A NOVEL GYSEL POWER DIVIDER AT 3GHZ FREQUENCY WITH EQUAL AND UNEQUAL POWER RATIO FOR ANTENNA APPLICATIONS

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ABSTRACT

Gysel Power divider is a novel approach to achieve unequal and equal power division and again suitable for termination with and without any transmission losses. This Power divider has advantage over Wilkinson power divider; it has high power handling capability. By making use of transmission line parameters, the simple closed form design equations are available for evaluation of various components. In this project both for equal and unequal power division parameters are studied and appropriate result are obtained. It is seen that this is good example for equal and unequal power division .In this paper I had designed the gysel power divider which works for equal as well as unequal power divider at 3 ghz frequency. Many antennas are operating at this frequency. It will work for high powers.

I. INTRODUCTION

In Wilkinson power divider due to the isolating resistor between port 2 and port 3 that cannot be used at high powers. And also needed to provide external circuits to compensate the parasitic capacitance effects in that but in gysel power divider we are not using any isolating resistors and it can be used for high power applications. Isolation is improved by -15 db and insertion loss -3db.Power Dividers plays a vital role in many microwave and radar applications such as mixers & phased array antennas, High power amplifiers .Among all these Wilkinson power divider and Gysel power divider are most popular divider used now a days due to its capability to handle more power. Recently Dual band applications for Gysel power divider has also been studies .Gysel power divider has attracted more attention because of its Capacity to handle high power. There is essential requirement for power to be divided unequally for wide range of applications. Implementing Gysel power divider for unequal power division asymmetrical multi-section and complex impedance matching and some other remedies to be used .Here power dividing ratio is kept less than 6 .In case of Wilkinson power divider, there are some ambiguities with equal and unequal power division because it is unable to realize the high characteristic impedance transmission lines.There are some novel techniques have been implemented to obtain unequal power with high power handling capacity The simple design implementation is performed in [7].Which is not up to the mark as it does not provide effective path for heat dissipation generated by isolation resisters. Now a days a new extremely unequal single band Wilkinson power divider is one which provides compact design and layout. Here Gysel power divider is good agreement over WPD. Gysel divider's external resister are grounded to provide a direct path for heat sinking .This Gysel power divider has been used in many high

Power handling applications. Earlier this design was used at single frequency only .There are many gateways for multisession equal wideband Gysel power divider. Even and Odd mode analysis is being performed for wideband unequal Gysel power divider .Until now, as per the analysis there are no proceedings over unequal dual band Gysel power divider.

K^2=p2/p3.

S21=-10log(p2/p1), s31=-10log(p3/p1)

S32=-10log(p3/p2).

II. DESIGN PROCEDURE AND THEORYTICAL ANALYSIS

The configuration of newly proposed modified Gysel power divider is as shown in figure .This consist of five sections of microstrip transmission line starting from Z1 to Z6 and two grounded isolation resisters (RoA and RoB) .Here at the output power dividing ratio is depending on k^2(k^2=P2/P3),for the proposed Gysel Power divider with asymmetrical structure. For the implementation of electrical length at the given center frequency of those transmission lines from Z1 to Z5 is 90^0 while for electrical length of Z6 it is 180^0. The PD is terminated with arbitrary impedances and has wide range applications .Again two grounded isolation resisters RoA and RoB are thin film resistors and should have commercially available values and because of this .The generated Gysel Power Divider has accurate unequal power dividing capability.

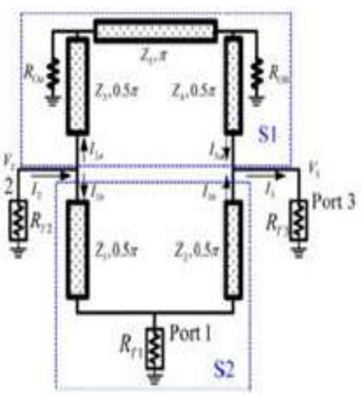
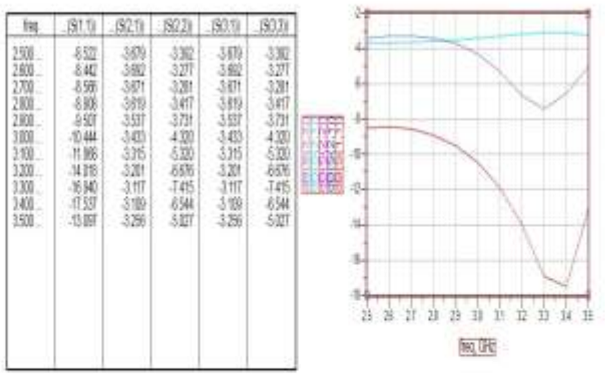


Fig.1 : Proposed Gysel Power Divider



freq	(S(1,1))	(S(2,1))	(S(2,2))	(S(3,1))	(S(3,2))
2.500	-8.522	-3.679	-3.362	-3.679	-3.362
2.600	-8.442	-3.692	-3.277	-3.692	-3.277
2.700	-8.595	-3.671	-3.281	-3.671	-3.281
2.800	-8.906	-3.619	-3.417	-3.619	-3.417
2.900	-9.507	-3.537	-3.731	-3.537	-3.731
3.000	-10.444	-3.433	-4.320	-3.433	-4.320
3.100	-11.866	-3.315	-5.320	-3.315	-5.320
3.200	-14.018	-3.201	-6.676	-3.201	-6.676
3.300	-16.940	-3.117	-7.415	-3.117	-7.415
3.400	-17.537	-3.109	-6.544	-3.109	-6.544
3.500	-13.097	-3.256	-5.027	-3.256	-5.027

Fig.2 : Simulation Results

As the terminal impedances of proposed structure are arbitrary real values .There is necessity of lossless PD and transmission is necessary and hence there is no current flowing through the grounded isolation resistors and hence power is dissipated. When port 1 is excited, the equivalent diagram is shown in a given figure and hence equivalent terminated impedances are given by

$$\text{RT1a} = \frac{(1+k^2)RT1}{k^2} \quad , \; R_{T1}b = (1+k^2)R_T \qquad (1)$$

Here electrical lengths used are 90 .The given circuit can again be simplified into two conventional quarter wavelength impedance transformer and their values are given by

Z1= $\sqrt{RT1RT2} = \sqrt{(1+k^2)RT1RT2}$ (2)

Z2= $\sqrt{RT1bRT3} = \sqrt{(1+k^2)RT1RT3}$

Now By using a concept of transmission line, The relation between V and I is given by

$$\begin{bmatrix} V_2 \\ I_{2a} \end{bmatrix} = \begin{bmatrix} A_{s1} & B_{s1} \\ C_{S1} & D_{S1} \end{bmatrix} \begin{bmatrix} V_3 \\ I_{3a} \end{bmatrix} \quad (3a)$$

$$\begin{bmatrix} V_2 \\ I_{2b} \end{bmatrix} = \begin{bmatrix} A_{s2} & B_{s2} \\ C_2 & D_{s2} \end{bmatrix} \begin{bmatrix} V_3 \\ I_{3b} \end{bmatrix} \quad (3b)$$

$I_2 = I_{2a} + I_2 b$

$I_3 = I_{3a} + I_3\ b$

Based on S1 and S2 in fig 1, ABCD parameters of these network is given by

$$\begin{bmatrix} A_{s1} & B_{s1} \\ C_{S1} & D_{S1} \end{bmatrix} = \begin{bmatrix} Z_3 Y_4 & Z_3 Z_4 (Y_{0a} + Y_{0b}) \\ 0 & Z_4 Y_3 \end{bmatrix}$$

$$\begin{bmatrix} A_{s2} & B_{s2} \\ C_2 & D_{s2} \end{bmatrix} = \begin{bmatrix} -Z_1 Y_2 & -Z_1 Z_2 Y_1 \\ 0 & -Z_2 Y_1 \end{bmatrix}$$

Again considering the case with excitation at port 2 Hence the perfect isolation and matching is achieved i.e for this ideal condition is $I_3=0$ and hence

$V_3 = 0$ Hence by combining with ideal condition results, We get are

$Bs_1 + Bs_2 = 0$,

$$R_{T2} = \frac{V_2}{I_2} = \frac{B_{s1}}{D_{s1} - D_{s2}}$$

After some manipulation it is as follows

$$Z_3 = \sqrt{\frac{R_{T2} R_{oA} R_{0B} (1+k^2)}{(R_{0A} + R_{0B})}}$$

$$Z_4 = \sqrt{\frac{R_{T3} R_{0A} R_{oB} (1+k^2)}{k^2 (R_{0A} + R_{oB})}}$$

When high power signal is excited at port 3, it is observed from the fig that port 2 should be isolated, in this case and hence $I_2=0$ and $V_2=0$.Due to reciprocity property of the passive circuit The equations derived in above design as this makes it possible to produce perfect output port matching and isolation also .For the condition that when all three ports are terminated by some 50 ohm impedance and appropriate values are chosen for isolation resistors. The practical range of k for 20 to 120 ohm micro-strip line is 1 to $\sqrt{4.76}$.

These are some design steps for the modified Gysel Power divider and as follows

1. For the practical implementation of this, the values of terminal impedances, The power dividing ratio k^2 and a band of frequency is known.
1. Choosing high power isolation resisters their normal value are determined based on given value all electrical parameters values are calculated by this .
2. The characteristic impedance is Z_6 is free variable operating wider bandwidth Z_6 chosen as 25 ohm
3. When transmission line implementation techniques and substrate for printed Circuit Board is selected ,Final layout can easily be synthesized from electrical parameters

III. SIMULATION AND RESULTS

For the theoretical and experimental implementation, operating at 3GHz is performed. For this power divider isolation resisters used, having values as R_0A=47 Ohm and R_{0B}= 56 are taken. And characteristic impedance is taken as Z_5=25 Ohm. The given experiment is performed in two ways.This is performed for different values of k^2 =2 and the impedance parameters for this are as follows.

Z1=61.24 Ohm , Z2=86.60 Ohm , Z3=61.91 Ohm, Z4=43.78 Ohm

Again the same divider is designed for k^2=4

And impedance parameters are as

Z1=77.46 Ohm , Z2=89.44 Ohm , Z3=55.38 Ohm, Z4=63.94 Ohm. This experiment is performed with silicon having dielectric constant of 4.4 and a thickness of 1.6mm.

The given diagram shows the results for that all the matching and isolation parameters are at appropriate values obtained .And the insertion loss is measured

This experiment is good agreement between simulated and measured values. Following tables gives the result of tabulation .At the 3 ghz frequency S21=-3.021 and S31=-3.002 and also these will tells that 50% of the power is dividing in one port and the remaining power is dividing to the other port at the operating frequency. We can operate easily and dividing powers to the number of antenna feeding networks (2 ports in the sense) this divider providing good isolation i.e. -67.878 db and the return loss also -66db when operating it as a equal power divider. If k changes impedance changes at their corresponding ports due to this the dividing power ratio among the ports also changes from base paper actually does for minute power division only by changing electrical length k changes due to this power also changes at ports but in this paper we used impedance formulas that will Suitable for any division ratios.

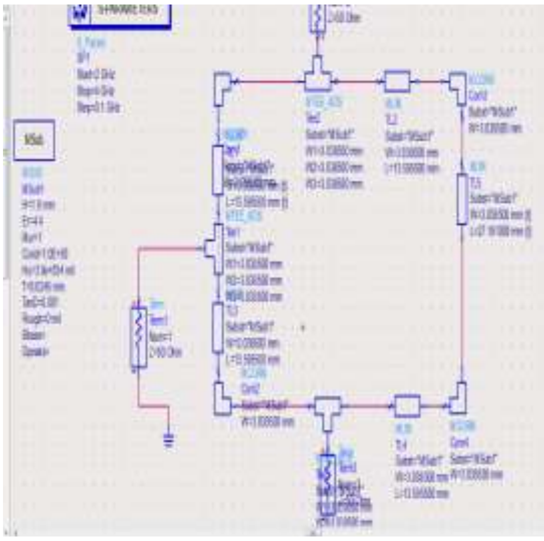


Fig.3 : Simulation Circuit Of Equal GPD Of k^2=3

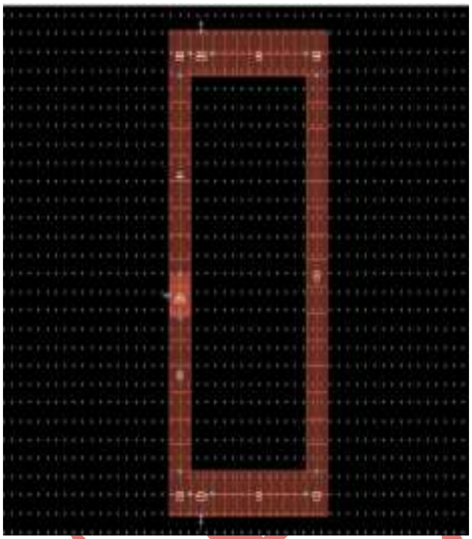


Fig.4 : EM simulation Layout Of Equal GPD Of K^2=3

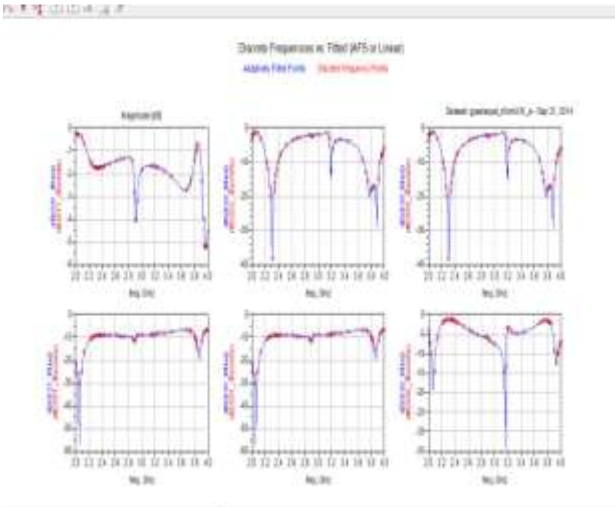


Fig.5 : Simulation Result Of Equal GPD

Fig.6 : Em Simulation Lay Out Of Equal power Divider Of k^2=3

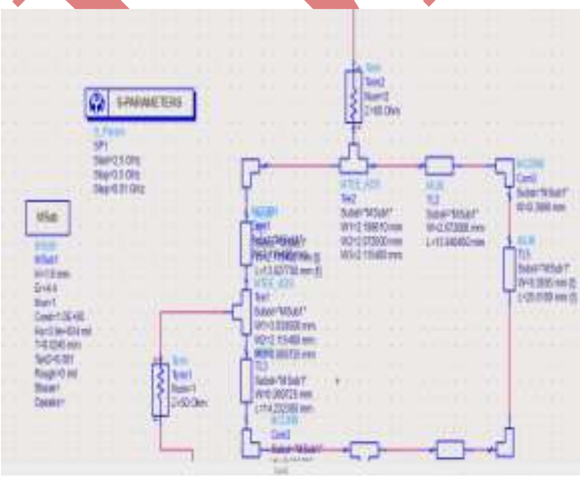


Fig.7 : Simulation Circuit Of GPD Of k^2=4

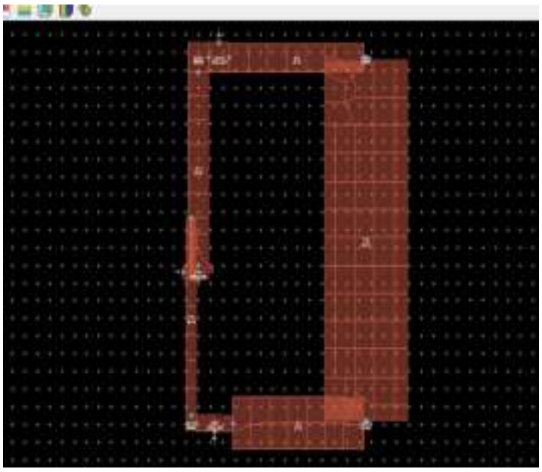


Fig.8 : EM Simulation Layout Of GPD OF k^2=4

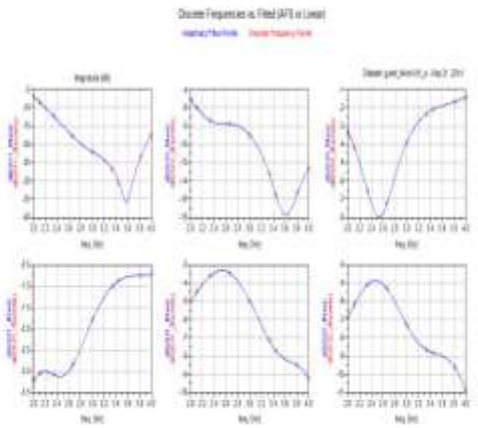


Fig.9: EM Simulation Result Of Unequal GPD OF k^2=4

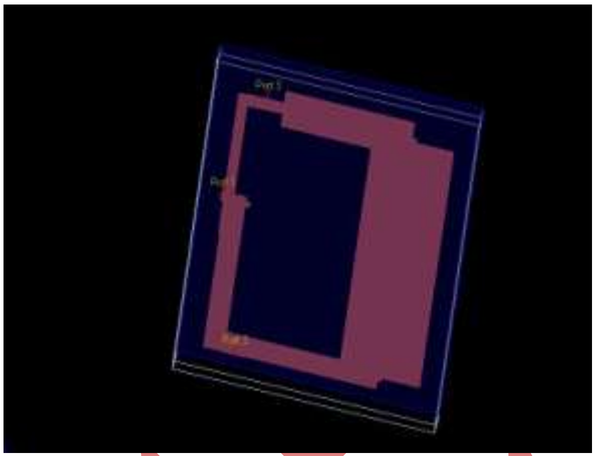


Fig.10: EM Simulation Layout Of Unequal GPD Of k^2=4

IV. CONCLUSION

An effective analytical method is proposed in this paper for designing of Gysel power divider for equal and unequal power division for different impedances values. According to proposed paper, in order to implement unequal power division there is no necessity of any extra output impedances. One more characteristic is that it can handle high power. So this modified Gysel power divider approach has good advantages and simple analytical design approach .This proceeds with its application in high power circuits. By using this formulas for k we can design any power divider depends upon our application the results we observed from the simulations is if we choose k=1 the power division among port 2 and port 3 are 50% and 50%.if we choose k=sqrt(2) the power division ratios among port 3 and port 3 are66.51% and 33.24%.for k=sqrt(3) we observed power division ratios at port 2 and port 3 are 71.12% and 27.43%.for k sqrt(4) the power division ratios among port 2 and port 3 are 79.83% and 19.94% respectively. We designed our gysel power divider at 3ghz frequency for antennas and horn antennas and yagi uda antennas which are operated at my design frequency. at antenna feeding networks we will use this power divider. We can achieve different power ratios among port 2 and port 3.depends upon our application we have to choose k value higher the k value higher the power division ratio.

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