both the links

4. When theta was made 2, the region shrinks and becomes tight as the minimum rate constraints increases, this is because if it difficult for both links to operate in region with increased data rate threshold.

Problem 5



Comments:

1. We have sorted our given noise to gain ratios vectors to get a neat curve, which will be easier to infer from
2. The above graph clearly represents the water filling model i.e. till the point of our total power is less than the sum of differences of noise to gain of previous channels we continue to pour our power in least noisy channels
3. As the water level increases, we then pour our total power to next least noise to gain channel and so on

Problem 6:

6. $\left[\log\left(1+\frac{P_1 g_1}{n_1}\right)-T_1\right]^2 + \left[\log\left(1+\frac{P_2 g_2}{n_2}\right)-T_2\right]^2$

2. $P_1 + P_2 \leq P_t$.

3. $P_1 \geq 0$

4. $P_2 \geq 0$

Equations:

$$-\left[\left[\log\left(1+\frac{P_1 g_1}{n_1}\right)-T_1\right]^2 + \left[\log\left(1+\frac{P_2 g_2}{n_2}\right)-T_2\right]^2\right]$$

$$-\lambda\left[(P_1+P_2-P_{tot}) - \left[v_1 P_1 + v_2 P_2\right]\right.$$

1. $\left.\frac{\partial L}{\partial P_i}\right|_{P^*, \lambda^*, \lambda^*} = 0$ 2. $\lambda^* \geq 0$, $v_i \geq 0$

3. $\sum P_i^* \leq P_{total}$ 4. $\lambda\left[\sum_{i=1}^{n} P_i - P_{tot}\right] = 0$

$-P_i \leq 0$ $v_i\left[-P_i\right] = 0$.

1. $\left.\frac{\partial L}{\partial P_i}\right|_{P^*, \lambda^*, v^*} = 0$

1. $\left[-2\cdot\left[\log\left(1+\frac{P_i g_i}{n_i}\right)-T_i\right]\cdot\frac{\frac{g_i}{n_i}}{\left(1+\frac{P_i g_i}{n_i}\right)}\right] - \lambda - v_i =$

$\boxed{v_i = 0}$

2. $\left[\log\left(1+\frac{P_i g_i}{n_i}\right)-T_i\right]\cdot\frac{\frac{g_i}{n_i}}{\left(1+\frac{P_i g_i}{n_i}\right)} = \lambda$

$$\sum_{i=1}^{2} \frac{2\left[T_i - \log\left(1+\frac{P_i g_i}{n_i}\right)\right]\cdot \frac{g_i}{n_i}}{\left(1+\frac{P_i g_i}{n_i}\right)} = \lambda$$

if : $\sum P_i < P_T$, $\lambda = 0$, we achieve T_i

~~if~~ $\cancel{\sum P_i >}$

else. we get lesser rate than T_i.

$x = my + c$.

$y = mx + c$.

Comments:

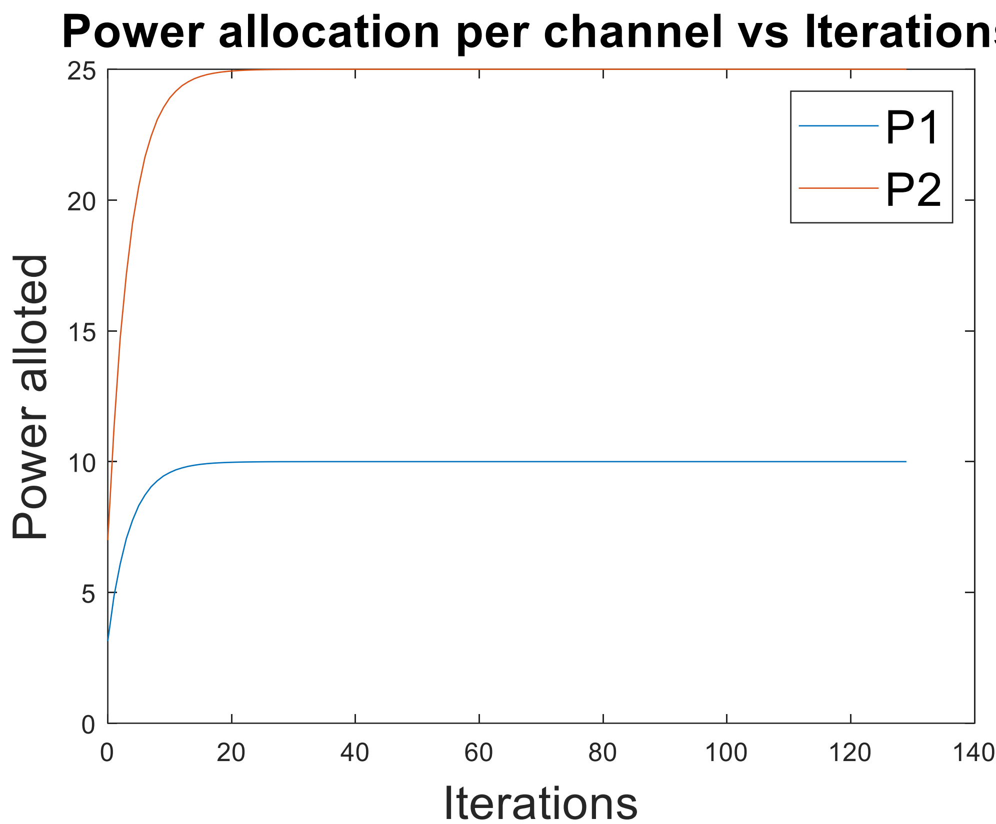
1. Here we have the above equation from which we can derive that it is different from the sum-rate maximation, there we got Pi = (1/lamda – gi/ni) which meant that we'll have maximum power for the least noise to gain ratio but here its not the same case it depends upon the curves for different total power we'll have different allocation for P1, P2
2. We also get from here that, which is greater among T1, T2 also has more power than other.

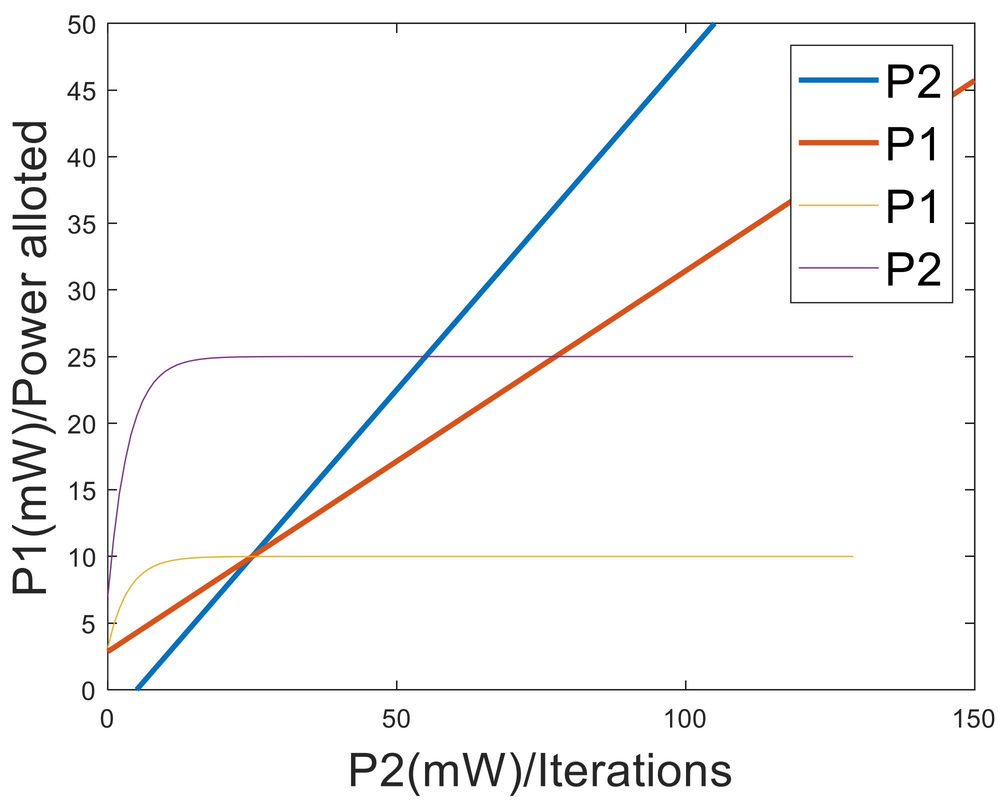
Problem 7:

(a). P1 = 10.22 mW, P2 = 25.75 mW was found to be the optimal power solution

(b). Using Fochini-Miljanic algorithm we found the answer to be P1 = 10.00 mW, P2 = 25.00 mW, which is approximately the same power results we found through the minimum power solution method

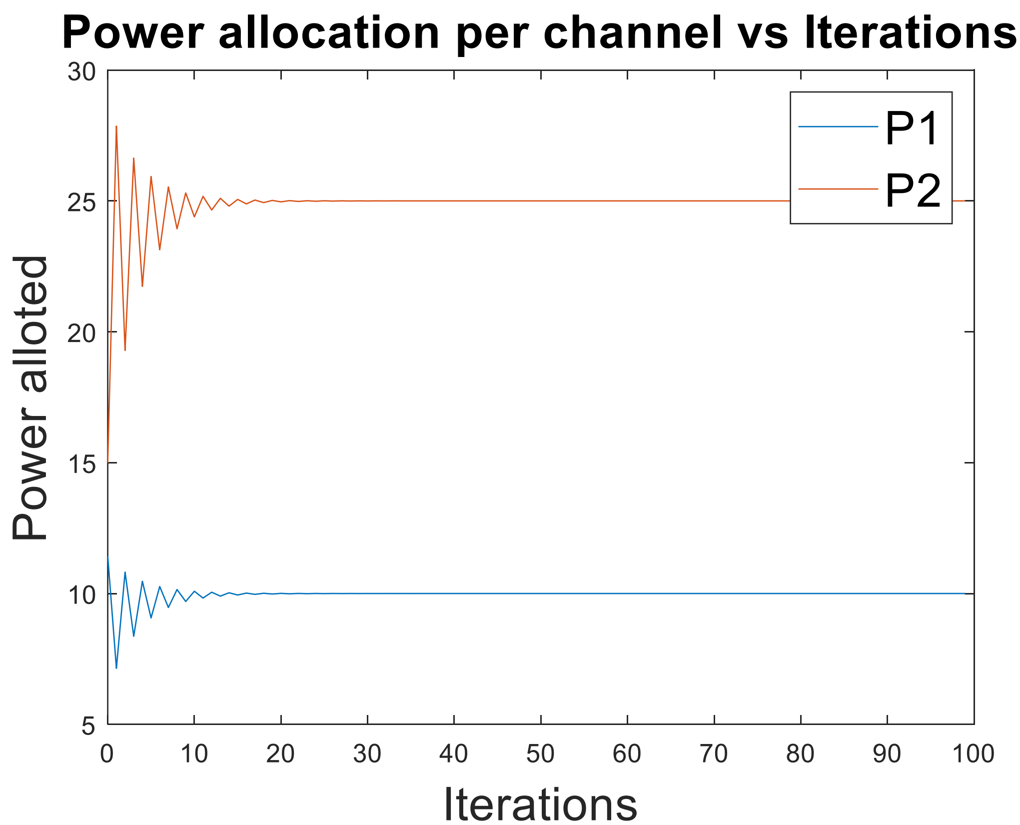
(c).

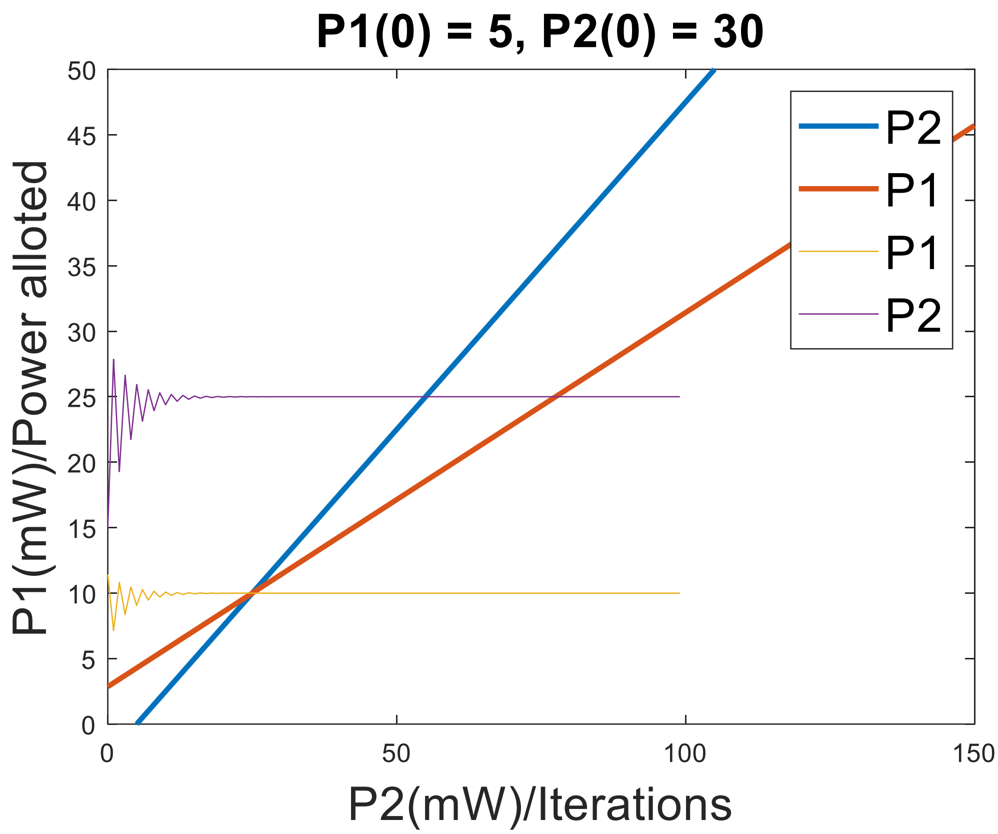

Power allocation per channel vs Iterations
Power alloted
Iterations
P1
P2
0
5
10
15
20
25
0
20
40
60
80
100
120
140

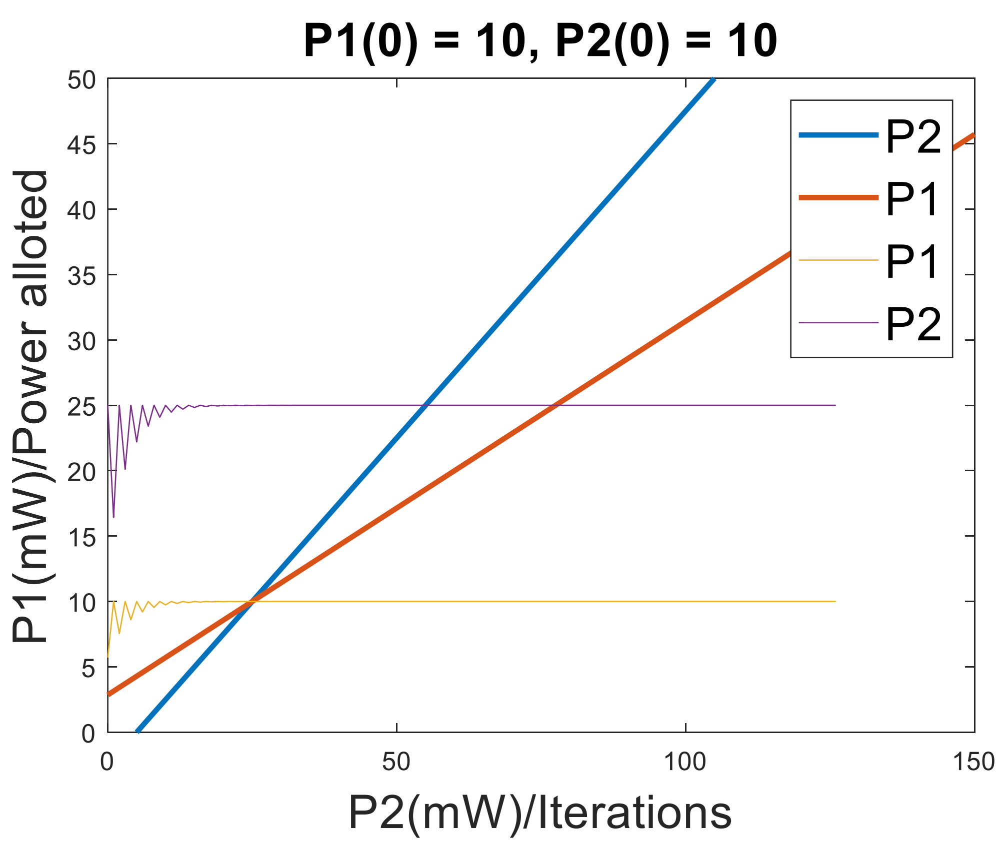

P1(mW)/Power alloted
P2(mW)/Iterations
P2
P1
P1
P2
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150

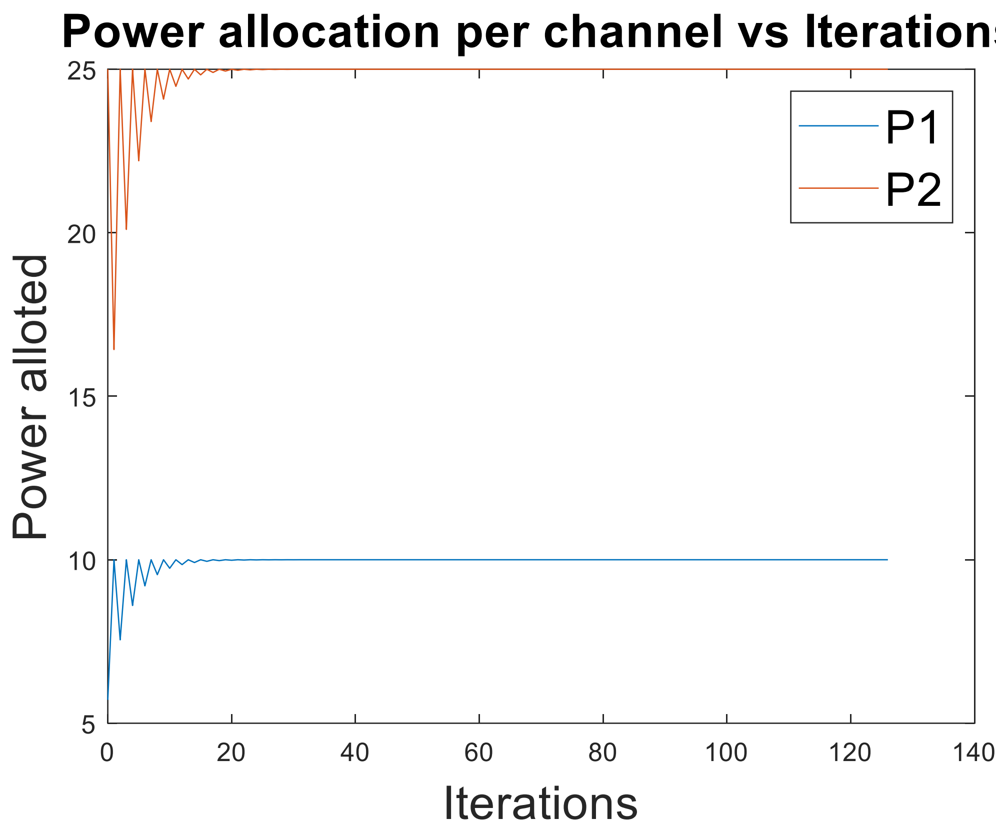
(d). No its not a good to start with 0 because, we'll always get the 0 for the next iterations

(e). For the initial values P1= 5 mW less than i.e. 5 mW and P2 = 5 mW more than i.e. 30 mW previous optimal values, the F-M algorithm converges. The following are some of the plots for different initial values.

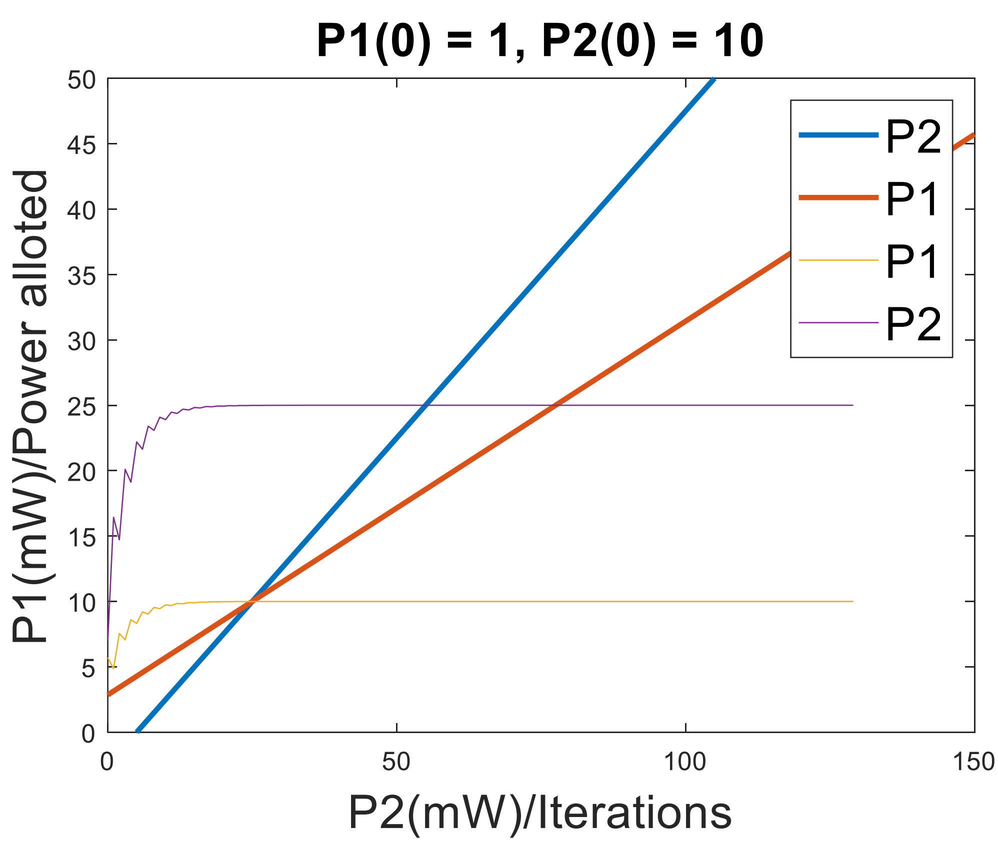



P1(0) = 5, P2(0) = 30
P2
P1
P1
P2
P1(mW)/Power alloted
P2(mW)/Iterations
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150

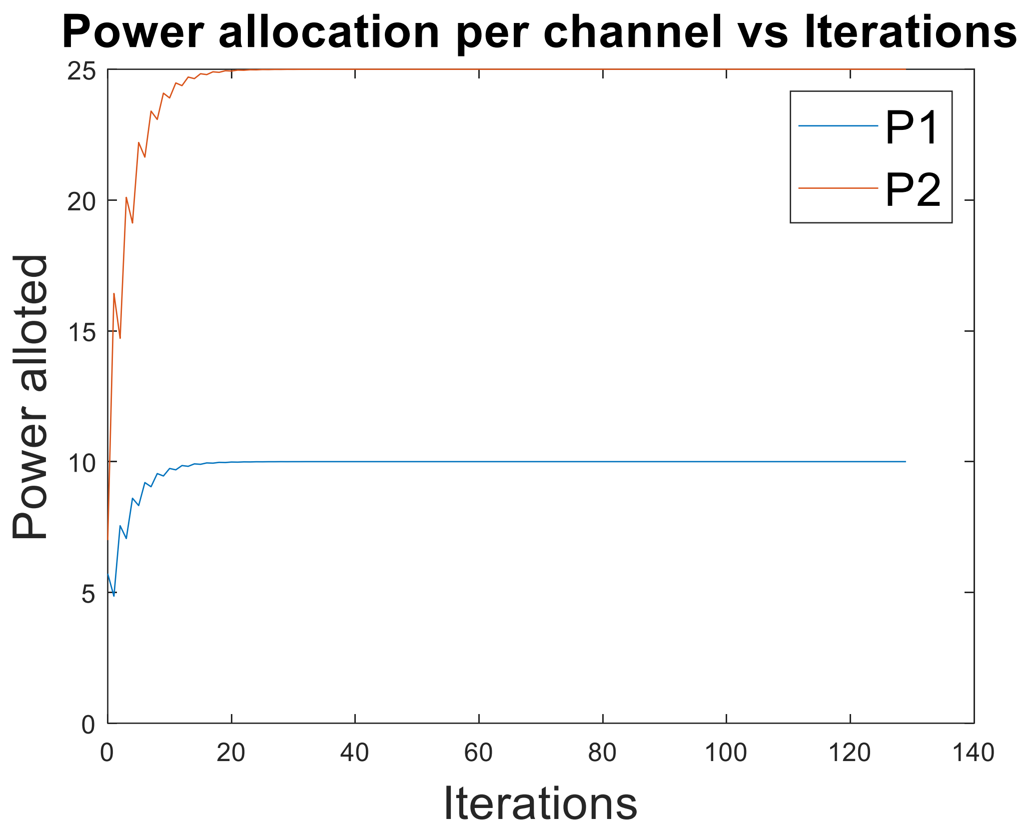

P1(0) = 10, P2(0) = 10
P2
P1
P1
P2
P1(mW)/Power alloted
P2(mW)/Iterations
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150



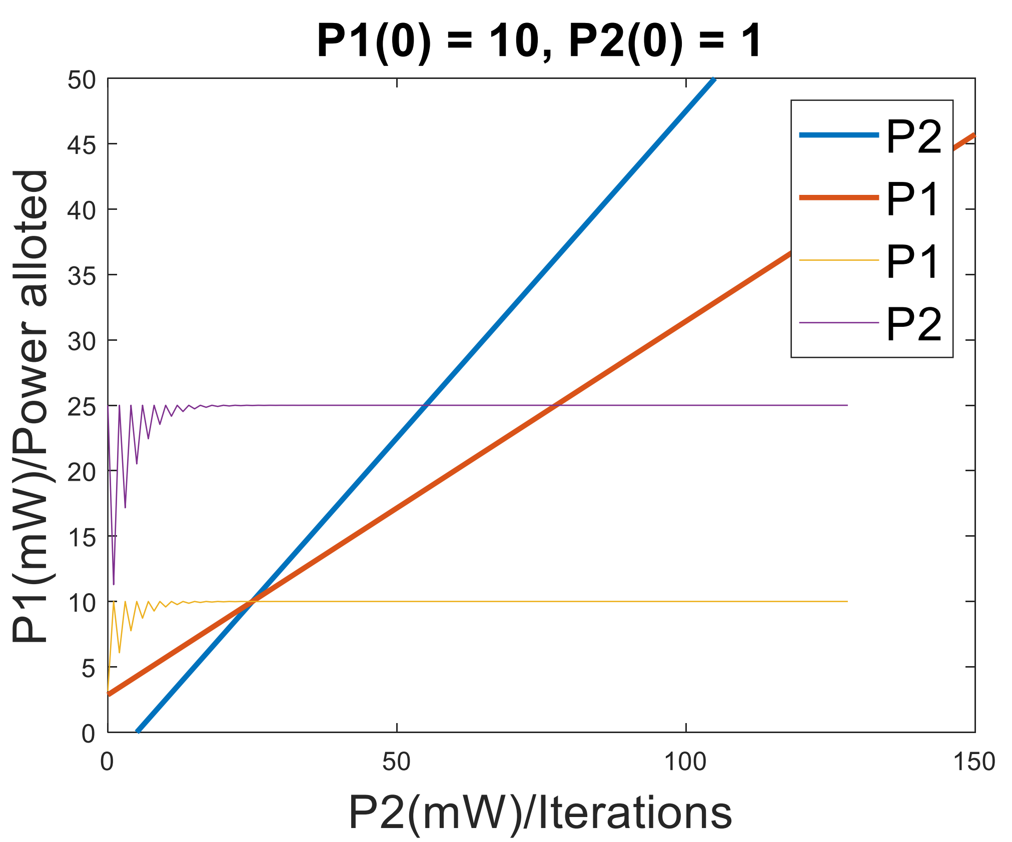
Power allocation per channel vs Iterations
P1
P2
Power alloted
Iterations
25
20
15
10
5
0
20
40
60
80
100
120
140



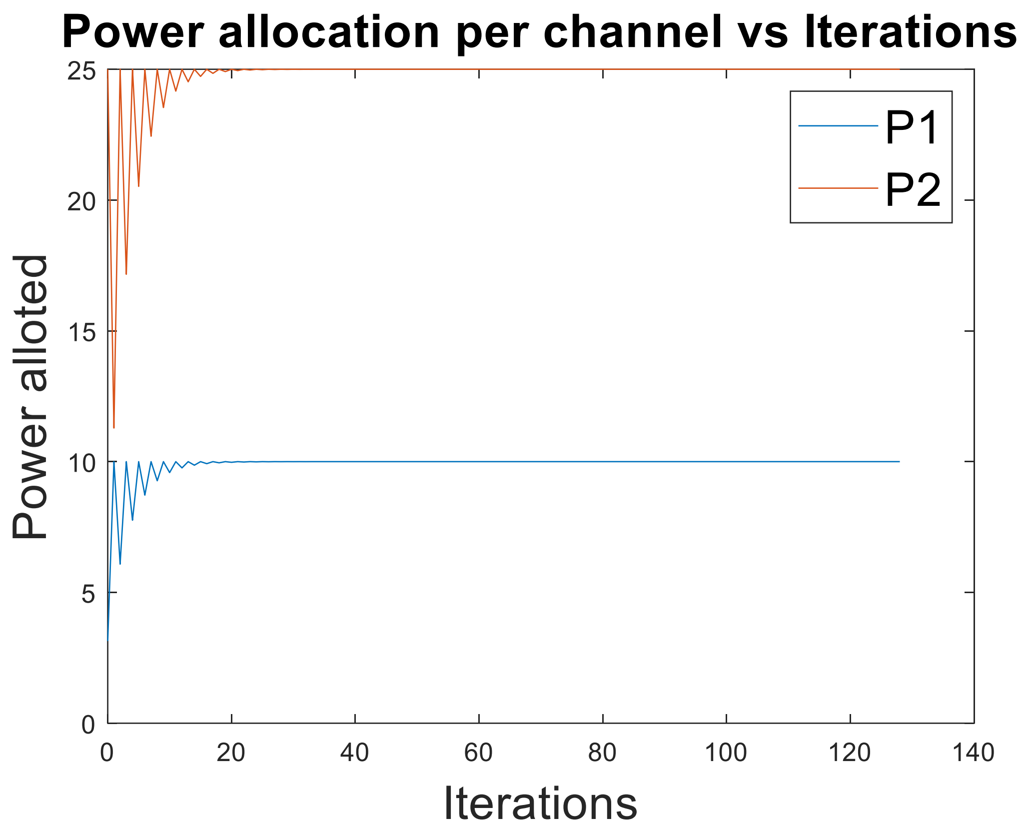
P1(0) = 1, P2(0) = 10
P2
P1
P1
P2
P1(mW)/Power alloted
P2(mW)/Iterations
50
45
40
35
30
25
20
15
10
5
0
0
50
100
150



Power allocation per channel vs Iterations
P1
P2
Power alloted
Iterations
0
5
10
15
20
25
0
20
40
60
80
100
120
140



P1(0) = 10, P2(0) = 1
P2
P1
P1
P2
P1(mW)/Power alloted
P2(mW)/Iterations
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150



Power allocation per channel vs Iterations
P1
P2
Power alloted
Iterations
0
5
10
15
20
25
0
20
40
60
80
100
120
140

EE597

oct 20th 22nd

Q2 $P_{Tx} = 23dBm$. $P_{Rx} = -10dBm$

Noise = -90dBm.

$d = 1m$

$$P_{Rx} = P_{Tx}\ K \log\left(\frac{d}{d_R}\right)$$

$$P_{Rx}(d) = P_{Rx}(1m) - 20\log d(1m)$$

$$P_{Rx}(1m) = -10dBm.$$

for $d_R = 1m = d$

~~PR (dBm)~~

$$P_{Rx} = P_{tx} + K - 10\eta \log\left(\frac{d}{d_R}\right)$$

$$\log\left(\frac{d}{d_R}\right) = \log(1) = 0$$

$$P_{Rx} = P_{tx} + K.$$

$$-10 = 23 + K$$

$$\boxed{K = -33dBm}.$$

$$P_{Rx} = SNR + P_{Noise} + (\text{Noise Figure})$$ ignore

$$P_{Rx} - P_{noise} = SNR.$$

~~SNR~~

$$P_{Rx} = P_{tx} + K - 10\log d.$$

$$SNR + P_{Noise} = P_{tx} + K - 10(\log d)\eta$$

$$SNR = P_{tx} - P_{noise} + K - 10\eta\log d$$

$$10(\log d)\eta = P_{tx} - P_{noise} + K - SNR$$

$$\log d = \frac{P_{tx} - P_{noise} + K - SNR}{10\eta}$$

$$\log d = \frac{-23 + 90 - 33 - SNR}{10\eta}$$

$$\left[\cancel{\log d} = \frac{\cancel{34} - SNR}{10\eta}\right]$$

Spec. effic. = $\frac{\text{Tx rate}}{\text{B.W}}$ ⟶ Goodput

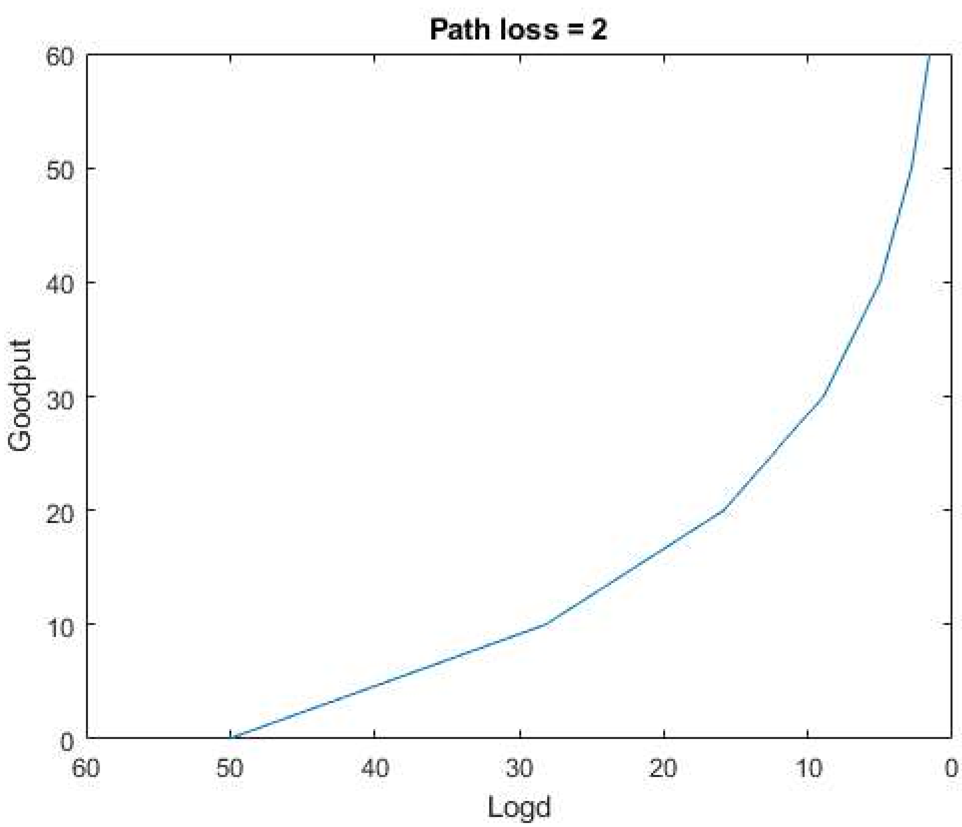
$$C = \log_2(1 + SNR)$$

$$\log d = \frac{+34 - SNR}{10\eta}$$

Contents

eta = 2

```
Snrdb = [0 5 10 15 20 25 30];
Snr = 10.^(Snrdb);
%for path loss = 2
eta = 2;
log_d_1 = (34-Snrdb)/(10*eta);
d_1 = 10.^(log_d_1);
c = [0 10 20 30 40 50 60];
figure(1);
plot(d_1, c);
title('Path loss = 2');
xlabel('Logd');
ylabel('Goodput');
set(gca, 'XDir','reverse');
```



eta = 4

```
%for path loss = 4
eta = 4;
log_d_2 = (34-Snrdb)/(10*eta);
d_2 = 10.^(log_d_2);
c2 = [0 10 20 30 40 50 60];
figure(2);
plot(d_2, c2);
```

```
title('Path loss = 4');
xlabel('Logd');
ylabel('Goodput');
set(gca, 'XDir','reverse');
```