通)，而N-通道電晶體145及146為非傳導的(斷開)。信號路徑自源101、經由驅動級105、經由級間匹配網路106延伸至節點140，經由第一AB類放大器電路109延伸至求和節點147，經由輸出匹配網路103且延伸至負載104。

在該實施例中，電晶體143至146中之每一者實際上包括具有45 μm/0.25 μm之W/L的一百(100)個並接N-通道場效電晶體。因此，電晶體143至146中之每一者為使第一AB類放大器電路109及第二AB類放大器電路110中之插入損失保持為低之大設備。

在第二操作模式中，功率放大器8以較低的平均輸出功率驅動負載104。數位控制信號Vcon具有數位低位準。因此，類比多工器電路107將節點140耦合至第二AB類放大器電路110之輸入節點142且使節點140自第一AB類放大器電路109之輸入節點141去耦。第一AB類放大器電路109被認為去能的。N-通道電晶體145及146為傳導的(接通)，而N-通道電晶體143及144為非傳導的(斷開)。信號路徑自源101、經由驅動級105、經由級間匹配網路106延伸至節點140，經由第二AB類放大器電路110延伸至求和節點147，經由輸出匹配網路103且延伸至負載104。

因此，在第一操作模式中，第一AB類放大器電路109用以驅動輸出端子117及負載104。在一實例中，電晶體121經偏壓以具有達成由所使用之蜂巢式通信標準所需之線性的最小傳導角。減小傳導角可增加效率。另一方面，在第二操作模式中，第二AB類放大器電路110用以驅動輸出端

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子117及負載104。以較低DC偏壓電壓及較低DC偏壓集電極電流來偏壓第二AB類放大器電路之電晶體124及125，以使得在以第二操作模式之較低輸出功率位準操作時不浪費DC功率。

不管功率放大器8是在第一操作模式還是第二操作模式中操作，整個功率放大器8之功率增益大體上相同。使用習知動態電流偏壓之功率放大器中功率增益的變化通常由功率電晶體中電流密度之變化引起。在圖3之實施例中，SiGe HBT電晶體121中之電流密度約略為DC偏壓電流除以電晶體121之發射面積。HBT電晶體之一者的發射面積為發射寬度與發射長度之乘積。總發射面積為組成電晶體121之一百個構成性電晶體之發射面積的總和。類似地，SiGe HBT電晶體124及125中之電流密度約略為DC偏壓電流除以電晶體124或電晶體125之發射面積。組成電晶體124及電晶體125之構成性HBT電晶體中的每一者具有與組成第一AB類放大器109之電晶體121之HBT電晶體相同的尺寸。然而，在第二AB類放大器電路110之電晶體124及125中的每一者中僅存在二十個此等HBT電晶體。因此，第二AB類放大器電路110之電晶體124及125的總發射面積為第一AB類放大器電路109之電晶體121之總發射面積的百分之二十。因為將第二AB類放大器電路110中之DC偏壓電流設定為二十毫安培且將第一AB類放大器電路109中之DC偏壓電流設定為一百毫安培，所以兩個放大器電路中之功率電晶體內的電流密度相同。使兩個放大器電路之電流密度

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保持相同有助於使兩個放大器電路之功率增益保持相同。

然而，存在使功率增益在兩種操作模式中維持相同的其他因素。第一AB類放大器電路109之輸出與第二AB類放大器電路110之輸出之間的輸出連接將寄生效應增加至每一放大器之輸出，此減少總功率增益。然而，增加的寄生效應用以減少兩個放大器之功率增益之間的任何差，此係因為在第一操作模式與第二操作模式之間切換時第二級之輸入阻抗幾乎不變。

諧振技術亦用以幫助確保功率放大器8之功率增益在兩種操作模式之每一者中相同。最佳化第二AB類放大器電路110之輸出與求和節點147之間的連接以及第一AB類放大器電路109與求和節點147之間的連接，以藉由使第一AB類放大器電路109之輸出電容部分地諧振而提高第二操作模式(低功率操作模式)中之增益。因為第二AB類放大器電路110之輸出阻抗高於第一AB類放大器電路109之輸出阻抗，所以節點147上之寄生電容對低功率增益具有更大的降級作用。藉由使第二操作模式(低功率操作)中之寄生電容部分地諧振，而使第一操作模式與第二操作模式之間的增益差進一步減少。

在說明性實施例中，電感148為第二AB類放大器電路110之輸出與求和節點147之間的導線之電感。電感148具有約0.2 nH之值且該電感之量值由導線布局確定。電感148經設定以達成諧振。電容器符號149表示第一AB類放大器電路之輸出電容。其具有約5 pF之電容。電容器符號

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150表示第二AB類放大器電路110之輸出上之寄生電容。其具有約1 pF之值。電容器151及152具有20 pF之值。當使用此等值時，達成有益的增益穩定化諧振。

圖6為展示在水平尺度上功率放大器8之輸出功率的圖式。總DC偏壓電流展示於垂直尺度上(參見圖右側之刻度)。虛線200展示在使用習知恆定電壓偏壓(CV)之情況下DC偏壓電流將呈現之狀態。線201展示由圖3之功率放大器8抽取的DC偏壓電流。"DDB"標號指示"雙動態偏壓"，其為用以描述圖3之功率放大器8所使用之技術的術語。確定功率放大器是在第一操作模式還是第二操作模式中操作之預定輸出功率為16 dBm。如圖6中所示，功率放大器8在以低於16 dBm之較低輸出功率操作時抽取較少DC偏壓電流。

在圖6之左側存在命名為"機率分佈函數%"之刻度。該刻度係針對曲線202，其係作為功率放大器輸出功率之函數的CDMA機率分佈函數(PDF)。收集及分析蜂巢式電話使用之經驗資料以確定蜂巢式電話在何等百分比時間以何等輸出功率位準來傳輸。曲線202之左分支部分表明蜂巢式電話僅在小的百分比之時間以極低功率位準操作。曲線202之右分支部分表明蜂巢式電話僅在小的百分比之時間以極高功率位準操作。曲線202之中央峰表明蜂巢式放大器在大部分時間以中度功率位準操作。應注意，線201在比線200與該中度功率位準區域相交處更低的DC偏壓電流位準處與該中度功率位準區域相交。此代表蜂巢式電話可

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由單次電池充電提供操作之實質的功率節省及時間量的延長。

圖7為展示為約百分之五的WCDMA輸出功率PDF(機率分佈函數)之圖3功率放大器8之平均功率效率的圖表。標號"DDB"指示雙動態偏壓且標識功率放大器8之資料點。標註為"DCB"之點標識使用習知動態電流偏壓技術之功率放大器的資料點。標註為"CV"之點標識使用恆定電壓偏壓而未使用任何動態偏壓技術之功率放大器的資料點。

圖8為展示圖3之功率放大器8之功率增益如何在大的輸出功率範圍內恆定的曲線圖。標註為"DDB"之線300指示圖3之功率放大器8的功率增益。功率放大器8之功率增益在輸出功率在40 dB範圍內變化時之變化小於5 dB。標註為"DCB"之線301指示使用動態電流偏壓技術之習知功率放大器所呈現之功率增益的情況。在16 dBm處之垂直虛線標識確定功率放大器8是在第一操作模式還是第二操作模式中操作之預定輸出功率位準。線301指示大於15 dB的增益變化。

圖9展示對於具有及不具有數位預失真(DP)之兩種狀況，在5 MHz下以ACPR(鄰近通道功率比)而量測之PA 8之線性。使用無記憶數位預失真線性化電路，但其僅用於高於16 dBm之第一操作模式(高功率模式)中。此為ACPR在"DP後"曲線中不連續之原因。在數位預失真情況下ACPR改良至少8 dB，且滿足WCDMA線性規範之最大輸出功率自22.4 dBm改良至26 dBm。功率放大器8具有在功率放大

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器輸出功率高達26 dBm下優於-33 dBc的ACPR(鄰近通道功率比)。此滿足最大輸出功率之WCDMA的3類需求。因此，峰值PAE(功率增加效率)改良了百分之六十(自17%至27%)。

對複數個輸出功率範圍中之每一者使用不同AB類放大器電路的技術可擴大為使用兩個以上AB類放大器電路。圖10為對所達成之平均功率效率與所使用之AB類放大器電路之數目的比較。一功率放大器可(例如)使用三個不同AB類放大器電路及確定在給定操作條件下將使用三個放大器電路中之哪個的兩個預定輸出功率位準。若干因素會影響AB類功率放大器電路之最佳數目，包括：與更多放大器電路及一大的類比多工器相關之所增加的複雜性及寄生效應，增益變化及在最低輸出功率位準下減少之功率消耗。舉例而言，使用三個AB類放大器電路比僅使用兩個AB類放大器電路之其對應物(參見圖3)達成更好的平均效率(8.9%)。然而，對應電路複雜性增加且可達成之功率增益歸因於所增加的寄生效應而降低。增加更多放大器電路會導致進一步的收益遞減，所以在圖1之蜂巢式電話1中採用包括兩個AB類功率放大器電路之圖3的拓撲結構。

圖11為根據一新穎態樣之方法的簡化流程圖。對蜂巢式電話是在第一操作模式還是第二操作模式中操作進行確定(步驟400)。在一實例中，第一操作模式為"通話"模式，且第二操作模式為"等待"模式。在一實例中，數位基頻積體電路4確定且輸出數位信號Vcon，數位信號Vcon之數位邏

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輯位準指示蜂巢式電話是在第一操作模式還是第二操作模式中操作。

若蜂巢式電話在第一操作模式中操作，則第一AB類放大器電路用以(步驟401)驅動功率放大器(PA)輸出端子。以第一DC偏壓集電極電流及第一DC偏壓集電極-發射極電壓來偏壓第一AB類放大器電路內之功率電晶體(由多個並接電晶體組成)。

另一方面，若蜂巢式電話在第二操作模式中操作，則第二AB類放大器電路用以(步驟402)驅動功率放大器(PA)輸出端子。以第二DC偏壓集電極電流及第二DC偏壓集電極-發射極電壓來偏壓第二AB類放大器電路內之功率電晶體(由多個並接電晶體組成)。在第一操作模式為涉及與第二操作模式相比以較高輸出功率操作功率放大器之模式的情況下，第一DC偏壓集電極電流大於第二DC偏壓集電極電流，且第一DC偏壓集電極-發射極電壓大於第二DC偏壓集電極-發射極電壓。藉由對第一AB類放大器電路及第二AB類放大器電路中之功率電晶體適當設定大小，使得第一AB類放大器電路與第二AB類放大器電路之功率電晶體中的發射極電流密度在兩種操作模式中大體上保持相等，從而使功率放大器之功率增益在兩種操作模式中之每一者中大體上相同。

儘管上文為達成指導目的而描述某些具體實施例，但此專利文獻之教示具有一般應用性且不限於上文所描述之具體實施例。儘管在上文圖3之實例中第一及第二放大器電

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路為AB類放大器，但使用不同放大器電路以在複數個不同操作模式中之每一者中驅動功率放大器輸出端子的技術可包括其他類放大器。並非所使用之所有放大器需要在相同類中操作。舉例而言，在第一操作模式中使用之第一放大器可在AB類中操作且在第二操作模式中使用之第二放大器可在C類中操作。儘管上文將放大器電路109及110稱作AB類放大器電路，但放大器電路109及110可以其他類放大器之傳導角操作長達小部分的時間。舉例而言，在一些實施例中，AB類放大器110在一短時段內被猛烈驅動以致其所剪輯之度數導致其傳導角達180度，但該剪輯度數僅在極小部分的時間內發生。因此，在不脫離下文陳述之申請專利範圍之範疇的情況下可對所述具體實施例之各種特徵進行各種修改、改變及組合。

【圖式簡單說明】

圖1為根據一新穎態樣之蜂巢式電話的高階圖。

圖2為圖1之蜂巢式電話之RF收發器電路的更詳細圖式。

圖3為圖2之RF收發器電路之功率放大器的電晶體階圖。

圖4為產生由圖3之功率放大器使用之偏壓電壓之偏壓電路的電路圖。

圖5為說明用以將放大器確定為與A類、B類或C類放大器相對之AB類放大器之方法的圖式。

圖6為展示由圖3之功率放大器消耗之總DC電流與功率放大器之輸出功率之間的圖式。

圖7為展示與利用另外兩種習知動態偏壓技術之功率放

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大器相比的圖3之功率放大器之平均功率效率的圖式。

圖8為展示圖3之功率放大器之功率增益如何在寬輸出功率範圍內穩定之圖式。

圖9展示在5 MHz下以ACPR(鄰近通道功率比)加以量測之圖3之功率放大器的線性。

圖10為說明藉由將對於每一不同輸出功率之操作模式而使用一不同AB類放大器電路之技術擴大至三個或三個以上不同AB類放大器電路及三個或三個以上相應輸出功率操作模式而可達成之平均功率效率的圖式。

圖11為根據一新穎態樣之方法的簡化流程圖。

【主要元件符號說明】

1	蜂巢式電話
2	天線
3	RF收發器電路
3A	RF收發器積體電路
4	數位基頻積體電路
5	天線轉換器
6	雙工器
7	SAW濾波器
8	功率放大器
9	信號鏈
10	本地振盪器
11	低雜訊放大器
12	混頻器

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13	基頻濾波器
14	類比數位轉換器
15	信號鏈
16	基頻濾波器
17	混頻器
18	可變增益放大器
19	驅動放大器
20	數位類比轉換器
21	本地振盪器
100	系統
101	模型信號源
102	輸入匹配網路
103	輸出匹配網路
104	模型負載
105	驅動級
106	級間匹配網路
107	類比多工器電路
108	輸出求和網路
109	第一AB類放大器電路
110	第二AB類放大器電路
111	輸入端子
112	積體電路晶片
113	結合襯墊
114	電感

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115	結合襯墊
116	電感
117	輸出端子
118	電感器
119	電容器
120	結合襯墊電容
121	電晶體
122	電感
123	電感
124	電晶體
125	電晶體
126	導線
127	導線
128	導線
129	Vcc結合襯墊
130	接地導線
131	偏壓電路
132	偏壓電路
133	偏壓電路
134	偏壓電路
135	電流增益輔助電路
136	電流鏡緩衝器
137	信號導線
138	輸入端子

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139	功率偵測器
140	節點
141	輸入節點
142	輸入節點
143	N-通道電晶體
144	N-通道電晶體
145	N-通道電晶體
146	N-通道電晶體
147	求和節點
148	電感
149	輸出電容
150	寄生電容
151	電容器
152	電容器

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十、申請專利範圍：

1. 一種方法，其包含：

在一第一操作模式中，使用一第一AB類放大器電路將第一信號驅動至一輸出端子上，其中該第一AB類放大器電路包括一以一第一偏壓電流I1及一第一集電極-發射極偏壓電壓V1來偏壓之第一功率電晶體，其中該等第一信號處於一高於一千兆赫之頻帶中，且其中一第二AB類放大器電路在該第一操作模式期間被去能；及

在一第二操作模式中，使用該第二AB類放大器電路將第二信號驅動至該輸出端子上，其中該第二AB類放大器電路包括一以一第二偏壓電流I2及一第二集電極-發射極偏壓電壓V2來偏壓之第二功率電晶體，其中I1>I2，其中V1>V2，其中該第一AB類放大器電路在該第二操作模式期間被去能，其中該等第二信號處於該高於一千兆赫之頻帶中，且其中將該第一AB類放大器電路及該第二AB類放大器電路整合至一單一積體電路上。

2. 如請求項1之方法，其中該單一積體電路為一WCDMA(寬頻分碼多向近接)功率放大器積體電路。

3. 如請求項1之方法，其中該第一操作模式為其中該第一AB類放大器電路經由該輸出端子傳遞一較高平均輸出功率之一模式，其中該第二操作模式為其中該第二AB類放大器電路經由該輸出端子傳遞一較低平均輸出功率之一模式。

4. 如請求項1之方法，其進一步包含：

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將一數位信號接收於該單一積體電路之一端子上，其中若該數位信號具有一第一數位邏輯值，則該第一AB類放大器電路在該第一操作模式中驅動該輸出端子，且其中若該數位信號具有一第二數位邏輯值，則該第二AB類放大器電路在該第二操作模式中驅動該輸出端子。

5. 如請求項4之方法，其進一步包含：

使用一功率偵測器以產生該數位信號。

6. 如請求項4之方法，其進一步包含：

在一數位基頻積體電路中產生該數位信號。

7. 如請求項1之方法，其中該第二AB類放大器電路進一步包含一第三功率電晶體，其中在該第二操作模式中該第二偏壓電流I2在一電流路徑中自一電源電壓節點、經由該第二功率電晶體、經由該第三功率電晶體而流至一接地節點。

8. 如請求項1之方法，其中該第一AB類放大器電路及該第二AB類放大器電路為一功率放大器之部分，且其中該功率放大器具有在該功率放大器之一輸出功率在一40 dB之範圍內變化時變化小於5 dB之一功率增益。

9. 如請求項1之方法，其中該第一功率電晶體在該第一操作模式中具有一第一DC偏壓電流密度，且其中該第二功率電晶體在該第二操作模式中具有一第二DC偏壓電流密度，其中該第一DC偏壓電流密度與該第二DC偏壓電流密度大體上相同。

10. 如請求項1之方法，其中該第一AB類放大器電路及該第

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二AB類放大器電路為一功率放大器之部分，且其中該功率放大器具有一大於一WCDMA(寬頻分碼多向近接)輸出功率PDF(機率分佈函數)之百分之四的平均功率效率(APE)。

11. 如請求項1之方法，其進一步包含：

使用一電感以使該第一AB類放大器電路之一輸出電容部分地諧振，其中該第一AB類放大器電路之一輸出節點由一第一導線耦合至一求和節點，其中該電感為自該第二AB類放大器電路之一輸出節點延伸且延伸至該求和節點之一第二導線的一電感。

12. 如請求項1之方法，其中該第一功率電晶體包含並接之複數個電晶體，且其中該第二功率電晶體包含並接之複數個電晶體。

13. 如請求項1之方法，其中該第一功率電晶體具有一發射極及一集電極，其中該發射極連接至一接地節點，且其中該集電極連接至該輸出端子。

14. 一種電路，其包含：

一輸出端子；

一具有一輸入引線及一輸出引線之第一放大器，該輸出引線耦合至該輸出端子，其中該第一放大器包括一以一第一偏壓電流I1及一第一偏壓電壓V1來偏壓之第一功率電晶體；

一具有一輸入引線及一輸出引線之第二放大器，該輸出引線耦合至該輸出端子，其中該第二放大器包括一以

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一第二偏壓電流I2及一第二偏壓電壓V2來偏壓之第二功率電晶體；及

一類比多工器，其具有一輸入引線、一第一輸出引線、一第二輸出引線及一選擇輸入引線，其中若一第一數位邏輯值出現於該選擇輸入引線上，則該類比多工器經由該第一輸出引線耦合其輸入引線上之一信號且將該信號耦合至該第一放大器之該輸入引線上以使得該第一放大器將該信號之一功率放大型式驅動至該輸出端子上，其中若一第二數位邏輯值出現於該選擇輸入引線上，則該類比多工器經由該第二輸出引線耦合其輸入引線上之該信號且將該信號耦合至該第二放大器之該輸入引線上以使得該第二放大器將該信號之一功率放大型式驅動至該輸出端子上，其中在該多工器之該輸入引線上的該信號處於一高於一千兆赫之頻帶中，其中I1>I2，其中V1>V2，其中該第一功率電晶體在該第一放大器驅動該輸出端子時具有一第一DC偏壓電流密度，其中該第二功率電晶體在該第二放大器驅動該輸出端子時具有一第二DC偏壓電流密度，其中該第一DC偏壓電流密度與該第二DC偏壓電流密度大體上相同。

15. 如請求項14之電路，其中該電路為一積體電路，該電路進一步包含：

一耦合至該類比多工器之該選擇輸入引線的輸入端子，其中該輸入端子及該輸出端子為該積體電路之端子。

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16. 如請求項14之電路，其進一步包含：

一產生一數位信號之功率偵測器，該數位信號被供應至該類比多工器之該選擇輸入引線上。

17. 如請求項14之電路，其中該電路為一WCDMA(寬頻分碼多向近接)功率放大器積體電路。

18. 如請求項17之電路，其中該功率放大器具有一大於一WCDMA(寬頻分碼多向近接)輸出功率PDF(機率分佈函數)之百分之四的平均功率效率(APE)。

19. 如請求項14之電路，其中該第二放大器進一步包括一第三功率電晶體，其中該第二偏壓電流I2串聯流過該第二功率電晶體且接著流過該第三功率電晶體。

20. 如請求項14之電路，其中該電路為一發射器鏈中之一驅動放大器的一部分，其中該信號之該功率放大型式由該驅動放大器輸出且由一功率放大器進一步放大。

21. 一種功率放大器，其能夠放大處於一高於一千兆赫之頻帶中之信號且具有在該功率放大器之一輸出功率在一40 dB之範圍內變化時變化小於5 dB之一功率增益，其中該功率放大器具有一在高達26 dBm之功率放大器輸出功率下優於-33 dBc之ACPR(鄰近通道功率比)，且其中該功率放大器具有一大於一WCDMA(寬頻分碼多向近接)輸出功率PDF(機率分佈函數)之百分之四的平均功率效率(APE)。

22. 如請求項21之功率放大器，其中該功率放大器為一積體電路之部分且包含：

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一輸出端子，該功率放大器自該輸出端子輸出處於該頻帶中之該等信號之一放大型式；

一具有一輸入及一輸出之第一放大器電路，其中該第一放大器電路之該輸出耦合至該輸出端子；

一具有一輸入及一輸出之第二放大器電路，其中該第二放大器電路之該輸出耦合至該輸出端子；及

一具有一第一輸出及一第二輸出之類比多工器，其中該第一輸出耦合至該第一放大器電路之該輸入，且其中該第二輸出耦合至該第二放大器電路之該輸入。

23. 如請求項22之功率放大器，其中該積體電路進一步包含：

一控制端子，其耦合至該類比多工器之一選擇輸入。

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十一、圖式：

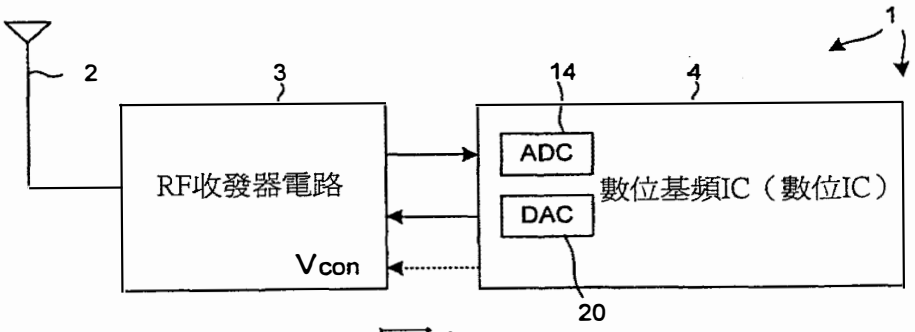


圖1

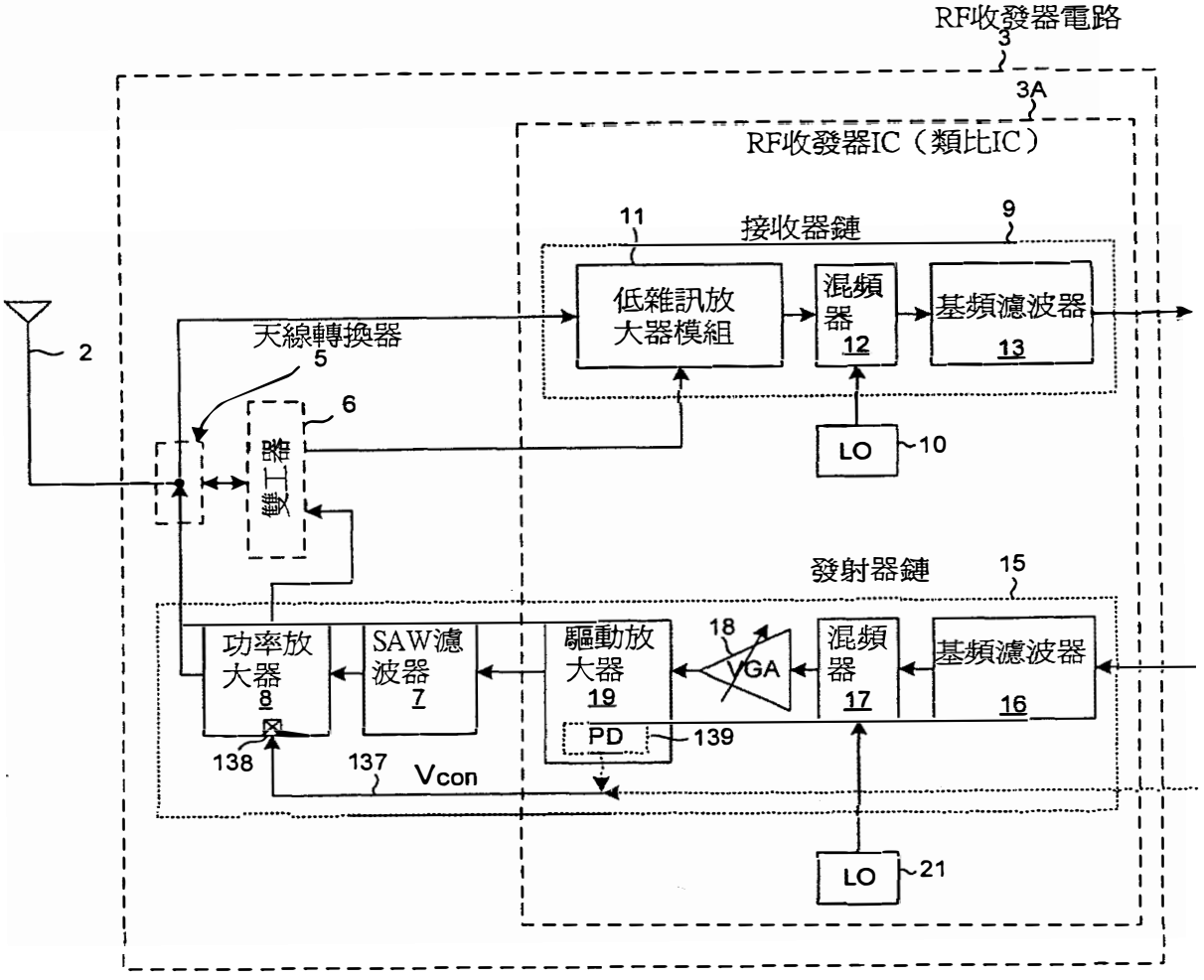


圖2

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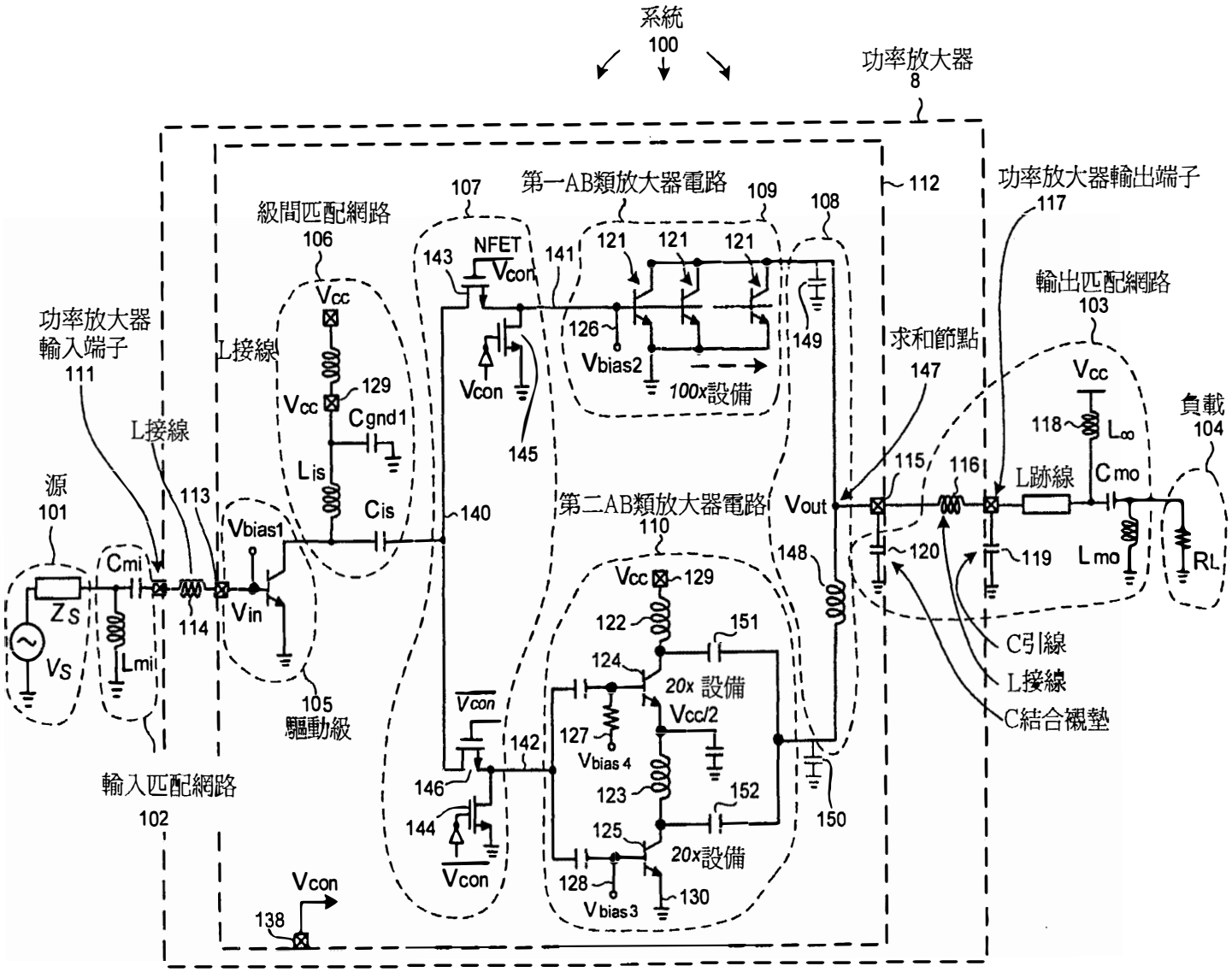

系統
100
功率放大器
8
112
功率放大器輸出端子
117
第一AB類放大器電路
107
109
108
級間匹配網路
106
NFET
Vcon
143
141
121
121
121
126
Vbias2
100x設備
149
輸出匹配網路
103
求和節點
147
功率放大器
輸入端子
111
L接線
Vcc
129
Cgnd1
Lis
Cis
145
140
Vcc
118
Lω
負載
104
L接線
源
101
113
Vbias1
第二AB類放大器電路
110
Vout
115
116
L跡線
Cmo
Cmi
Zs
Vs
Lmi
114
Vin
105
驅動級
Vcc
129
122
151
124
20x 設備
Vcc/2
127
Vbias 4
123
152
125
20x設備
128
Vbias 3
130
150
148
120
119
Lmo
RL
C引線
L接線
C結合襯墊
Vcon
142
146
144
Vcon
Vcon
138
輸入匹配網路
102

圖3

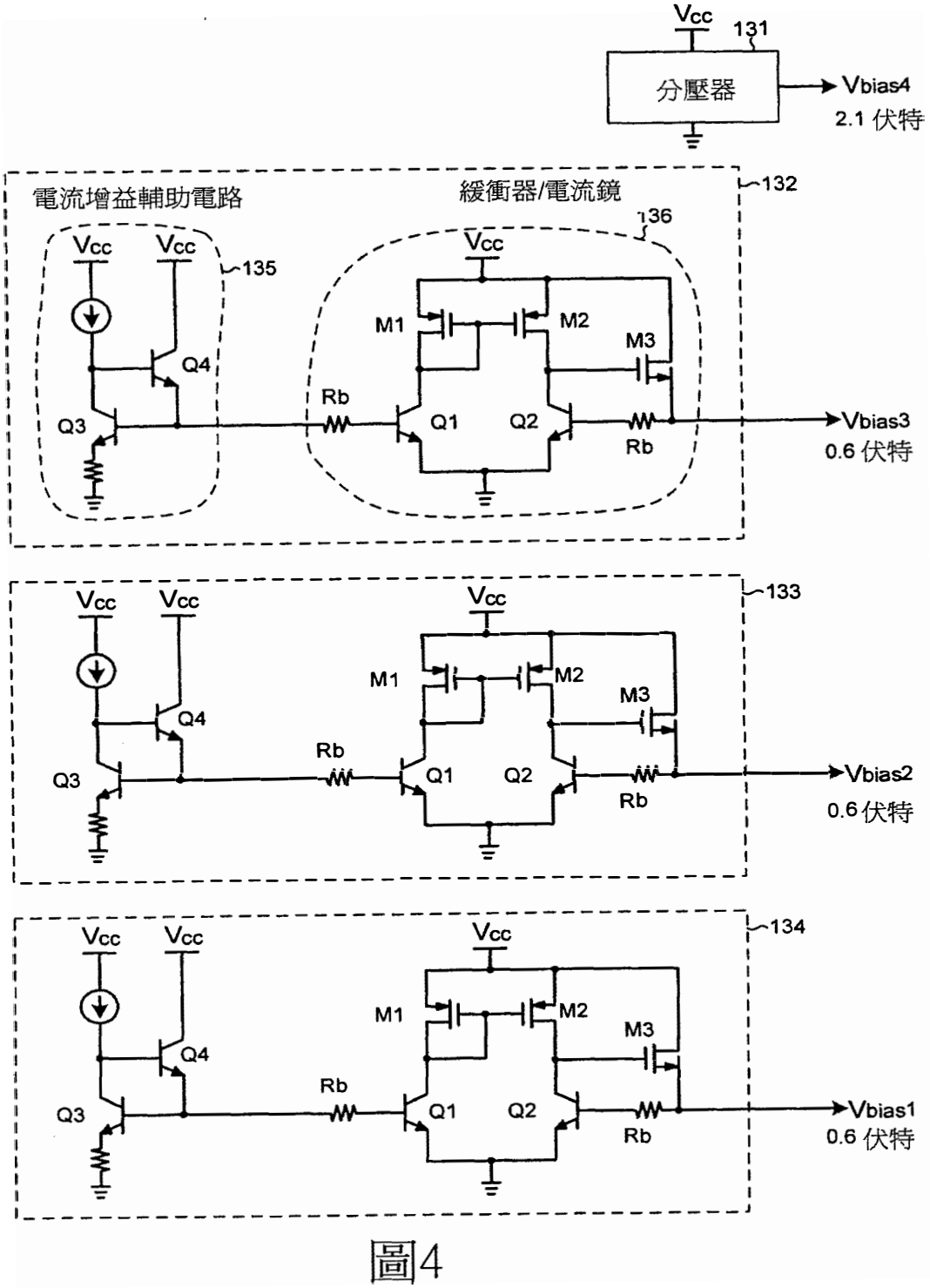


圖4

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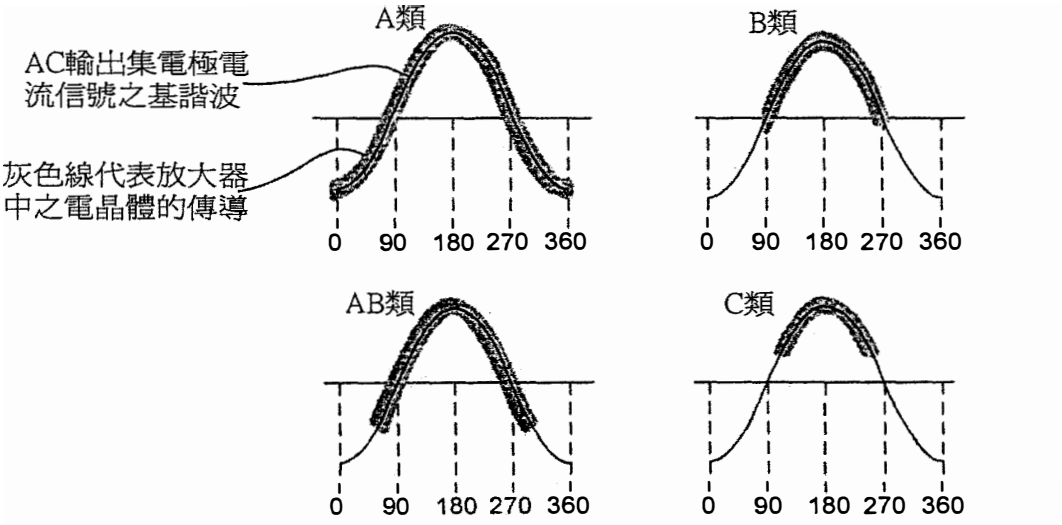


圖5

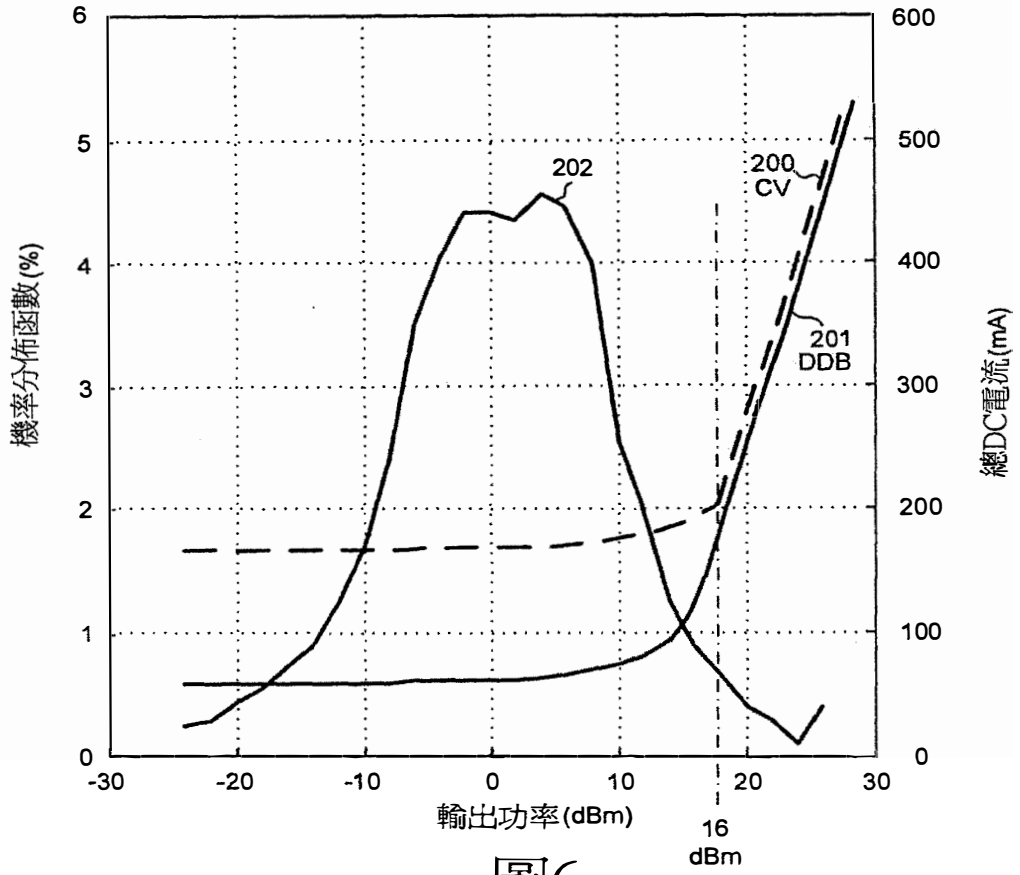


圖6

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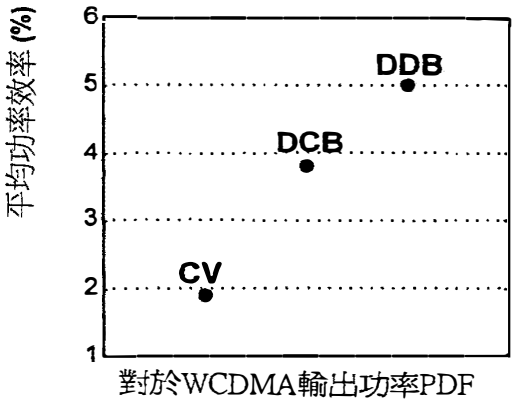

平均功率效率 (%)
6
5
4
3
2
1
DDB
DCB
CV
對於WCDMA輸出功率PDF

圖7

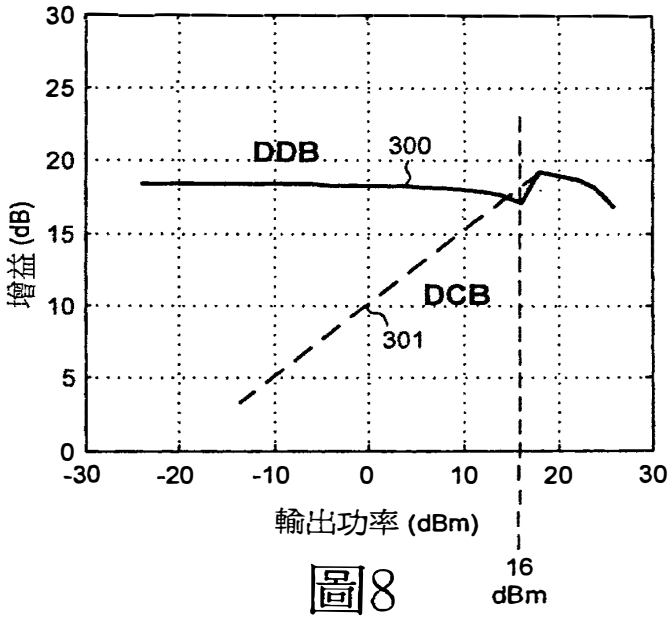

增益 (dB)
30
25
20
15
10
5
0
DDB
300
DCB
301
-30
-20
-10
0
10
20
30
輸出功率 (dBm)
16
dBm

圖8

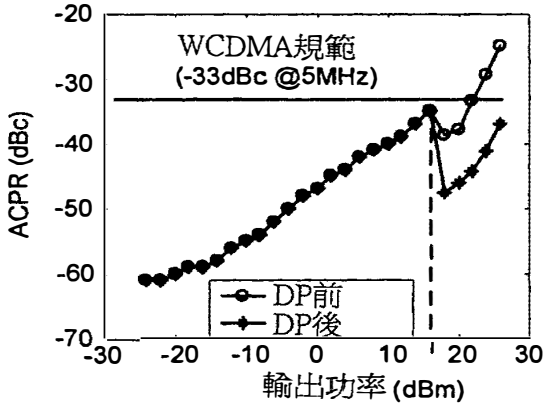

ACPR (dBc)
-20
-30
-40
-50
-60
-70
WCDMA規範
(-33dBc @5MHz)
DP前
DP後
-30
-20
-10
0
10
20
30
輸出功率 (dBm)

圖9

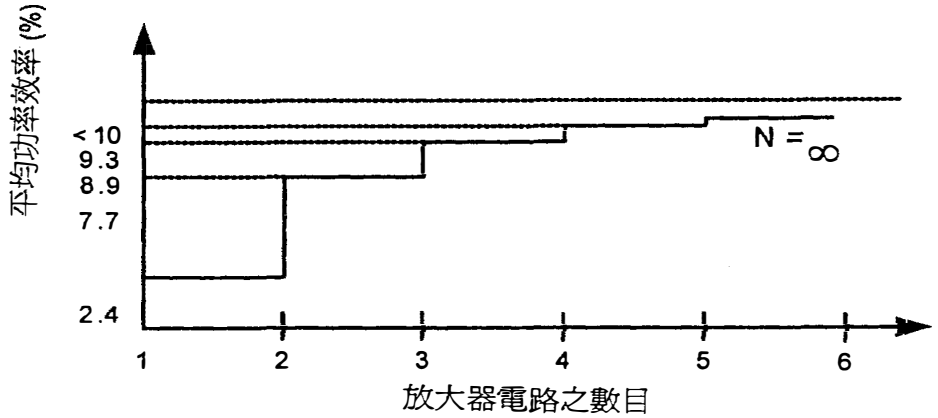

平均功率效率 (%)
< 10
9.3
8.9
7.7
2.4
N = ∞
1
2
3
4
5
6
放大器電路之數目

圖10

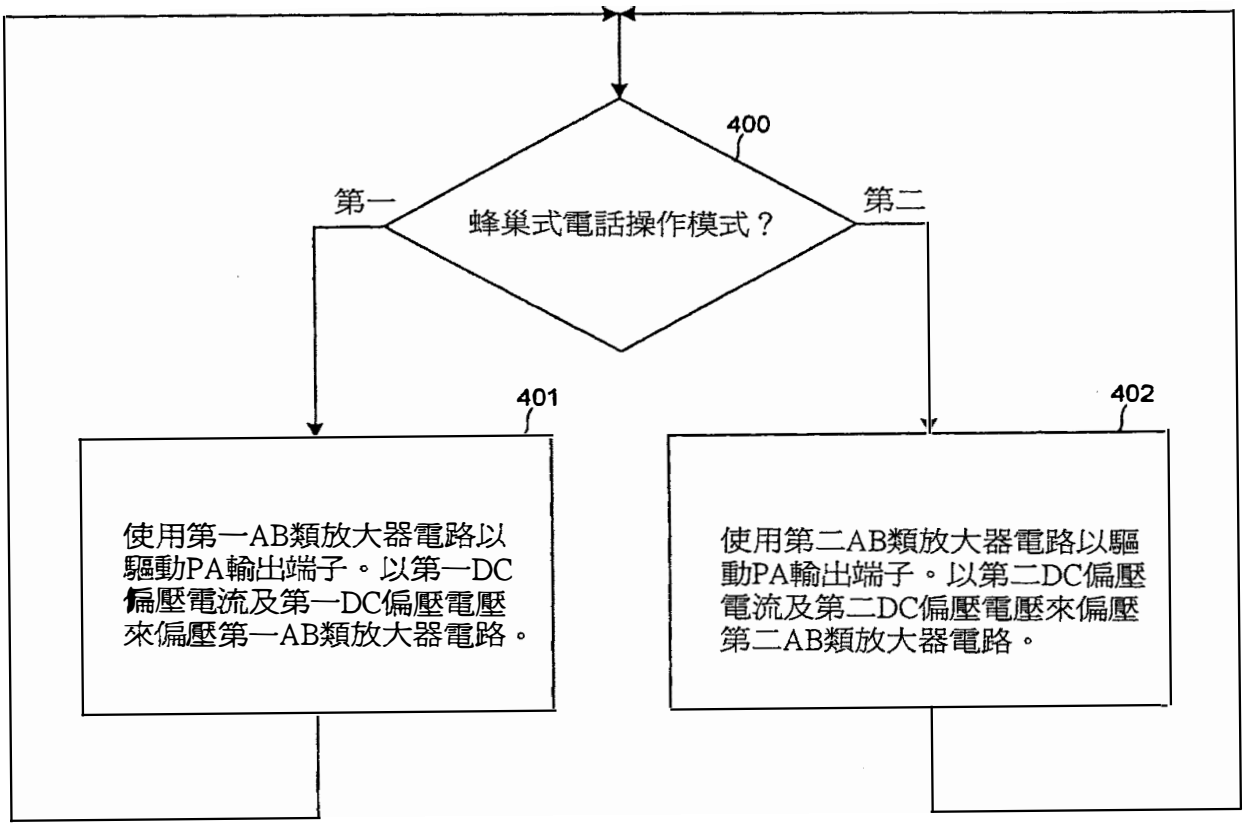


圖11

EX-1002 0193
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

Search terms：(2) 200810347 【印出】

Patent/Publication No.	200810347 Patent I332749
Title	Power amplifier circuit having a bias signal inputted into an input terminal and method thereof
Publication Date	2008/02/16
Application Date	2006/08/14
Application No.	095129780 Espacenet
Abstract	An adjustable gain power amplifier circuit includes a power amplifying unit to receive and amplify an input signal to generate an output signal; a power detecting unit to detect power of the input signal to generate a detecting signal; and a biasing control unit to generate a biasing signal according to the detecting signal and to output the biasing signal.
Individual	F

Information on this system is for reference only, it cannot be used as grounds for approval or rejection.
In all instances of discrepancy, official publication from TIPO shall prevail and should be consulted.

I332749

公告本

發明專利說明書

（本說明書格式、順序及粗體字，請勿任意更動，※記號部分請勿填寫）

※ 申請案號：95129780

※ 申請日期：95.8.14　　※IPC 分類：H03F 3/20 (2006.01)
H03G 3/20 (2006.01)

一、發明名稱：（中文/英文）

提供偏壓訊號至輸入端的功率放大電路與其方法 / POWER AMPLIFIER CIRCUIT HAVING A BIAS SIGNAL INPUTTED INTO AN INPUT TERMINAL AND METHOD THEREOF

二、申 請 人：（共 1 人）

姓名或名稱：（中文/英文）

瑞昱半導體股份有限公司 / REALTEK SEMICONDUCTOR CORP.

代表人：（中文/英文）

葉博任 / YEH, PO-LEN

住居所或營業所地址：（中文/英文）

新竹科學園區創新二路二號 /

2 Innovation Rd. II, Science Park, HsinChu , Taiwan, R.O.C.

國　籍：（中文/英文）

中華民國 / TWN

三、發明人：（共 1 人）

姓　名：（中文/英文）

1. 劉仁傑 / LIU, REN-CHIEH

國　籍：（中文/英文）

1. 中華民國 / TWN

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四、聲明事項：

☐ 主張專利法第二十二條第二項☐第一款或☐第二款規定之事實，其事實發生日期為：　年　月　日。

☐ 申請前已向下列國家（地區）申請專利：

【格式請依：受理國家（地區）、申請日、申請案號　順序註記】

☐ 有主張專利法第二十七條第一項國際優先權：

☐ 無主張專利法第二十七條第一項國際優先權：

☐ 主張專利法第二十九條第一項國內優先權：

【格式請依：申請日、申請案號　順序註記】

☐ 主張專利法第三十條生物材料：

☐ 須寄存生物材料者：

國內生物材料　【格式請依：寄存機構、日期、號碼　順序註記】

國外生物材料　【格式請依：寄存國家、機構、日期、號碼　順序註記】

☐ 不須寄存生物材料者：

所屬技術領域中具有通常知識者易於獲得時，不須寄存。

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五、中文發明摘要：

一種可調整增益的功率放大電路，其包含有一功率放大單元，用來接收一輸入訊號並進行功率放大以產生一輸出訊號；一功率偵測單元，用來偵測該輸入訊號之功率以產生一偵測訊號；以及一偏壓控制單元，用來根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號。

六、英文發明摘要：

An adjustable gain power amplifier circuit includes a power amplifying unit to receive and amplify an input signal to generate an output signal; a power detecting unit to detect power of the input signal to generate a detecting signal; and a biasing control unit to generate a biasing signal according to the detecting signal and to output the biasing signal.

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七、指定代表圖：

(一)本案指定代表圖為：第（ 1 ）圖。

(二)本代表圖之元件符號簡單說明:

100	功率放大電路
102	功率放大單元
104	功率偵測單元
106	偏壓控制單元

八、本案若有化學式時，請揭示最能顯示發明特徵的化學式：

無

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九、發明說明：

【發明所屬之技術領域】

本發明係提供一種功率放大電路，尤指一種提供偏壓訊號至輸入端的功率放大電路與其方法。

【先前技術】

在現今的無線通訊領域中，功率放大單元主要是將輸出訊號放大至一可合理的振幅，因此，在無線通訊系統中，功率放大單元所消耗系統的能量極大。為了節省系統的能量消耗，理想的功率放大單元應隨著所需環境的改變而輸出適合功率的訊號。習知技術是透過改變功率放大單元的電源供應使功率放大單元操作在不同的輸出功率範圍中，因此當需要高功率輸出時，便藉由提昇電源電壓而使功率放大單元增加輸出功率，相反地，當需要低功率輸出時，便藉由降低電源電壓而使功率放大單元減少輸出功率，藉以控制功率放大單元的電源效率(power efficiency)。

然而，採用上述方法會面臨到下列三個問題:第一，由於電源電壓為供應功率放大單元之直流電源，因此改變電源電壓大小必須由一切換穩壓電路(switching regulator)實現，如此就會造成外接元件的增加而提高了製作成本；第二，因受限於輸出功率和元件操作電壓，功率放大單元之電源電壓可以容許改變量小，使切換穩壓電路的效率降

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低，連帶造成整個功率放大單元的效率降低；第三，習知技術之切換穩壓電路的頻率低，當和功率放大單元共同使用時會造成整體的迴路頻寬(loop bandwidth)下降。因此，習知技術應用切換穩壓電路來實現可調增益功率放大單元只適用在頻道頻寬(channel bandwidth)較低的系統，例如GSM 系統和 PHS 系統。

【發明內容】

因此，本發明之主要目的在於提供一種提供偏壓訊號至輸入端的功率放大電路與其方法，其可動態調整功率放大單元的工作偏壓點，因而改變功率放大單元不同操作功率時的增益或操作電流(supply current)來提高輸出功率和電源效率。

依據本發明實施例，其提供一種可調整增益的功率放大電路。該功率放大電路包含有：一功率放大單元，用來接收之一輸入訊號並進行功率放大以產生一輸出訊號；一功率偵測單元，用來偵測該輸入訊號之功率以產生一偵測訊號；以及一偏壓控制單元，用來根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號。

依據本發明實施例，其另提供一種可調整增益的功率放大電路。該功率放大電路包含有：一功率放大單元，用

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來接收一輸入訊號並進行功率放大以產生一輸出訊號；一波封偵測單元(Envolope Detector)，用來偵測該輸入訊號之波封(Envolope)以產生一偵測訊號；以及一偏壓控制單元，用來根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號。

依據本發明實施例，其提供一種調整一功率放大器之增益的方法。該功率放大器可接收一輸入訊號並對該輸入訊號進行功率放大以產生一輸出訊號。該方法包含有：偵測該輸入訊號之功率以產生一偵測訊號；根據該偵測訊號產生一偏壓訊號，並輸出該偏壓訊號至該輸入端；以及根據該偏壓訊號調整該功率放大器之增益。

【實施方式】

請參考第 1 圖，第 1 圖為本發明之第一實施例中可調整增益之功率放大電路的電路圖。功率放大電路 100 包含有一功率放大單元 102；一功率偵測單元 104，耦接於一輸入訊號 f_{in}；以及一偏壓控制單元 106，耦接於功率偵測單元 104 與功率放大單元 102 之一輸入端 N2。功率放大電路 100 更包含有一電容 C_c 耦接於功率放大電路 100 的輸入端 N1 和功率放大單元 102 之間，用以阻隔輸入訊號 f_{in} 的直流電壓部份。功率放大單元 102 可對其輸入端 N2 所接收之輸入訊號 f_{in} 進行功率放大以於其輸出端 N3（亦為功率放大電路 100 的輸出端）產生一輸出訊號 f_{out}，而功率偵測單

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元 104 則用來偵測輸入訊號 f_{in} 之功率以產生一偵測訊號，以及偏壓控制單元 106 用來根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號至功率放大單元 102 的輸入端 N2。

於第 1 圖所示的實施例中，功率放大單元 102 為一習知功率放大單元，其中功率放大單元 102 的輸入端 N2 耦接至功率放大單元 102 內部一 N-型電晶體的閘極端，且功率放大單元 102 具有一固定之電源電壓 V_{dd}（固定直流偏壓）及一接地端 GND，因此，輸入端 N2 上的直流偏壓將決定功率放大單元 102 的操作增益。功率偵測單元 104 具有一電容 C_{in} 耦接至輸入端 N1，另一端則耦接至一 N-型電晶體 M1 的閘極端，其中功率偵測單元 104 之輸出端為 N-型電晶體 M1 的汲極端。為了能夠精確地偵測出一輸入訊號 f_{in} 的功率，因此功率放大電路 100 將 N-型電晶體 M1 之閘極端偏壓在夾止電壓(Pinch-off Voltage)。偏壓控制單元 106 包含有一由二 P-型電晶體 M2、M3 組成之電流鏡、一二極體連接(diode-connected)的 N-型電晶體 M4 以及一電感 L_{in}。請注意，於另一實施例中，功率放大電路中可另加一匹配電路單元，使得功率放大單元 102 的輸出端 N3 與該匹配電路單元處於阻抗匹配的狀態，此亦為本發明之範疇。

當輸入訊號 f_{in} 由輸入端 N1 輸入時，輸入訊號 f_{in} 之直流部份會被電容 C_{in} 去除，只剩下交流訊號會進入 N-型電

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晶體 M1 之閘極端，因此在 N-型電晶體 M1 之汲極端會輸出放大輸入訊號 f_{in} 之交流部份的半波型電流訊號。此時，由 P-型電晶體 M2、M3 組成之電流鏡會將該半波型電流訊號耦合至 N-型電晶體 M4，接著， N-型電晶體 M4 會依據該半波型電流訊號而經由電感 L_{in} 提供一直流偏壓予功率放大單元 102 的輸入端 N2。由上述之操作過程可以得知，當輸入訊號 f_{in} 之能量越大時，即振幅越大，則直流偏壓越高而使得功率放大單元 102 之直流電流 I_d 越大；反之亦然。請注意，本實施例中電感 L_{in} 僅係一阻抗元件之一例子，本發明並不以此為限，換句話話，本實施例中電感 L_{in} 亦可以用其他的元件取代，例如，一電阻元件。

請參考第 2 圖，第 2 圖為第 1 圖所示之功率放大單元 102 之操作增益對輸出訊號 f_{out} 之功率的特性曲線圖，其中特性曲線 202 係為習知功率放大單元的操作特性，而特性曲線 204 則為本發明功率放大單元 102 的操作特性。如第 2 圖之特性曲線 202 所示，隨著操作功率增加，操作增益會慢慢降低，而在操作增益降低至 1dB 點時，習知功率放大單元係具有輸出功率 P_{1dB}'。因此，延續第 1 圖之說明，在本實施例中，在輸入訊號 f_{in} 為低功率時，功率放大單元 102 之操作增益降低 1dB 點的輸出功率 P_{1dB} 係高於輸出功率 P_{1dB}'，因此當功率放大單元 102 降低其操作增益時，等效上就可以達到提高 P_{1dB} 輸出功率的效果（如特性曲線 204 所示）。

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請參考第 3 圖，第 3 圖為第 1 圖所示之功率放大單元 102 之直流電流 I_d 對輸出訊號 f_{out} 之功率的特性曲線圖。如第 3 圖所示，特性曲線 302 為不管輸出訊號 f_{out} 功率多強，直流電流 I_d 均一樣時的情況，可以看出在小功率時直流電流形同浪費。曲線 304 為輸出功率強弱隨著直流電流改變的情況，可以看出在低功率時直流電流降低，如此就可以提高功率放大單元 102 的電源效率(power efficiency)。因此本發明可調整增益的功率放大電路 100 可依據輸入訊號 f_{in} 之強度大小而動態調整功率放大單元 102 之操作增益以達到最高的 P_{1dB} 輸出功率和最佳的電源效率。

請參考第 4 圖，第 4 圖為本發明第二實施例之可調整增益之功率放大電路 400 的示意圖。功率放大電路 400 包含有一功率放大單元 102（具有固定直流偏壓 V_{dd}）；一功率偵測單元 104，耦接於一輸出訊號 f_{out}；以及一偏壓控制單元 402，耦接於功率偵測單元 104 與功率放大單元 102 之一輸入端 N2。相較於第 1 圖所示之偏壓控制單元 106，本實施例中的偏壓控制單元 402 另包含有一功率位準調整單元 404。功率放大電路 400 更包含有一電容 C_c 耦接於其輸入端 N1 和功率放大單元 102 之間，用以阻隔輸入訊號 f_{in} 的直流電壓部份，以及一電容 C_{out} 耦接於功率放大單元 102 之一輸出端 N3（亦為功率放大電路 400 的輸出端）以阻隔一輸出訊號 f_{out} 的直流電壓部份。功率放大單元 102 可對其

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輸入端 N2 所接收之輸入訊號 f_{in} 進行功率放大以產生輸出訊號 f_{out}，而功率偵測單元 104 則用來偵測輸出訊號 f_{out} 之功率以產生一偵測訊號，以及偏壓控制單元 402 用來根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號至功率放大單元 102 的輸入端 N2。如第 4 圖所示，功率位準調整單元 404 包含有一第一輸入端耦接於功率偵測器 104 以及一第二輸入端耦接至一調整位準 V-，而功率偵測器 104 所輸出的偵測訊號經由調整位準 V-調整後輸入一緩衝單元，其中該緩衝單元接收功率位準調整單元所輸出之調整後的偵測訊號，且該緩衝單元係耦接至偏壓控制單元 402 的電流鏡。請注意，於另一實施例中，功率放大電路中可另加一匹配電路單元，使得功率放大單元 102 的輸出端 N3 與該匹配電路單元處於阻抗匹配的狀態，此亦為本發明之範疇。

當輸入訊號 f_{in} 由輸入端 N1 輸入時，輸入訊號 f_{in} 之直流部份會被電容 C_c 去除，只剩下交流訊號會進入功率放大單元 102 內之 N-型電晶體的閘極端，接著，功率放大單元功率 102 便放大輸入訊號 f_{in} 並於輸出端 N3 輸出一輸出訊號 f_{out}。輸出訊號 f_{out} 經由電容 C_{out} 將直流電壓阻隔並將輸出訊號 f_{out} 之交流部份耦合至 N-型電晶體 M1'之閘極端，然後， N-型電晶體 M1'之汲極端會放大輸出訊號 f_{out} 之交流部份而產生半波型電流訊號，由於該半波型電流訊號之功率較高而無法直接耦合至偏壓控制單元 402 之電流鏡，

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此時功率位準調整裝置 404 會將功率偵測器 104 輸出的偵測訊號功率往下調整上述的調整位準 V-。此時，由二 P-型電晶體 M2'、M3'組成之電流鏡會將調降功率後之該半波型電流訊號耦合至一二極體連接之 N-型電晶體 M4'，最後，N-型電晶體 M4'會依據該半波型電流訊號經由電感 L_{in}'提供一直流偏壓予功率放大單元 102 的輸入端 N2。由上述之操作過程可以得知，當輸入訊號 f_{in} 之能量越大時，即振幅越大，則直流偏壓越高而使得功率放大單元 102 之直流電流 I_d 越大；反之亦然。功率放大電路 400 之操作增益對輸出訊號 f_{out} 之功率的特性以及直流電流 I_d 對輸出訊號 f_{out} 之功率的特性分別與第一實施例之第 2 圖和第 3 圖所示特性相同。請注意，本實施例中電感 L_{in}'僅係一阻抗元件之一例子，本發明並不以此為限，換句話話，本實施例中電感 L_{in}'亦可以用其他的元件取代，例如，一電阻元件。

在本發明之另一實施例中，功率偵測單元 104 可為一波封偵測單元(Envelope Detector)，亦可達到相同之效果，且為本發明之範疇。

請參考第 5 圖，第 5 圖為本發明第一實施例之調整一功率放大單元之增益之方法的流程圖。該功率放大單元可對其輸入端所接收之一輸入訊號進行功率放大以產生一輸出訊號，該方法包含有下列步驟：

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步驟 502：開始；

步驟 504：偵測該輸入訊號之功率以產生一偵測訊號；

步驟 506：根據該偵測訊號提供一偏壓訊號；

步驟 508：耦合該偏壓訊號至該功率放大單元之該輸入端；以及

步驟 510：該功率放大單元依據該偏壓訊號調整其操作增益以對該輸入訊號進行功率放大。

步驟 510 包含有當該輸入訊號之能量越大時，即振幅越大，則該偏壓訊號越高而使得該功率放大單元之直流電流越大；反之亦然。如此會提升該功率放大單元之 P_{1dB} 輸出功率和提升該功率放大單元之電源效率。

請參考第 6 圖，第 6 圖為本發明第二實施例之調整一功率放大單元之增益之方法的流程圖。該功率放大單元可對其輸入端所接收之一輸入訊號進行功率放大以產生一輸出訊號，該方法包含有下列步驟：

步驟 602：開始；

步驟 604：偵測該輸出訊號之功率以產生一偵測訊號；

步驟 606：根據該偵測訊號提供一偏壓訊號；

步驟 608：耦合該偏壓訊號至該功率放大單元之該輸入端；以及

步驟 610：該功率放大單元依據該偏壓訊調整其操作增

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益以對該輸入訊號進行功率放大。

步驟 610 包含有當該輸入訊號之能量越大時，即振幅越大，則該偏壓訊號越高使得該功率放大單元之直流電流越大；反之亦然。如此會提升該功率放大單元之 P_{1dB} 輸出功率和提升該功率放大單元之電源效率。

請注意，在說明書及後續的申請專利範圍當中使用了某些詞彙來指稱特定的元件。所屬領域中具有通常知識者應可理解，硬體製造商可能會用不同的名詞來稱呼同一個元件。本說明書及後續的申請專利範圍並不以名稱的差異來作為區分元件的方式，而是以元件在功能上的差異來作為區分的準則。在通篇說明書及後續的請求項當中所提及的「包含」係為一開放式的用語，故應解釋成「包含但不限定於」。以外，「耦接」一詞在此係包含任何直接及間接的電氣連接手段。因此，若文中描述一第一裝置耦接於一第二裝置，則代表該第一裝置可直接電氣連接於該第二裝置，或透過其他裝置或連接手段間接地電氣連接至該第二裝置。

以上所述僅為本發明之較佳實施例，凡依本發明申請專利範圍所做之均等變化與修飾，皆應屬本發明之涵蓋範圍。

【圖式簡單說明】

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第 1 圖為本發明第一實施例之可調整增益之功率放大電路的電路圖。

第 2 圖為第 1 圖所示之功率放大單元之操作增益對輸出訊號之功率的特性曲線圖。

第 3 圖為第 1 圖所示之功率放大單元之直流電流對輸出訊號之功率的特性曲線圖。

第 4 圖為本發明第二實施例之可調整增益之功率放大電路的示意圖。

第 5 圖為本發明第一實施例之調整一功率放大單元之增益之方法的流程圖。

第 6 圖為本發明第二實施例之調整一功率放大單元之增益之方法的流程圖。

【主要元件符號說明】

100、400	功率放大電路
102	功率放大單元
104	功率偵測單元
106、402	偏壓控制單元
202、204、302、304	特性曲線
404	功率位準調整裝置

EX-1002 0209
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

99年4月28日修正本

十、申請專利範圍：

1. 一種可調整增益的功率放大電路，其包含有：

一功率放大單元，其係接收一輸入訊號並進行功率放大以產生一輸出訊號；

一功率偵測單元，其係偵測該輸入訊號之功率以產生一偵測訊號，其中該功率偵測單元包含有：

一電容，具有一第一端耦接於該功率放大單元之一輸入端，該電容去除該輸入訊號之一直流成分訊號以產生該輸入訊號之一交流成分訊號；以及

一第一電晶體，具有一閘極端耦接於該電容之一第二端，且該第一電晶體之該閘極端係實質上偏壓在一夾止電壓，該第一電晶體放大該輸入訊號之該交流成分訊號以產生該偵測訊號；以及

一偏壓控制單元，其係根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號。

2. 如申請專利範圍第 1 項所述之功率放大電路，其中該偏壓控制單元包括有：

二電晶體，其中該二電晶體組成一電流鏡；

一二極體連接的電晶體，耦接於該電流鏡；以及

一電感，具有一端直接連接於該二極體連接的電晶體的一汲極端。

EX-1002 0210
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

3. 如申請專利範圍第 1 項所述之功率放大電路，其中該偏壓控制單元輸出該偏壓訊號至該功率放大單元之一輸入端，以及該偏壓控制單元包含有：

二電晶體，其中該二電晶體組成一電流鏡；

一二極體連接的電晶體，耦接於該電流鏡；以及

一電阻，具有一第一端直接連接於該二極體連接的電晶體的一汲極端以及具有一第二端輸出該偏壓訊號。

4. 如申請專利範圍第 1 項所述之功率放大電路，其中該偏壓控制單元輸出該偏壓訊號至該功率放大單元。

5. 如申請專利範圍第 1 項所述之功率放大電路，其中該功率偵測單元為一波封偵測單元(Envelope Detector)。

6. 如申請專利範圍第 1 項所述之功率放大電路另包含一匹配電路單元，使得該功率放大單元與該匹配電路單元匹配。

7. 一種可調整增益的功率放大電路，其包含有：

一功率放大單元，其係接收一輸入訊號並進行功率放大以產生一輸出訊號；

一功率偵測單元，耦接於該功率放大單元的一輸出端，

EX-1002 0211
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

該功率偵測單元偵測該輸出訊號之功率以產生一偵測訊號；以及

一偏壓控制單元，耦接於該功率放大單元的一輸入端，該偏壓控制單元根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號至該功率放大單元的該輸入端，該偏壓控制單元包含有：

一功率位準調整裝置，耦接於該功率偵測單元，該功率位準調整裝置調整該偵測訊號以產生一調整後的偵測訊號；

一電感，耦接於該功率位準調整裝置，該電感依據該調整後的偵測訊號來產生該偏壓訊號；

一緩衝單元，耦接於該功率位準調整裝置，該緩衝單元接收該調整後的偵測訊號；

一電流鏡，具有一第一端耦接於該緩衝單元；以及

一二極體連接的電晶體，具有一閘極端耦接於該電流鏡的一第二端，以及一汲極端耦接於該電感的一第一端；

其中該電感的一第二端輸出該偏壓訊號至該功率放大單元的該輸入端，以及該功率偵測單元係一波封偵測單元。

8. 如申請專利範圍第 7 項所述之功率放大電路，另包含一匹配電路單元，使得該功率放大單元與該匹配電路單元匹配。

EX-1002 0212
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

9. 一種可調整增益的功率放大電路，其包含有：

一功率放大單元，其係接收一輸入訊號並進行功率放大以產生一輸出訊號；

一功率偵測單元，耦接於該功率放大單元的一輸出端，該功率偵測單元偵測該輸出訊號之功率以產生一偵測訊號；以及

一偏壓控制單元，耦接於該功率放大單元的一輸入端，該偏壓控制單元根據該偵測訊號提供一偏壓訊號，並輸出該偏壓訊號至該功率放大單元的該輸入端，該偏壓控制單元包含有：

一功率位準調整裝置，耦接於該功率偵測單元，該功率位準調整裝置調整該偵測訊號以產生一調整後的偵測訊號；

一電阻，耦接於該功率位準調整裝置，該電阻依據該調整後的偵測訊號來產生該偏壓訊號；

一緩衝單元，耦接於該功率位準調整裝置，該緩衝單元接收該調整後的偵測訊號；

一電流鏡，具有一第一端耦接於該緩衝單元；以及

一二極體連接的電晶體，具有一閘極端耦接於該電流鏡的一第二端，以及一汲極端耦接於該電阻的一第一端；

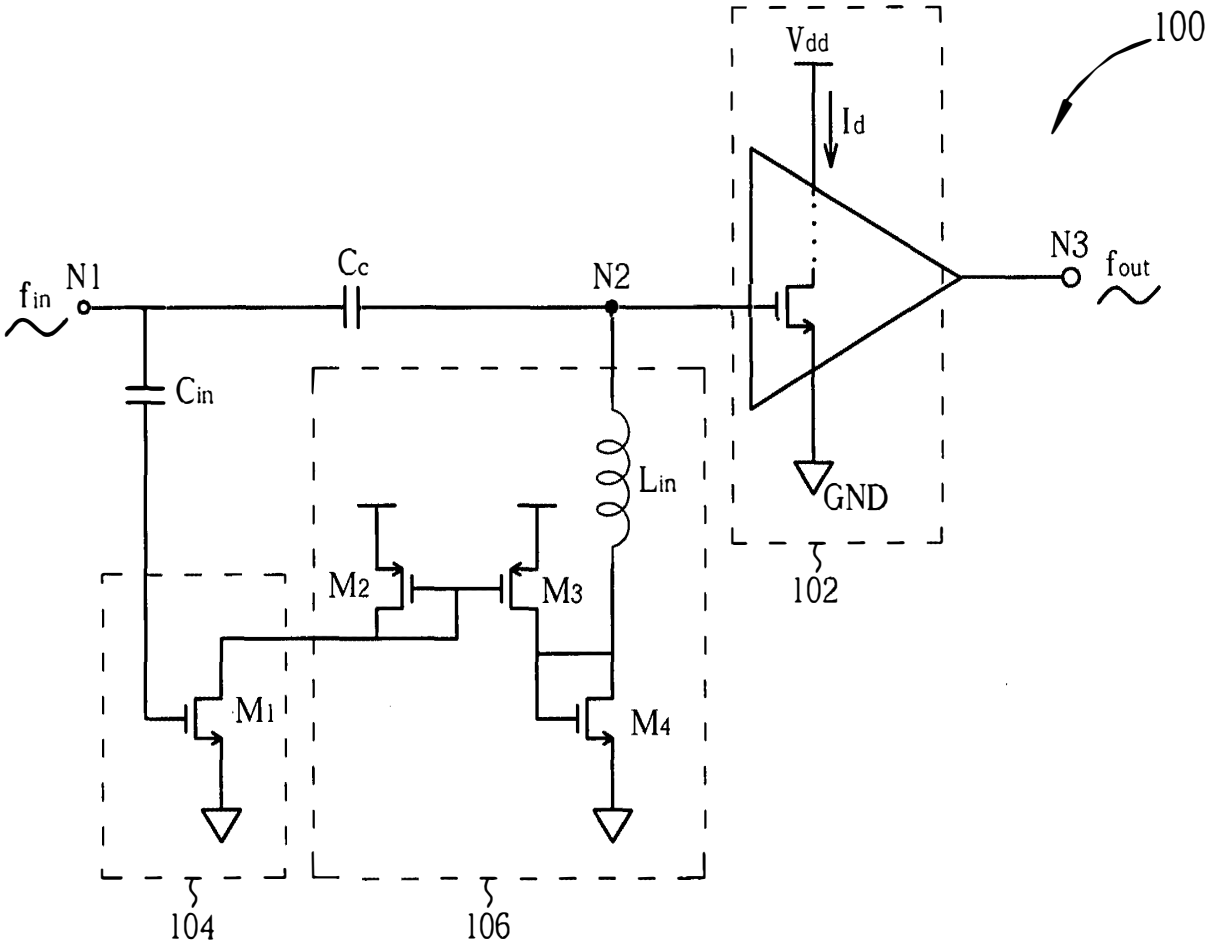
其中該電阻的一第二端輸出該偏壓訊號至該功率放大單元的

EX-1002 0213
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

該輸入端，以及該功率偵測單元係一波封偵測單元。

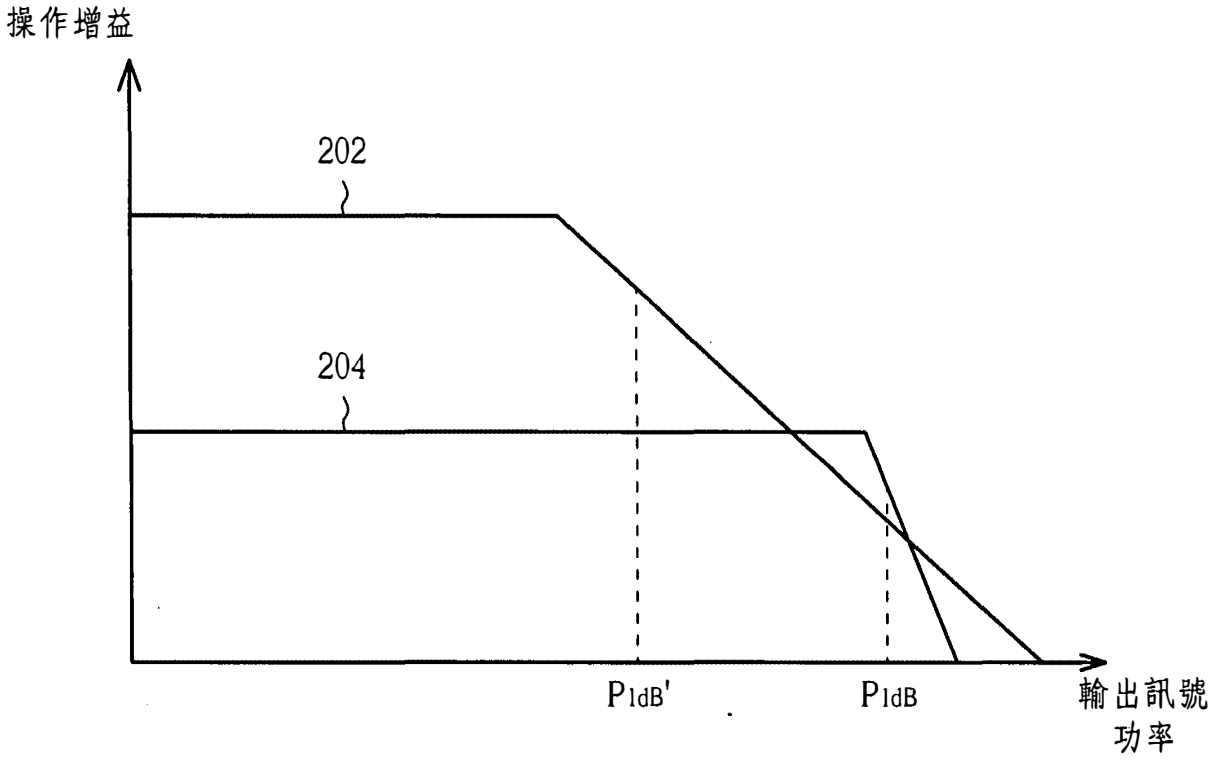
十一、圖式：

EX-1002 0214
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

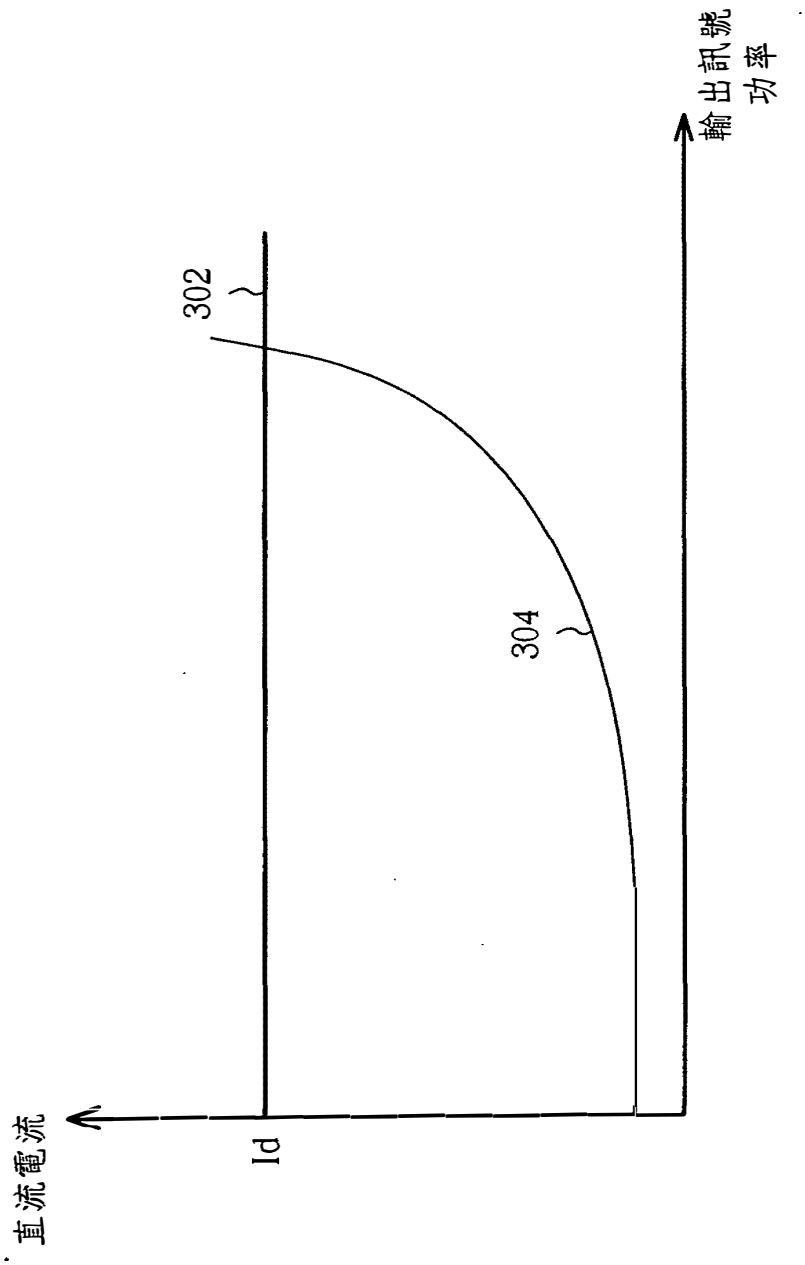


第1圖

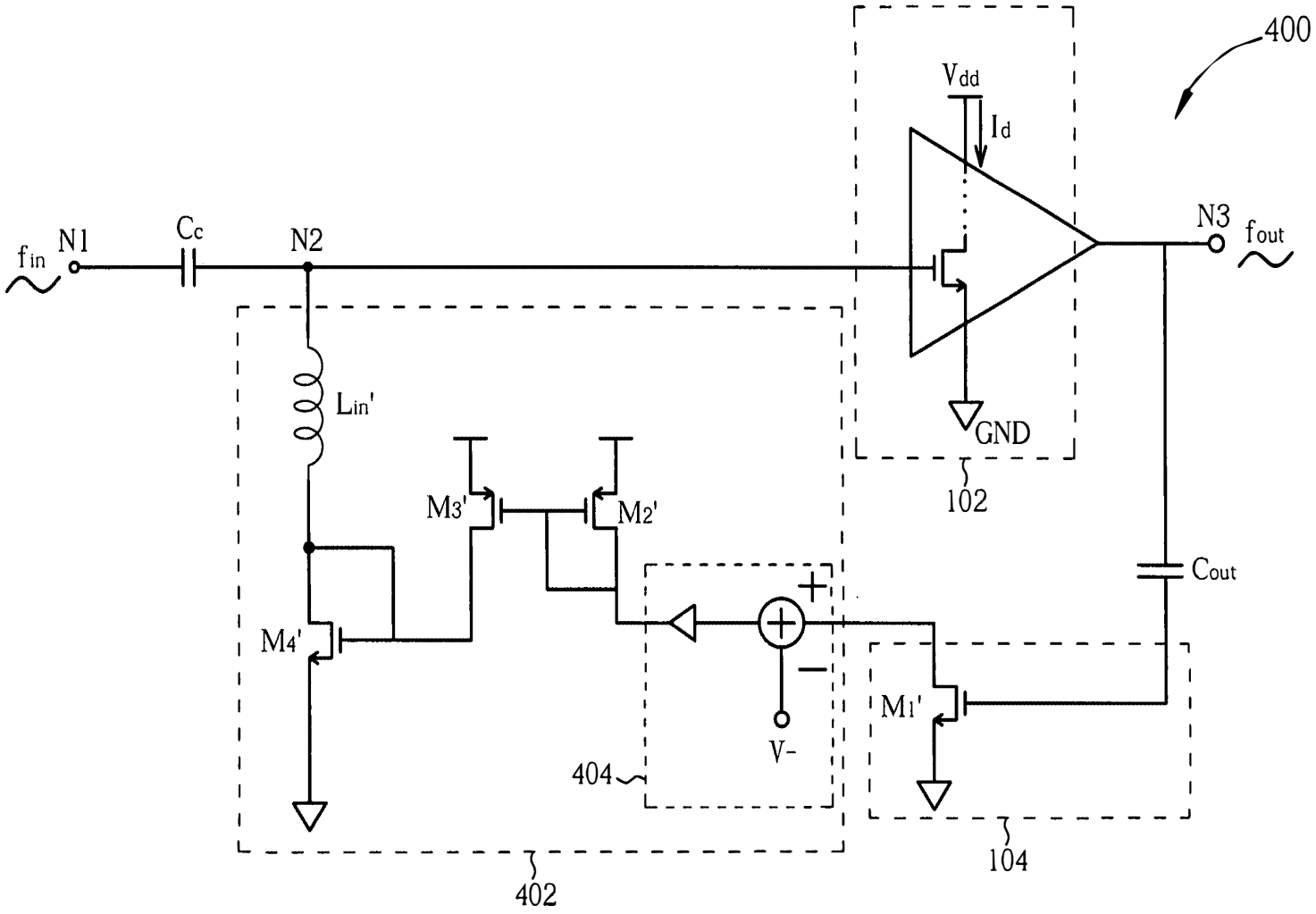
98. 9. 25 日修正替換頁



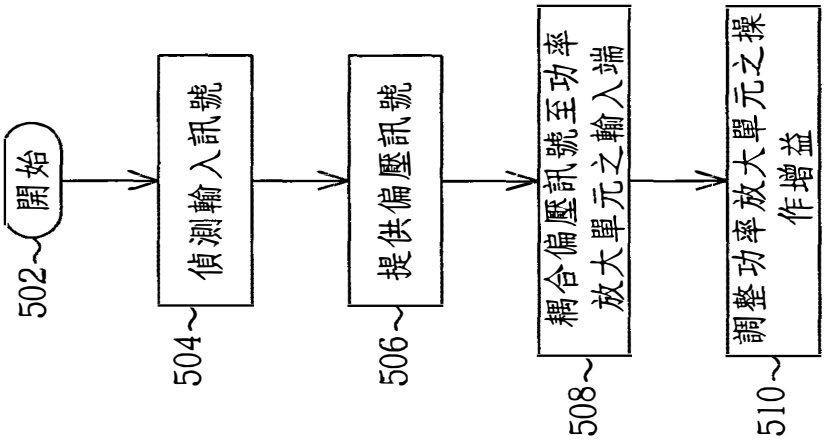
第2圖



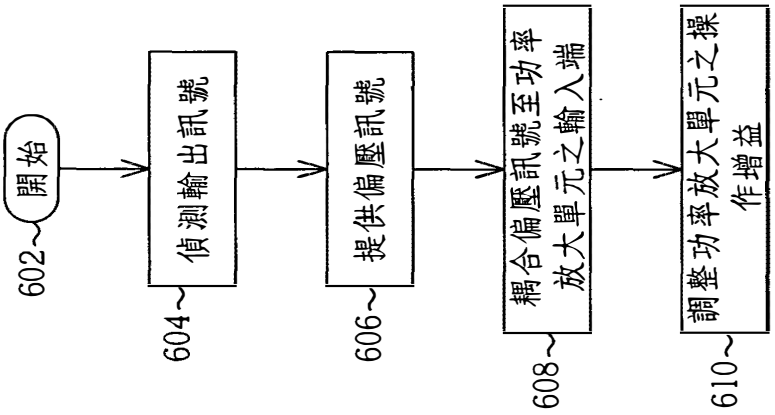
第3圖


400
Vdd
Id
N3
fout
fin
N1
Cc
N2
Lin'
GND
102
M3'
M2'
Cout
M4'
V-
M1'
404
104
402

第4圖


開始
502
偵測輸入訊號
504
提供偏壓訊號
506
耦合偏壓訊號至功率放大單元之輸入端
508
調整功率放大單元之操作增益
510

第5圖


602
開始
604
偵測輸出訊號
606
提供偏壓訊號
608
耦合偏壓訊號至功率放大單元之輸入端
610
調整功率放大單元之操作增益

第6圖

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:

CHRISTENSEN MICHAEL R.

KNOBBE MARTENS OLSON & BEAR, LLP 2040 MAIN STREET, 14TH FLOOR IRVINE CA 92614 USA

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Date of mailing *(day/month/year)* 28 NOVEMBER 2012 (28.11.2012)	
Applicant's or agent's file reference SKYWRKS280WO	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. **PCT/US2012/037065**	International filing date *(day/month/year)* **09 MAY 2012 (09.05.2012)**

Applicant

SKYWORKS SOLUTIONS, INC. et al

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:

   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   Where? Directly to the International Bureau of WIPO, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 . 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90bis.1 and 90bis.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices.

In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months.

For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the PCT Applicant's Guide, National Chapters.

Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea	Authorized officer COMMISSIONER
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8755

Form PCT/ISA/220 (July 2010)

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IRVINE INT.
DEC 06 2012
KNOBBE, MARTENS,
OLSON & BEAR, LLP

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for three months from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Services => PCT Services

ID : PCT international application number
PW : **5BLY7NK2**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com
Email: ipkc@ipkcenter.com
Phone: +1 703 388 1066
Fax: +1 703 388 1084

Notes to Form PCT/ISA/220 (July 2010)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
SKYWRKS280WO		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US2012/037065	**09 MAY 2012 (09.05.2012)**	13 MAY 2011 (13.05.2011)

Applicant

SKYWORKS SOLUTIONS, INC. et al

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of **3** sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of:
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☐ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No. **4**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figure is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/037065

A. CLASSIFICATION OF SUBJECT MATTER

H03F 1/30(2006.01)i, H03F 3/24(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H03F 1/30; G05F 3/02; H03F 1/36; H03F 3/21; H03F 1/02; H03F 3/04; H03F 1/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: amplifier, time dependent, RC, bias

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7821335 B2 (SHIRAMIZU NOBUHIRO et al.) 26 October 2010 See column 10, line 66 - column 11, line 3; and figure 1.	1-28
A	US 2009-0195318 A1 (KANG LI-HUNG et al.) 06 August 2009 See paragraphs [0013]-[0034]; and figures 1-5.	1-28
A	US 2005-0134374 A1 (HENCH JOHN J. et al.) 23 June 2005 See paragraphs [0117]-[0118]; and figures 13A.	1-28
A	JP 2000-252766 A (FUJITSU QUANTUM DEVICE KK) 14 September 2000 See abstract; paragraphs [0046]-[0049]; and figure 1.	1-28

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 NOVEMBER 2012 (23.11.2012)	**28 NOVEMBER 2012 (28.11.2012)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer KIM, Sang Keol Telephone No. 82-42-481-5742

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2012/037065

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7821335 82	26.10.2010	CN 101414805 A	22.04.2009
		CN 101414805 8	18.05.2011
		JP 2009-100337 A	07.05.2009
		US 2009-0102552 A1	23.04.2009
US 2009-0195318 A1	06.08.2009	US 7612613 B2	03.11.2009
US 2005-0134374 A1	23.06.2005	US 7053705 B2	30.05.2006
JP 2000-252766 A	14.09.2000	JP 03471648 82	12.09.2003
		JP 3471648 82	02.12.2003
		US 6331799 81	18.12.2001

Form PCT/ISA/210 (patent family annex) (July 2009)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
CHRISTENSEN MICHAEL R.

KNOBBE MARTENS OLSON & BEAR, LLP 2040 MAIN STREET, 14TH FLOOR IRVINE CA 92614 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**28 NOVEMBER 2012 (28.11.2012)**
Applicant's or agent's file reference: SKYWRKS280WO	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2012/037065	**09 MAY 2012 (09.05.2012)**	13 MAY 2011 (13.05.2011)

International Patent Classification (IPC) or both national classification and IPC

H03F 1/30(2006.01)i, H03F 3/24(2006.01)i

Applicant

SKYWORKS SOLUTIONS, INC. et al

I. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [x] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	23 NOVEMBER 2012 (23.11.2012)	KIM, Sang Keol Telephone No.82-42-481-5742

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/037065

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/037065

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-28	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-28	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-28	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 7821335 B2 (SHIRAMIZU NOBUHIRO et al.) 26 October 2010

D2: US 2009-0195318 A1 (KANG LI-HUNG et al.) 06 August 2009

D3: US 2005-0134374 A1 (HENCH JOHN J. et al.) 23 June 2005

D4: JP 2000-252766 A (FUJITSU QUANTUM DEVICE KK) 14 September 2000

1. Novelty and Inventive Step

1.1. Independent claim [1]

The subject matter of **claim** [1] differs from these prior art documents in that a power amplifier system comprising: a bias block for biasing the power amplifier, the bias block including a time-dependent signal generator configured to shape an enable signal of power amplifier to generate a control current, and a primary biasing circuit configured to generate a bias current for the power amplifier based at least partly on the correction current. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, **claim** [1] meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

1.2. Dependent claims [2-17]

Claims [2-17] are dependent on **claim** [1] and therefore meet the requirements of PCT Article 33(2) and (3).

Continued on Supplemental Box

EX-1002 0229
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2012/037065

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

In claim 15, line 1, 'the primary bias circuit' lacks proper antecedent basis.
In claim 17, line 1, 'the primary bias circuit' lacks proper antecedent basis.

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of :

Box V

1.3. Independent claim [18]

The subject matter of **claim** [18] differs from these prior art documents in that a method of biasing a power amplifier comprising: the step of shaping an enable signal using a time-dependent signal generator to generate a control current; the step of generating a bias current for a power amplifier using a primary biasing circuit, the primary biasing circuit configured to use the correction current to correct for a viariation in gain the power amplifier when the power amplifier is enable. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, **claim** [18] meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

1.4. Dependent claims [19-22]

Claims [19-22] are dependent on **claim** [18] and therefore meet the requirements of PCT Article 33(2) and (3).

1.5. Independent claim [23]

The subject matter of **claim** [23] differs from these prior art documents in that a bias circuit for biasing a power amplifier comprising: a time-dependent signal generator configured to shape an enable signal of the power amplifier to generate a control current; a primary biasing block configured to generate a bias current for the power amplifier based at least partly on the correction current. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, **claim** [23] meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

1.6. Dependent claims [24-28]

Claims [24-28] are dependent on **claim** [23] and therefore meet the requirements of PCT Article 33(2) and (3).

2. Industrial Applicability

Claims [1-28] are industrially applicable under PCT Article 33(4).

EX-1002 0231
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

Electronic Acknowledgement Receipt

EFS ID:	28492981
Application Number:	15377842
International Application Number:	
Confirmation Number:	1052
Title of Invention:	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
First Named Inventor/Applicant Name:	Ping Li
Customer Number:	20995
Filer:	David R. Trossen/Alanna Wai
Filer Authorized By:	David R. Trossen
Attorney Docket Number:	SKYWRKS.280C3
Receipt Date:	28-FEB-2017
Filing Date:	13-DEC-2016
Time Stamp:	18:26:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		IDS_SKYWRKS-280C3.pdf	59157 5704b98525b1ece73c00d37718df6b02df69df05	yes	4

	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Information Disclosure Statement (IDS) Form (SB08)		3	4	
	Transmittal Letter		1	2	
Warnings:					
Information:					
2	Foreign Reference	CN101414805A_wAbstract.PDF	2093387 b80ac95fdb34c13b35b8a04cea562763c1 39d9	no	38
Warnings:					
Information:					
3	Foreign Reference	JP2000-252766_wAbstract.PDF	855690 4a6bf81e5083662d52f47897950e9bef99b6 c764	no	14
Warnings:					
Information:					
4	Foreign Reference	JP2007-19784_wAbstract.PDF	986238 9ec011310d4736eb1197cd8130528ba0c03 988e6	no	17
Warnings:					
Information:					
5	Foreign Reference	TW-200746621_wAbstract.PDF	1852053 d357685b9e12a70667127706c8f9d27c801 1b967	no	44
Warnings:					
Information:					
6	Foreign Reference	TW-200810347_wAbstract.PDF	912171 71ea58ef52c6a05f0053b4d217ce4159a546 65bb	no	27
Warnings:					
Information:					
7	Non Patent Literature	YOON_WLAN_InGaP_GaAs_Power_Amplifier_October2009.PDF	540474 5fd4dca1e751054d409f71dc42740e835c87 a134	no	3
Warnings:					

Information:					
8	Non Patent Literature	SiGeSemiconductor_March2010.PDF	348031 7124e8d23887d6f8be8c2a67cdef09b0681651a4	no	10
Warnings:					
Information:					
9	Non Patent Literature	2012-11-28_ISR_WrittenOpinion_SKYWRKS-280WO.pdf	536796 a4af0b9dc6783930400b243df8528cc59a3Ca4c8	no	11
Warnings:					
Information:					
		Total Files Size (in bytes):	8183997		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/377,842	12/13/2016	Ping Li	SKYWRKS.280C3	1052

20995 7590 02/27/2017

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER
NGUYEN, HIEU P

ART UNIT	PAPER NUMBER
2842	

NOTIFICATION DATE	DELIVERY MODE
02/27/2017	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jayna.cartee@knobbe.com
efiling@knobbe.com

EX-1002 0235
Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

Office Action Summary	Application No. 15/377,842	Applicant(s) LI ET AL.	
	Examiner HIEU NGUYEN	Art Unit 2842	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) 1-20 is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Double Patenting

Claims 1-20 are rejected on the ground of nonstatutory obviousness-type **double patenting** as being unpatentable over claims 1-20 of U.S. Patent No. 9,136,803. Although the conflicting claims are not identical, they are not patentably distinct from each other because all of the limitations of the present claims are present in the patented claims.

Claim Rejections - 35 USC § 103

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-6, 8-12, 14-17, 19 and 20 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over **WAKITA et al.** (U.S. 8,692,619).

Regarding claims 1 and 10, WAKITA et al. (hereinafter, **Ref~619**) discloses (see Figures 1-6 and related text for details) a mobile device/method comprising:

a transceiver configured to generate a radio frequency signal (at 101 of Fig. 1 and a power amplifier enable signal (Vcont disposed at 143 of Fig. 1) as seen/expected;

a power amplifier (103 of Fig. 1) configured to provide amplification to the radio frequency signal, the power amplifier configured to receive a bias signal (disposed at base of transistor 103 of Fig. 1) that biases the power amplifier; and

a bias circuit (at least 111 and/or 112 and/or 203 of Fig. 1 can be read as the claimed bias circuit OR at least it is functionally equivalent to it) configured to receive the power amplifier enable signal and to generate the bias signal, the bias circuit including a gain correction circuit (122 of Fig. 1 can be read as the claimed circuit OR at least it is functionally equivalent to it) configured to generate (via output of 202 of Fig. 1) a correction current in response to activation of the power amplifier enable signal, and a primary biasing circuit (111 of Fig. 1) configured to generate the bias signal based on the correction current and the power amplifier enable signal as expected, **meeting claims 1 and 10**.

Regarding claim 2, Ref~619 discloses the mobile device of claim 1 wherein the primary bias circuit includes a first transistor (107 of Fig. 1), the correction current configured to change a current flowing through the first transistor as expected, **meeting claim 2**.

Regarding claim 3, Ref~619 discloses the mobile device of claim 2 wherein the primary bias circuit further includes a resistor (131 of Fig. 1), the first transistor configured to receive the power amplifier enable signal via the resistor as seen/expected, **meeting claim 3**.

Regarding claim 4, Ref~619 discloses the mobile device of claim 2 wherein the primary bias circuit further includes a second transistor (151 of Fig. 1) electrically coupled to the first

transistor and configured to provide the bias signal to the power amplifier as expected, **meeting claim 4**.

Regarding claim 5, Ref~619 discloses the mobile device of claim 1 wherein the power amplifier includes an output configured to provide a wireless local area network signal, the power amplifier enable signal operable to pulse the output of the power amplifier as also expected depending on specifications/applications, **meeting claim 5**.

Regarding claims 6 and 12, Ref~619 discloses the mobile device wherein the gain correction circuit includes a time-dependent signal generator (at least 202 of Fig. 1 can be read as the claimed generator) configured to generate a control current in response to activation of the power amplifier enable signal, and a current amplifier (120 and/or 119 of Fig. 1 can be read as the claimed amplifier) configured to generate the correction current by amplifying the control current as seen/expected, **meeting claims 6**.

Regarding claim 8, Ref~619 discloses the mobile device of claim 6 wherein the current amplifier is configured to receive the power amplifier enable signal as expected, **meeting claim 8**.

Regarding claim 9, Ref~619 discloses the mobile device of claim 6 wherein the time-dependent signal generator receives the power amplifier enable signal at an input (at based of transistor 120) and generates the control current at an output (emitter of transistor 119 of Fig. 1), the time-dependent signal generator including a capacitor (121 of Fig. 1) and a first resistor (162 of Fig. 1) electrically connected in a first electrical path from the input to the output as expected, **meeting claim 9**.

Regarding claim 10, Ref~619 discloses the mobile device of claim 9 wherein the time-dependent signal generator further includes a second resistor (131 of Fig. 1) electrically connected in a second electrical path from the input to the output as seen/expected, **meeting claim 10**.

Regarding claims 14-17, 19 and 20, limitations from these claims can be rejected in the same manner as described above in claims 1-6 and 8-10, since same features with similar language are being presented here, in addition to the fact that it would have been obvious to employ the claimed "integrated" circuit attached to the claimed "package substrate" as well-known and/or widely-used in the field in order to at least minimize space and/or cost...etc., **meeting claim 14-17, 19 and 20**.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hieu Nguyen whose telephone number is 571-272-8577. The examiner can normally be reached on M-F 8-5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Robert Pascal can be reached on 571-272-1769. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/Hieu Nguyen/
Primary Examiner
Group Art Unit: 2842

Notice of References Cited	Application/Control No. 15/377,842	Applicant(s)/Patent Under Reexamination LI ET AL.	
	Examiner HIEU NGUYEN	Art Unit 2842	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8,692,619 B2	04-2014	Wakita; Kazuya	H03F1/0261	330/289
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L7	414	(burst|boost|transient) and EVM	USPAT	OR	OFF	2017/02/17 14:59
L8	62	(burst|boost|transient) and EVM and 330/$.ccls.	USPAT	OR	OFF	2017/02/17 14:59
L9	145	(burst|boost|transient) and EVM and 330/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:00
L10	148	(burst|boost|transient|start$up) and EVM and 330/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:00
L11	23	(burst|boost|transient|start$up) and mirror and EVM and 330/$.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:01
L12	14	(burst|boost|transient|start$up) and mirror and EVM and 330/285,296,298,288-289.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:01
L13	320	(burst|boost|transient|start$up) and mirror and 330/285,296,298,288-289.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:01
L14	86	(burst|boost|transient|start$up) and mirror and (RC|(time adj constant)) and 330/285,296,298,288-289.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:02
L15	197	(burst|boost|transient|start$up) and bias$4 and (RC|(time adj constant)) and 330/285,296,298,288-289.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/17 15:06
S1	50	(boost$4 with current) and 330/285,296,289.ccls.	USPAT	OR	OFF	2017/02/16 20:55
S2	10	(boost$4 with current) and RC and 330/285,296,289.ccls.	USPAT	OR	OFF	2017/02/16 20:55
S8	3	(boost$4 with current) and EVM and 330/$.ccls.	USPAT	OR	OFF	2017/02/16 21:13
S11	15	(boost$4 with current) and EVM	USPAT	OR	OFF	2017/02/16 21:13
S12	204	burst and EVM	USPAT	OR	OFF	2017/02/16

						21:15
S13	3	burst and DEVM	USPAT	OR	OFF	2017/02/16 21:15
S14	3	burst and (dynamic adj EVM)	USPAT	OR	OFF	2017/02/16 21:16
S15	3	burst and (dynamic adj error adj vector)	USPAT	OR	OFF	2017/02/16 21:16
S16	11	burst and (dynamic adj error adj vector)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/16 21:16

EAST Search History (Interference)

< This search history is empty>

2/17/2017 3:09:36 PM
C:\Users\hnguyen35\Documents\EAST\Workspaces\15377842.wsp

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15377842	LI ET AL.
	Examiner	Art Unit
	HIEU NGUYEN	2842

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
330	285	02/17/2017	hn
330	296	02/17/2017	hn
330	288	02/17/2017	hn
330	289	02/17/2017	hn

SEARCH NOTES		
Search Notes	Date	Examiner
EAST	02/17/2017	hn

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/HIEU NGUYEN/ Primary Examiner, Art Unit 2842

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15377842	LI ET AL.
	Examiner	Art Unit
	HIEU NGUYEN	2842

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	02/17/2017								
	1	✓								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
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	18	✓								
	19	✓								
	20	✓								

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BIB DATA SHEET

CONFIRMATION NO. 1052

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
15/377,842	12/13/2016	455	2842	SKYWRKS.280C3

APPLICANTS

SKYWORKS SOLUTIONS, INC., Woburn, MA;

INVENTORS

Ping Li, Dunstable, MA;
Paul T. DiCarlo, Marlborough, MA;

**** CONTINUING DATA ***************************

This application is a CON of 14/825,053 08/12/2015
which is a CON of 14/242,150 04/01/2014 PAT 9136803
which is a CON of 13/468,749 05/10/2012 PAT 8717101
which claims benefit of 61/486,186 05/13/2011

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

12/21/2016

Foreign Priority claimed	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
☐ Yes ☑ No	MA	7	20	3

35 USC 119(a-d) conditions met ☐ Yes ☑ No ☐ Met after Allowance

Verified and Acknowledged /HIEU P NGUYEN/ Examiner's Signature

hn Initials

ADDRESS

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614
UNITED STATES

TITLE

APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS

FILING FEE RECEIVED		
1600	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 15/377,842

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1600

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRPART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/377,842	12/13/2016	2842	1600	SKYWRKS.280C3	20	3

CONFIRMATION NO. 1052

FILING RECEIPT

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614



Date Mailed: 12/23/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Ping Li, Dunstable, MA;
Paul T. DiCarlo, Marlborough, MA;

Applicant(s)

SKYWORKS SOLUTIONS, INC., Woburn, MA;

Power of Attorney: The patent practitioners associated with Customer Number 20995

Domestic Priority data as claimed by applicant

This application is a CON of 14/825,053 08/12/2015
which is a CON of 14/242,150 04/01/2014 PAT 9136803
which is a CON of 13/468,749 05/10/2012 PAT 8717101
which claims benefit of 61/486,186 05/13/2011

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 12/21/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/377,842**

Projected Publication Date: 03/30/2017

Non-Publication Request: No

Early Publication Request: No

Title

APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS

Preliminary Class

330

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

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Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	15/377,842
Filing Date	December 13, 2016
First Named Inventor	Ping Li
Title	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
Art Unit	2842
Examiner Name	Unassigned
Attorney Docket Number	SKYWRKS.280C3

SIGNATURE of Applicant or Patent Practitioner

Signature	/David Trossen/	Date (Optional)	December 14, 2016
Name	David Trossen	Registration Number	59406
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 20995

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Skyworks Solutions, Inc.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	April 7, 2014
Name	Donald Bollella		
Title	Chief Patent Counsel		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Please Direct All Correspondence to Customer Number 20995

RESCISSION OF ANY PRIOR DISCLAIMERS AND REQUEST TO REVISIT ART

Inventors	:	Ping Li et al.
App. No	:	15/377,842
Filed	:	December 13, 2016
For	:	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
Examiner	:	Unassigned
Art Unit	:	2842
Conf #	:	1052

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The claims of the present application are different and possibly broader in scope than the claims pursued in the parent applications. To the extent any prior amendments or characterizations of the scope of any claim or referenced art could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicant hereby rescinds and retracts such disclaimer. Accordingly, the references previously considered in the parent applications may need to be re-visited.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Knobbe, Martens, Olson & Bear, LLP

Respectfully submitted,

Dated: December 14, 2016

/David Trossen/
David Trossen
Registration No. 59,406
Attorney of Record
Customer No. 20995
(415) 954-4114

Electronic Acknowledgement Receipt

EFS ID:	27795692
Application Number:	15377842
International Application Number:	
Confirmation Number:	1052
Title of Invention:	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
First Named Inventor/Applicant Name:	Ping Li
Customer Number:	20995
Filer:	David R. Trossen/ThuyQuyen Nguyen
Filer Authorized By:	David R. Trossen
Attorney Docket Number:	SKYWRKS.280C3
Receipt Date:	14-DEC-2016
Filing Date:	
Time Stamp:	16:47:52
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Power of Attorney	POA_SKYWRKS-280C3.pdf	159682 8a538cb053deebb1e4846fe981113a90c71328bd	no	3

Warnings:

Information:					
2	Miscellaneous Incoming Letter	Rescission_SKYWRKS-280C3.pdf	14826 29c3b98b883800f2aad97f2a4470d2f7ee4cb2c6	no	1
Warnings:					
Information:					
			Total Files Size (in bytes):	174508	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Ping		Li	

Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

City	Dunstable	State/Province	MA	Country of Residence	US

Mailing Address of Inventor:

Address 1	41 Adams Street
Address 2	

City	Dunstable	State/Province	MA
Postal Code	01827	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Paul	T.	DiCarlo	

Residence Information (Select One) ◉ US Residency Non US Residency Active US Military Service

City	Marlborough	State/Province	MA	Country of Residence	US

Mailing Address of Inventor:

Address 1	19 Miele Road
Address 2	

City	Marlborough	State/Province	MA
Postal Code	01752	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

PTO/AIA/14 (11-15)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	20995
Email Address	efiling@knobbe.com Add Email Remove Email

Application Information:

Title of the Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS		
Attorney Docket Number	SKYWRKS.280C3	**Small Entity Status Claimed** ☐	
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	7	**Suggested Figure for Publication (if any)**	4

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	14/825053	2015-08-12

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/825053	Continuation of	14/242150	2014-04-01	9136803	2015-09-15

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/242150	Continuation of	13/468749	2012-05-10	8717101	2014-05-06

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
13/468749	Claims benefit of provisional	61/486186	2011-05-13

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[j] (if applicable)

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
Title of Invention	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	SKYWORKS SOLUTIONS, INC.		
Mailing Address Information For Applicant:			
Address 1	20 Sylvan Road		
Address 2			
City	Woburn	**State/Province**	MA
Country	US	Postal Code	01801
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
	Application Number	
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Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

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If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

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Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

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Signature:

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This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/David Trossen/			Date (YYYY-MM-DD)	2016-12-13
First Name	David	Last Name	Trossen	Registration Number	59406

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	SKYWRKS.280C3
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This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the PatentCooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	APPARATUS AND METHODS FOR BIASING A POWER AMPLIFIER

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ■ United States application or PCT international application number 14/242,150 filed on April 1, 2014

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Ping Li Date: 8-10-2015

Signature:

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional form for each additional inventor.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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- ☐ The attached application, or
- ☒ United States application or PCT international application number 14/242,150 filed on April 1, 2014.

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LEGAL NAME OF INVENTOR

Inventor: Paul T. DiCarlo Date: 12/5/2014

Signature: Paul T. DiCarlo

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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Patent Application No. 14/825,053, filed August 12, 2015 titled "APPARATUS AND METHODS FOR POWER AMPLIFIER BIASING," which is a continuation of U.S. Patent Application No. 14/242,150, filed April 1, 2014, titled "APPARATUS AND METHODS FOR BIASING A POWER AMPLIFIER," which is a continuation of U.S. Patent Application No. 13/468,749, filed May 10, 2012, titled "APPARATUS AND METHODS FOR BIASING POWER AMPLIFIERS," which claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application No. 61/486,186, filed May 13, 2011 titled "APPARATUS AND METHODS FOR BIASING POWER AMPLIFIERS," each of which are herein incorporated by reference in their entireties.

BACKGROUND

Field

[0002] Embodiments of the invention relate to electronic systems, and in particular, to radio frequency (RF) electronics.

Description of the Related Technology

[0003] RF power amplifiers can be used to boost the power of a RF signal having a relatively low power. Thereafter, the boosted RF signal can be used for a variety of purposes, included driving the antenna of a transmitter.

[0004] Power amplifiers can be included in mobile phones to amplify a RF signal for transmission. For example, in mobile phones that communicate using a wireless local area network (WLAN) protocol and/or any other suitable communication standard, a power amplifier can be used to amplify the RF signal. It can be important manage the amplification of a RF signal, as amplifying the RF signal to an incorrect power level can cause a wireless device to transmit out of band.

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Kangxi Communication Technologies (Shanghai) Co., Ltd. v. Skyworks Solutions, Inc.

[0005] There is a need for improved power amplifier systems. Furthermore, there is a need for improving power amplifier biasing.

SUMMARY

[0006] In certain embodiments, the present disclosure relates to a power amplifier system including a power amplifier configured to amplify a radio frequency (RF) signal and a bias block for biasing the power amplifier. The bias block includes a time dependent signal generator configured to shape an enable signal of the power amplifier to generate a control current, a current amplifier configured to amplify the control current to generate a correction current, and a primary biasing circuit configured to generate a bias current for the power amplifier based at least partly on the correction current. The bias current is configured to correct for a variation in gain of the power amplifier when the power amplifier is enabled.

[0007] In several embodiments, the time dependent signal generator includes a resistor-capacitor (RC) network. In accordance with a number of embodiments, the RC network includes a first resistor and a first capacitor electrically connected in series between the current amplifier and an input of the bias circuit configured to receive the enable signal. In several embodiments, the RC network further includes a second resistor having a first end electrically connected to the input of the current mirror and a second end electrically connected to the input of the bias circuit configured to receive the enable signal.

[0008] According to certain embodiments, the second resistor has a resistance ranging between about 10 kΩ and about 100 kΩ., the first capacitor has a capacitance ranging between about 10 pF and about 100 pF, and the first resistor has a resistance ranging between about 10 kΩ and about 100 kΩ.

[0009] In a number of embodiments, the current amplifier includes a current mirror. In several embodiments, the current mirror includes a first bipolar transistor and a second bipolar transistor, the first bipolar transistor including an emitter electrically connected to an emitter of the second bipolar transistor and to a power low voltage, and a collector electrically connected to a base of the first bipolar transistor and to a base of the second bipolar transistor, the collector of the first bipolar transistor configured to receive at least a portion of the control current. In certain embodiments, the current mirror further

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includes a resistor, a third bipolar transistor and a fourth bipolar transistor, the third bipolar transistor including an emitter electrically connected to an emitter of the fourth bipolar transistor and to the power low voltage, and a collector electrically connected to a first end of the resistor, to the collector of the second bipolar transistor, to a base of the third bipolar transistor, and to a base of the fourth bipolar transistor, the collector of the fourth bipolar transistor configured to generate the compensation current. In several embodiments, the resistor further includes a second end configured to receive the enable signal.

[0010] According to some embodiments, the power amplifier system further includes a transceiver for providing the RF signal to the power amplifier.

[0011] In a number of embodiments, the power amplifier includes a bipolar transistor having an emitter, a base and a collector, the base configured to receive the RF signal and the bias current. In certain embodiments, the emitter is electrically connected to a power low voltage and the collector is configured to generate an amplified version of the RF signal.

[0012] In several embodiments, the primary bias circuit includes a first resistor, a second resistor, a first bipolar transistor, and a second bipolar transistor, the first resistor including a first end electrically connected to the emitter of the first bipolar transistor at a node configured to receive the correction current, and a second end electrically connected to a first end of the second resistor at a node of the bias circuit configured to receive the enable signal, the second resistor including a second end electrically connected to a collector of the first bipolar transistor, a base of the first bipolar transistor, and to a base of the second bipolar transistor. According to certain embodiments, the second bipolar transistor includes a collector electrically connected to a battery voltage and an emitter configured to generate the bias current. In a number of embodiments, the primary bias circuit further includes a third bipolar transistor having an emitter electrically connected to the power low voltage and a base and a collector electrically connected to the emitter of the first bipolar transistor.

[0013] In certain embodiments, the present disclosure relates to a method of biasing a power amplifier. The method includes shaping an enable signal using a time-dependent signal generator to generate a control current, amplifying the control current using a current amplifier to generate a correction current, and generating a bias current for a power

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amplifier using a primary biasing circuit, the primary biasing circuit configured to use the correction current to correct for a variation in gain of the power amplifier when the power amplifier is enabled.

[0014] In a number of embodiments, shaping the enable signal includes using a resistor capacitor (RC) network of the time dependent signal generator. In some embodiments, the RC network includes a first resistor and a first capacitor electrically connected in series, the RC network configured to receive the enable signal and to generate the control current.

[0015] In several embodiments, amplifying the control current further includes amplifying the control current using a current mirror of the current amplifier.

[0016] In accordance with a number of embodiments, generating the bias current includes shaping the bias current so as to compensate for a gain variation of a heterojunction bipolar transistor (HBT).

[0017] In certain embodiments, the present disclosure relates to a bias circuit for biasing a power amplifier. The bias circuit includes a time dependent signal generator configured to shape an enable signal of the power amplifier to generate a control current, a current amplifier configured to amplify the control current to generate a correction current, and a primary biasing block configured to generate a bias current for the power amplifier based at least partly on the correction current. The bias current is configured to correct for a variation in gain of the power amplifier when the power amplifier is enabled.

[0018] In several embodiments, the time dependent signal generator includes a resistor-capacitor (RC) network. In a number of embodiments, the RC network includes a first resistor and a first capacitor electrically connected in series between the current amplifier and an input of the bias circuit configured to receive the enable signal.

[0019] In accordance with certain embodiments, the current amplifier includes a current mirror.

[0020] In several embodiments, the primary bias block includes a first resistor, a second resistor, a first bipolar transistor, and a second bipolar transistor, the first resistor including a first end electrically connected to the emitter of the first bipolar transistor at a node configured to receive the correction current, and a second end electrically connected to a

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first end of the second resistor at a node of the bias circuit configured to receive the enable signal, the second resistor including a second end electrically connected to a collector of the first bipolar transistor, a base of the first bipolar transistor, and to a base of the second bipolar transistor. In a number of embodiments, the second bipolar transistor includes a collector electrically connected to a battery voltage and an emitter configured to generate the bias current.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Figure 1 is a schematic diagram of a power amplifier module for amplifying a radio frequency (RF) signal.

[0022] Figure 2 is a schematic block diagram of an example wireless device that can include one or more of the power amplifier modules of Figure 1.

[0023] Figure 3A is a schematic block diagram of one example of a power amplifier system.

[0024] Figure 3B is a schematic block diagram of another example of a power amplifier system.

[0025] Figure 4 is a schematic block diagram of one example of a power amplifier system including a power amplifier bias block according to one embodiment.

[0026] Figure 5 is a circuit diagram of a power amplifier bias block according to one embodiment.

[0027] Figure 6 is a graph of one example of collector current versus time.

[0028] Figure 7A is a graph of one example of dynamic error vector magnitude (EVM) versus output power.

[0029] Figure 7B is a graph of another example of dynamic EVM versus output power.

[0030] Figure 8 is a flow chart illustrating a method for biasing a power amplifier in accordance with one embodiment.

[0031] Figure 9 is a circuit diagram of a time-dependent signal generator in accordance with one embodiment.

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[0032] Figure 10A is a schematic diagram of one example of a packaged power amplifier module.

[0033] Figure 10B is a schematic diagram of a cross-section of the packaged power amplifier module of Figure 10A taken along the lines 10B–10B.

DETAILED DESCRIPTION OF EMBODIMENTS

[0034] The headings provided herein, if any, are for convenience only and do not necessarily affect the scope or meaning of the claimed invention.

[0035] Apparatus and methods for biasing power amplifiers are disclosed herein. In certain implementations, a power amplifier and a power amplifier bias block are provided. The power amplifier can be used to amplify a radio frequency (RF) signal for transmission, and the power amplifier bias block can be used to bias the power amplifier. The power amplifier bias block can receive an enable signal that can be used to enable or disable the power amplifier so as to pulse the power amplifier's output.

[0036] In certain implementations, the power amplifier bias block includes a primary biasing circuit and a gain correction block including a time-dependent signal generator and a current amplifier. The time-dependent signal generator or control block can be used to shape the enable signal so as to generate a control current, which can be amplified by the current amplifier to generate a correction current. The power amplifier bias block can generate a bias current for the power amplifier using the primary biasing circuit and the correction current. The correction current can be used to adjust the magnitude of the bias current so as to compensate for a variation in gain of the power amplifier over time when the power amplifier is transitioned from a disabled state to an enabled state. For example, shortly after a power amplifier is enabled, absent compensation the current of a primary biasing circuit can come up slow due to thermal effects, and the power amplifier's gain can be low. By including the time-dependent signal generator and the current amplifier, a current boost can be provided to the power amplifier so as to provide the power amplifier with a substantially flat gain response versus time. Correcting for gain variation in the power amplifier can improve the power amplifier's performance, including, for example, the power amplifier's dynamic error vector magnitude (EVM).

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Overview of Power Amplifier Systems

[0037] Figure 1 is a schematic diagram of a power amplifier module 10 for amplifying a radio frequency (RF) signal. The illustrated power amplifier module (PAM) 10 can be configured to amplify an RF signal RF_IN to generate an amplified RF signal RF_OUT. As described herein, the power amplifier module 10 can include one or more power amplifiers, including, for example, multi-stage power amplifiers.

[0038] Figure 2 is a schematic block diagram of an example wireless or mobile device 11 that can include one or more of the power amplifier modules of Figure 1. The wireless device 11 can include power amplifier bias circuits implementing one or more features of the present disclosure.

[0039] The example wireless device 11 depicted in Figure 2 can represent a multi-band and/or multi-mode device such as a multi-band/multi-mode mobile phone. In certain embodiments, the wireless device 11 can include switches 12, a transceiver 13, an antenna 14, power amplifiers 17, a control component 18, a computer readable medium 19, a processor 20, and a battery 21.

[0040] The transceiver 13 can generate RF signals for transmission via the antenna 14. Furthermore, the transceiver 13 can receive incoming RF signals from the antenna 14.

[0041] It will be understood that various functionalities associated with the transmission and receiving of RF signals can be achieved by one or more components that are collectively represented in Figure 2 as the transceiver 13. For example, a single component can be configured to provide both transmitting and receiving functionalities. In another example, transmitting and receiving functionalities can be provided by separate components.

[0042] Similarly, it will be understood that various antenna functionalities associated with the transmission and receiving of RF signals can be achieved by one or more components that are collectively represented in Figure 2 as the antenna 14. For example, a single antenna can be configured to provide both transmitting and receiving functionalities. In another example, transmitting and receiving functionalities can be provided by separate

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antennas. In yet another example, different bands associated with the wireless device 11 can be provided with different antennas.

[0043] In Figure 2, one or more output signals from the transceiver 13 are depicted as being provided to the antenna 14 via one or more transmission paths 15. In the example shown, different transmission paths 15 can represent output paths associated with different bands and/or different power outputs. For instance, the two example power amplifiers 17 shown can represent amplifications associated with different power output configurations (e.g., low power output and high power output), and/or amplifications associated with different bands. Although Figure 2 illustrates a configuration using two transmission paths 15, the wireless device 11 can be adapted to include more or fewer transmission paths 15.

[0044] The power amplifiers 17 can be used to amplify a wide variety of RF signals. For example, one or more of the power amplifiers 17 can receive an enable signal that can be used to pulse the output of the power amplifier to aid in transmitting a wireless local area network (WLAN) signal or any other suitable pulsed signal. Each of the power amplifiers 17 need not amplify the same type of signal. For example, one power amplifier can amplify a WLAN signal, while another power amplifier can amplify, for example, a Global System for Mobile (GSM) signal, a code division multiple access (CDMA) signal, a W-CDMA signal, a Long Term Evolution (LTE) signal, or an EDGE signal.

[0045] One or more features of the present disclosure can be implemented in the foregoing example modes and/or bands, and in other communication standards.

[0046] In Figure 2, one or more detected signals from the antenna 14 are depicted as being provided to the transceiver 13 via one or more receiving paths 16. In the example shown, different receiving paths 16 can represent paths associated with different bands. Although Figure 2 illustrates a configuration using four receiving paths 16, the wireless device 11 can be adapted to include more or fewer receiving paths 16.

[0047] To facilitate switching between receive and transmit paths, the switches 12 can be configured to electrically connect the antenna 14 to a selected transmit or receive path. Thus, the switches 12 can provide a number of switching functionalities associated with an operation of the wireless device 11. In certain embodiments, the switches 12 can include a

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number of switches configured to provide functionalities associated with, for example, switching between different bands, switching between different power modes, switching between transmission and receiving modes, or some combination thereof. The switches 12 can also be configured to provide additional functionality, including filtering and/or duplexing of signals.

[0048] Figure 2 shows that in certain embodiments, a control component 18 can be provided for controlling various control functionalities associated with operations of the switches 12, the power amplifiers 17, and/or other operating component(s). Non-limiting examples of the control component 18 are described herein in greater detail.

[0049] In certain embodiments, a processor 20 can be configured to facilitate implementation of various processes described herein. For the purpose of description, embodiments of the present disclosure may also be described with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, may be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the acts specified in the flowchart and/or block diagram block or blocks.

[0050] In certain embodiments, these computer program instructions may also be stored in a computer-readable memory 19 that can direct a computer or other programmable data processing apparatus to operate in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the acts specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operations to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus

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provide steps for implementing the acts specified in the flowchart and/or block diagram block or blocks.

[0051] The battery 21 can be any suitable battery for use in the wireless device 11, including, for example, a lithium-ion battery.

[0052] Figure 3A is a schematic block diagram of one example of a power amplifier system 26. The illustrated power amplifier system 26 includes the switches 12, the antenna 14, the battery 21, a directional coupler 24, a power amplifier bias block 30, a power amplifier 32, and a transceiver 33. The illustrated transceiver 33 includes a baseband processor 34, an I/Q modulator 37, a mixer 38, and an analog-to-digital converter (ADC) 39.

[0053] The baseband signal processor 34 can be used to generate an I signal and a Q signal, which can be used to represent a sinusoidal wave or signal of a desired amplitude, frequency, and phase. For example, the I signal can be used to represent an in-phase component of the sinusoidal wave and the Q signal can be used to represent a quadrature component of the sinusoidal wave, which can be an equivalent representation of the sinusoidal wave. In certain implementations, the I and Q signals can be provided to the I/Q modulator 37 in a digital format. The baseband processor 34 can be any suitable processor configured to process a baseband signal. For instance, the baseband processor 34 can include a digital signal processor, a microprocessor, a programmable core, or any combination thereof. Moreover, in some implementations, two or more baseband processors 34 can be included in the power amplifier system 26.

[0054] The I/Q modulator 37 can be configured to receive the I and Q signals from the baseband processor 34 and to process the I and Q signals to generate a RF signal. For example, the I/Q modulator 37 can include DACs configured to convert the I and Q signals into an analog format, mixers for upconverting the I and Q signals to radio frequency, and a signal combiner for combining the upconverted I and Q signals into a RF signal suitable for amplification by the power amplifier 32. In certain implementations, the I/Q modulator 37 can include one or more filters configured to filter frequency content of signals processed therein.

[0055] The power amplifier bias block 30 can receive an enable signal ENABLE from the baseband processor 34 and a battery or power high voltage V_{CC} from the battery 21,

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and can use the enable signal ENABLE to generate a bias current I_{BIAS} for the power amplifier 32. Although Figure 3A illustrates the battery 21 directly generating the power high voltage V_{CC}, in certain implementations the power high voltage V_{CC} can be a regulated voltage generated by a regulator that is electrically powered using the battery 21. The power amplifier 32 can receive the RF signal from the I/Q modulator 37 of the transceiver 33, and can provide an amplified RF signal to the antenna 14 through the switches 12.

[0056] The directional coupler 24 can be positioned between the output of the power amplifier 32 and the input of the switches 12, thereby allowing an output power measurement of the power amplifier 32 that does not include insertion loss of the switches 12. The sensed output signal from the directional coupler 24 can be provided to the mixer 38, which can multiply the sensed output signal by a reference signal of a controlled frequency so as to downshift the frequency content of the sensed output signal to generate a downshifted signal. The downshifted signal can be provided to the ADC 39, which can convert the downshifted signal to a digital format suitable for processing by the baseband processor 34. By including a feedback path between the output of the power amplifier 32 and the baseband processor 34, the baseband processor 34 can be configured to dynamically adjust the I and Q signals to optimize the operation of the power amplifier system 26. For example, configuring the power amplifier system 26 in this manner can aid in controlling the power added efficiency (PAE) and/or linearity of the power amplifier 32.

[0057] Figure 3B is a schematic block diagram of another example of a power amplifier system 60. The illustrated power amplifier system 60 includes a power amplifier bias block 40, the battery 21, the power amplifier 32, an inductor 62, a first capacitor 63, a second capacitor 42, an impedance matching block 64, the switches 12, and the antenna 14.

[0058] The illustrated power amplifier 32 includes a bipolar transistor 61 having an emitter, a base, and a collector. The emitter of the bipolar transistor 61 can be electrically connected to a first or power low voltage V_1, which can be, for example, ground, and a radio frequency input signal RF_IN can be provided to the base of the bipolar transistor 61 through the first capacitor 42. The bipolar transistor 61 can amplify the RF input signal RF_IN and provide the amplified RF signal at the collector. The bipolar transistor 61 can be any suitable

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device. In one implementation, the bipolar transistor 61 is a heterojunction bipolar transistor (HBT).

[0059] The power amplifier 32 can be configured to provide the amplified RF signal to the switches 12. The impedance matching block 64 can be used to aid in terminating the electrical connection between the power amplifier 32 and the switches 12. For example, the impedance matching block 64 can be used to increase power transfer and/or reduce reflections of the amplified RF signal.

[0060] The inductor 62 can be included to aid in electrically powering the power amplifier 32 with the power high voltage V_{CC} from the battery 21 while choking or blocking high frequency RF signal components.. The inductor 62 can include a first end electrically connected to the power high voltage V_{CC} and a second end electrically connected to the collector of the bipolar transistor 61. The first or decoupling capacitor 63 is electrically connected between the power high voltage V_{CC} and the power low voltage V_1 and can provide a low impedance path to high frequency signals, thereby reducing the noise of the power high voltage V_{CC}, improving power amplifier stability, and/or improving the performance of the inductor 62 as a RF choke.

[0061] The power amplifier bias block 40 is configured to receive an enable signal ENABLE and the battery or power high voltage V_{CC}. The power amplifier bias block 40 can use the enable signal ENABLE and the battery voltage V_{CC} to generate a bias current I_{BIAS} for biasing the power amplifier 32. For example, as illustrated in Figure 3B, the power amplifier bias block 40 can be used to generate a bias current I_{BIAS} that can be used to bias the base of the bipolar transistor 61 of the power amplifier 32. The power amplifier bias block 40 can use the enable signal ENABLE to control or vary a magnitude of the bias current I_{BIAS} so as to enable or disable the power amplifier and thereby pulse the power amplifier's output. For example, when the enable signal ENABLE indicates the power amplifier 32 should be activated, the power amplifier bias block 40 can change the amplitude of the bias current I_{BIAS} so as to achieve a desired gain of the power amplifier 32. Similarly, when the enable signal ENABLE indicates that the power amplifier 32 should be deactivated, the power amplifier bias block 40 can decrease the bias current I_{BIAS} such that the gain of the power amplifier 32 is equal to about 0.

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[0062] Although Figure 3B illustrates one implementation of the power amplifier 32, skilled artisans will appreciate that the teachings described herein can be applied to a variety of power amplifier structures, including, for example, multi-stage power amplifier structures and/or power amplifiers employing other transistor structures.

Overview of Power Amplifier Bias Circuits

[0063] In certain implementations described herein, a power amplifier bias block includes a primary biasing circuit and a gain correction block including a time-dependent signal generator and a current amplifier. The time-dependent signal generator can be used to shape the enable signal of the power amplifier so as to generate a control current, which can be amplified by the current amplifier to generate a correction current. The primary biasing circuit can use the correction current to correct for a variation in gain of the power amplifier that can occur shortly after the power amplifier is enabled. Compensating for gain variation in the power amplifier can improve the power amplifier's performance, including, for example, the power amplifier's dynamic error vector magnitude (EVM).

[0064] Including both the current amplifier and the time-dependent signal generator can permit the power amplifier bias block to be included on-die with the power amplifier. For example, by amplifying the control current generated by the time-dependent signal generator, the magnitude of the components of the time-dependent signal generator can be reduced to a size suitable for on-chip integration. In certain implementations, the time-dependent signal generator can include a resistor-capacitor (RC) network, and the current amplifier can be used to amplify the control current so as to reduce a magnitude of the resistor and/or capacitor needed to generate a suitable correction current, thereby permitting the time-dependent signal generator to be integrated on-chip with the power amplifier.

[0065] Figure 4 is a schematic block diagram of one example of a power amplifier system 70 including a power amplifier bias block 50 according to one embodiment. The illustrated power amplifier system 70 includes the power amplifier bias block 50, the battery 21, and the power amplifier 32. The power amplifier 32 can be a single or multi-stage power amplifier, and in certain implementations can be similar to the power amplifier 32 described above with reference to Figure 3B. The battery 21 can be any suitable battery, such

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as a lithium-ion battery, and be used to provide the battery or power high voltage V_{CC} to the power amplifier bias block 50 and to the power amplifier 32. The power amplifier bias block 50 and the power amplifier 32 can be integrated on a single die with one or more other components to form a packaged power amplifier module, which can be, for example, mounted to a RF circuit board associated with the wireless device 11 of Figure 2.

[0066] The power amplifier bias block 50 includes a gain correction block 71 and a primary biasing circuit 74. The gain correction block 71 includes a time-dependent signal generator or control block 72 and a current amplifier 73. The power amplifier bias block 50 can receive an enable signal ENABLE, and use the enable signal ENABLE to generate a bias current I_{BIAS} using charge stored on the battery 21. The bias current I_{BIAS} can be provided to, for example, a base of a bipolar transistor of the power amplifier 32, as was described earlier.

[0067] The enable signal ENABLE can be used to control the power amplifier 32 so as to pulse the output of the power amplifier 32. For example, when the power amplifier 32 is configured to transmit a WLAN signal, the enable signal ENABLE can be selectively controlled so as to pulse the output of the power amplifier 32.

[0068] The power amplifier 32 can be configured to operate in a relatively noisy environment. For example, a die including the power amplifier 32 and the power amplifier bias block 50 can be provided in an electronic system that includes other electronic components including other power amplifiers, such as power amplifiers amplifying GSM and/or EDGE signals. These electronic components can cause noise on the power high voltage V_{CC}. Additionally, the power amplifier 32 can also be exposed to other non-ideal operation conditions. For example, the power amplifier 32 and the power amplifier bias block 50 can be exposed to a thermal gradient, and thus can be at different operating temperatures. Furthermore, the level of the power high voltage V_{CC} can vary depending on a charge of the device that the power amplifier 32 and the power amplifier bias block 50 are used in. The power amplifier bias block 50 can be used to compensate for a gain variation of the power amplifier 32 arising from these sources, as well as from other sources.

[0069] The power amplifier bias block 50 includes the time-dependent signal generator 72, which can be used to generate a control current $I_{CONTROL}$ when the enable signal ENABLE is transitioned from a disabled state to an enabled state. The control current

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$I_{CONTORL}$ can be provided to the current amplifier 73, which can amplify the control current $I_{CONTROL}$ to generate a correction current $I_{CORRECTION}$. The correction current $I_{CORRECTION}$ can be used by the primary biasing circuit 74 to correct for a variation in gain over time that can occur shortly after the power amplifier 32 is enabled. For example, shortly after the power amplifier 32 is enabled, absent compensation the current of the primary biasing circuit 74 can come up slow due to thermal effects, and the gain of the power amplifier 32 can be low. By using the time-dependent signal generator 72 and the current amplifier 73 to provide a transient current boost to the power amplifier 32 after being enabled, the power amplifier 32 can be configured to have a substantially constant gain over time.

[0070] By including the current amplifier 73 to amplify the control current $I_{CONTROL}$ generated by the time-dependent signal generator 72, the magnitude of the components of the time-dependent signal generator 72 can be reduced. For example, the current amplifier 73 can be used to amplify the control current $I_{CONTROL}$ so as to reduce a size of a component of the time-dependent signal generator 72 needed to generate a correction current with correct time constant, thereby permitting the time-dependent signal generator to be integrated on-chip with the power amplifier 32.

[0071] The primary bias circuit 74 can be configured to generate a relatively constant bias current output that can be adjusted by the correction current $I_{CORRECTION}$ to correct for a variation in gain of the power amplifier 32 that can occur shortly after the power amplifier 32 is enabled. In certain implementations, the primary bias circuit 74 can be a conventional bias circuit that is modified such that the output of the bias circuit is adjusted based on the amplitude of the correction current $I_{CORRECTION}$. Additional detail of the primary bias circuit 74 can be as described later below.

[0072] Figure 5 is a circuit diagram of a power amplifier bias block 80 according to one embodiment. The power amplifier bias block 80 includes a resistor-capacitor (RC) network 82, a current mirror 83, and a primary bias circuit 84. The RC network 82 operates as a time-dependent signal generator and the current mirror 83 operates as a current amplifier. The power amplifier bias block 80 is configured to receive an enable signal ENABLE and a battery or power high voltage V_{CC}, and to generate a bias current I_{BIAS}.

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[0073] The RC network 82 includes a first resistor 91, a second resistor 92, and a capacitor 90. The first resistor 91 includes a first end electrically connected to a first end of the capacitor 90 at an input of the RC network 82 configured to receive the enable signal ENABLE. The first resistor 91 further includes a second end electrically connected to a first end of the second resistor 92 at an output of the RC network 82 configured to provide the control current $I_{CONTROL}$ to the current mirror 83. The second resistor 92 further includes a second end electrically connected to a second end of the capacitor 90.

[0074] The RC network 82 can be used to shape the enable signal ENABLE so as to generate the control current $I_{CONTROL}$. For example, the capacitor 90 and the second resistor 92 can have an RC time-constant selected to achieve the desired shape of the control current $I_{CONTROL}$. The RC time-constant can be selected based on a system parameter of the electronic system that the power amplifier bias block 80 is used in, including, for example, a transition time of the enable signal ENABLE. In certain implementations, the time-constant of the second resistor 92 and the capacitor 90 is in the range of about 0.1 μs to about 10 μs, for example, about 1 μs.

[0075] In certain implementations, the capacitor 90 has a capacitance ranging between about 10 pF to about 50 pF, for example, about 25 pF. The second resistor 92 can have any suitable resistance, including, for example, a resistance in the range of about 10 kΩ to about 100 kΩ, for example, about 50 kΩ. Although one implementation of the capacitor 90 and the second resistor 92 is illustrated, other configurations are possible. For example, the order of the second resistor 92 and the capacitor 90 in the series combination of the second resistor 92 and the capacitor 90 can be reversed. The first resistor 91 can have any suitable value, including, for example, a resistance in the range of about 1 kΩ to about 20 kΩ, for example, about 10 kΩ. In certain implementations, such as the implementation shown in Figure 9, the first resistor 91 can be omitted.

[0076] To aid in reducing the area of the RC network 82, the current mirror 83 can be used to amplify the control current $I_{CONTROL}$ to generate the correction current $I_{CORRECTION}$. Thus, the amplifier 83 can be used to obtain a correction current $I_{CORRECTION}$ of a suitable magnitude, while reducing the size of the components of the RC network 82 relative to a scheme omitting a current amplifier. By amplifying the control current $I_{CONTROL}$ in this

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manner, the power amplifier bias block 80 can be integrated on-chip with a power amplifier without having to use a relatively large resistor, which may not provide enough current variation to provide suitable gain compensation.

[0077] The illustrated current mirror 83 includes a first NPN bipolar transistor 85, a second NPN bipolar transistor 86, a third NPN bipolar transistor 87, a fourth NPN bipolar transistor 88, and a resistor 89. The first NPN bipolar transistor 85 includes an emitter electrically connected to the first or power low voltage V_1, which can be, for example, ground, and a base and a collector electrically connected to a base of the second NPN bipolar transistor 86 at an input of the current mirror 83 configured to receive the control current $I_{CONTROL}$. The second NPN bipolar transistor 86 further includes an emitter electrically connected to the power low voltage V_1, and a collector electrically connected to a first end of the resistor 89, to a base of the fourth NPN bipolar transistor 88, and to a base and a collector of the third NPN bipolar transistor 87. The third and fourth NPN bipolar transistors 87, 88 each include an emitter electrically connected to the power low voltage V_1. The resistor 89 includes a second end configured to receive the enable signal ENABLE. The fourth NPN bipolar transistor 88 further includes a collector configured to generate the correction current $I_{CORRECTION}$.

[0078] The resistor 89 can have any suitable resistance, including, for example, a resistance selected based on the voltage level of power amplifier enable signal ENABLE and/or system requirements. In certain implementations, the resistor 89 has a resistance ranging between about 10 kΩ to about 50 kΩ, for example, about 20 kΩ. By electrically connected the second end of the resistor 89 to the enable signal ENABLE, the power consumption of the power amplifier bias block 80 can be reduced when the enable signal ENABLE is low. However, in other implementations, the current mirror 83 can be configured in other ways.

[0079] The current mirror 83 can have any suitable gain. In one implementation, the current mirror 83 is configured to amplify the control current $I_{CONTROL}$ by a factor ranging between about 5 to about 50, for example, about 10. As used herein, the term current mirror can refer to current amplification circuits including a plurality of current mirrors combined (e.g., cascaded) to achieve a target gain.

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[0080] The primary bias circuit 84 can be used to generate a bias current I_{BIAS} for a power amplifier, such as the power amplifier 32 of Figure 4. The illustrated primary bias circuit 84 includes a first resistor 96, a second resistor 97, a first NPN bipolar transistor 93, a second NPN bipolar transistor 94 and a third NPN bipolar transistor 95. The first resistor 96 includes a first end electrically connected to a first end of the second resistor 97 at an input of the primary bias circuit 84 configure to receive the enable signal ENABLE. The first resistor 96 further includes a second end electrically connected to an emitter of the second NPN bipolar transistor 94 and to a base and a collector of the first NPN bipolar transistor 93 at an input of the primary bias circuit 84 configured to receive the correction current $I_{CORRECTION}$. The first NPN bipolar transistor 93 further includes an emitter electrically connected to the power low voltage V_1. The second resistor 97 further includes a second end electrically connected to a base and a collector of the second NPN bipolar transistor 94 and to a base of the third NPN bipolar transistor 95. The third NPN bipolar transistor 95 further includes a collector electrically connected to the power high voltage V_{CC} and an emitter configured to generate the bias current I_{BIAS}.

[0081] The first NPN bipolar transistor 93 can aid in level-shifting the voltage of the emitter of the second NPN bipolar transistor 94, which in turn can impact the emitter voltage of the third NPN bipolar transistor 95. Thus, inclusion of the first NPN bipolar transistor 93 can aid in establishing suitable DC operating voltage levels of the power amplifier bias block 80.

[0082] The first and second resistors 96, 97 can be tuned to control the steady-state amplitude of the bias current I_{BIAS} when the enable signal ENABLE is activated. For example, the current through the second NPN bipolar transistor 94 can be established using the first and second resistors 96, 97, and can be mirrored using the third NPN bipolar transistor 95 to generate the bias current I_{BIAS}.

[0083] After the enable signal ENABLE becomes activated, the RC network 82 can generate a control current $I_{COTNROL}$ that can be amplified by the current mirror 83 to generate the correction current $I_{CORRECTION}$. As illustrated in Figure 5, the correction current $I_{CORRECTION}$ can be used to vary or change the current through the second NPN bipolar transistor 94. For example, when the correction current $I_{CORRECTION}$ decreases, the current

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through the second NPN bipolar transistor 94 can increase, which in turn can increase the bias current I_{BIAS} generated using the third NPN bipolar transistor 95. The second NPN bipolar transistor 94 can also aid in reversing the direction of the correction current $I_{CORRECTION}$ so that it is suitable to be provided to the base of the fifth NPN bipolar transistor 95. Although one variation of a primary bias circuit is illustrated, other implementations can be used.

[0084] Figure 6 is a graph 100 of one example of collector current versus time. The graph 100 begins at a time zero that is associated with enabling a power amplifier. The graph 100 includes a first plot 101, a second plot 102, a third plot 103, a fourth plot 104 and a fifth plot 105, which correspond to different battery voltage values. In particular, the first, second, third, fourth, and fifth plots 101-105 correspond to battery voltage values of about 3.2 V, about 3.4 V, about 3.6 V, about 3.8 V, and about 4.0 V, respectively.

[0085] In certain implementations described herein, a time-dependent signal generator is used to generate a signal that can be used to adjust a power amplifier's bias current during a time period within about 8 μs after the power amplifier is enabled. Thereafter the power amplifier's bias current can be substantially constant until the power amplifier's enable signal is deactivated. In certain implementations, the power amplifier's bias current can vary by more than about 50 % during the initial time period that the correction current is used to adjust the power amplifier's bias current.

[0086] Figure 7A is a graph 110 of one example of dynamic error vector magnitude (EVM) versus output power. The graph 110 is for one example of a power amplifier bias block that does not include a time-dependent signal generator and a current amplifier. The graph 110 includes plots of EVM versus output power for a variety of different battery voltage levels. For example, the graph 110 includes plots 111-119, which correspond to battery voltages ranging between about 3.2 V and about 4.2 V.

[0087] Figure 7B is a graph 120 of another example of dynamic EVM versus output power. The graph 120 is for one implementation of a power amplifier bias block that includes a time-dependent signal generator and a current amplifier. The graph 120 includes plots of EVM versus output power for a variety of different battery voltage levels. For example, the graph 120 includes plots 121-129, which correspond to battery voltages

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between about 3.2 V and about 4.2 V. The graph 120 shows that the EVM of the power amplifier system can be improved by including the time-dependent signal generator and the current amplifier.

[0088] Figure 8 is a flow chart illustrating a method 150 for biasing a power amplifier in accordance with one embodiment. It will be understood that the method 150 can include greater or fewer operations and the operations may be performed in any order, as necessary.

[0089] The method 150 starts at a block 151, in which an enable signal of a power amplifier is shaped using a time-dependent signal generator to generate a control current. The power amplifier can be any suitable power amplifier, such as a power amplifier configured to amplify a WLAN signal. In certain implementations, the time-dependent signal generator includes a resistor-capacitor (RC) network configured to generate a transient control current that begins after an enable signal of the power amplifier is activated. In certain implementations, the transient control current reaches a steady-state value within about 8 μs after the enable signal is activated. In certain implementations, the steady-state value of the transient control current can be about 0 mA.

[0090] In an ensuing block 152, the control current is amplified using the current amplifier to generate a correction current. In certain implementations, the current amplifier amplifies the correction circuit by a factor ranging between about 5 to about 50. The current amplifier can aid the time-dependent signal generator in shaping the enable signal by reducing the size of the circuit components of the time-dependent signal generator needed to achieve a desired time constant associated with gain compensation.

[0091] The method 150 continues at a block 153, in which a bias current for the power amplifier is generated using the primary biasing circuit. The primary biasing circuit is configured to use the correction current to generate a bias current for the power amplifier so as correct for a variation in gain of the power amplifier when the power amplifier is enabled. For example, the primary biasing circuit can be configured to adjust the amplitude of the bias current based on the correction current, such as by adding the correction current to a nominal bias current value.

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[0092] Figure 9 is a circuit diagram of a time-dependent signal generator 170 in accordance with one embodiment. The time-dependent signal generator 170 includes a resistor 92 and a capacitor 90, which can be similar to the resistor 92 and the capacitor 90 of the time-dependent signal generator 82 of Figure 5. However, in contrast to the time-dependent signal generator 82 of Figure 5, the time-dependent signal generator 170 of Figure 9 does not include the resistor 91 of Figure 4. In certain implementations, the time-constant of the resistor 92 and the capacitor 90 is in the range of about 0.1 μs to about 10 μs, for example, about 1 μs.

[0093] Figure 10A is a schematic diagram of one example of a packaged power amplifier module 300. Figure 10B is a schematic diagram of a cross-section of the packaged power amplifier module 300 of Figure 10A taken along the lines 10B–10B.

[0094] The packaged power amplifier module 300 includes an IC or die 301, surface mount components 303, wirebonds 308, a package substrate 320, and encapsulation 340. The package substrate 320 includes pads 306 formed from conductors disposed therein. Additionally, the die 301 includes pads 304, and the wirebonds 308 have been used to electrically connect the pads 304 of the die 301 to the pads 306 of the package substrate 301.

[0095] As illustrated in Figures 10A and 10B, the die 301 includes the power amplifier 32 and the power amplifier bias block 50 formed therein. The power amplifier bias block 50 includes the time dependent signal generator 72, the current amplifier 73, and the primary biasing circuit 74. In certain implementations, the time-dependent signal generator 72 can include a resistor-capacitor (RC) network, and the current amplifier 73 can be used to amplify a control current from the RC network to generate a correction current, which can be used by the primary biasing circuit 74 to generate a bias current for the power amplifier 32 that corrects for a gain variation of the power amplifier 32 associated with transitioning the power amplifier from a disabled state to an enabled state. Using the current amplifier 73 to amplify the control current from the time-dependent signal generator 72 can reduce a magnitude of the resistor and/or capacitor needed to generate a suitable correction current, thereby permitting the time-dependent signal generator 72 to be integrated on-chip with the power amplifier 32, as shown in Figure 10A.

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[0096] The packaging substrate 320 can be configured to receive a plurality of components such as the die 301 and the surface mount components 303, which can include, for example, surface mount capacitors and/or inductors.

[0097] As shown in Figure 10B, the packaged power amplifier module 300 is shown to include a plurality of contact pads 332 disposed on the side of the packaged power amplifier module 300 opposite the side used to mount the die 301. Configuring the packaged power amplifier module 300 in this manner can aid in connecting the packaged power amplifier module 300 to a circuit board such as a phone board of a wireless device. The example contact pads 332 can be configured to provide RF signals, bias signals, power low voltage(s) and/or power high voltage(s) to the die 301 and/or the surface mount components 303. As shown in Figure 10B, the electrically connections between the contact pads 332 and the die 301 can be facilitated by connections 333 through the package substrate 320. The connections 333 can represent electrical paths formed through the package substrate 320, such as connections associated with vias and conductors of a multilayer laminated package substrate.

[0098] In some embodiments, the packaged power amplifier module 300 can also include one or more packaging structures to, for example, provide protection and/or to facilitate handling of the packaged power amplifier module 300. Such a packaging structure can include overmold or encapsulation 340 formed over the packaging substrate 320 and the components and die(s) disposed thereon.

[0099] It will be understood that although the packaged power amplifier module 300 is described in the context of wirebond-based electrical connections, one or more features of the present disclosure can also be implemented in other packaging configurations, including, for example flip-chip configurations.

Applications

[0100] Some of the embodiments described above have provided examples in connection with mobile phones. However, the principles and advantages of the embodiments can be used for any other systems or apparatus that have needs for power amplifier systems.

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[0101] Such power amplifier systems can be implemented in various electronic devices. Examples of the electronic devices can include, but are not limited to, consumer electronic products, parts of the consumer electronic products, electronic test equipment, etc. Examples of the electronic devices can also include, but are not limited to, memory chips, memory modules, circuits of optical networks or other communication networks, and disk driver circuits. The consumer electronic products can include, but are not limited to, a mobile phone, a telephone, a television, a computer monitor, a computer, a hand-held computer, a personal digital assistant (PDA), a microwave, a refrigerator, an automobile, a stereo system, a cassette recorder or player, a DVD player, a CD player, a VCR, an MP3 player, a radio, a camcorder, a camera, a digital camera, a portable memory chip, a washer, a dryer, a washer/dryer, a copier, a facsimile machine, a scanner, a multi functional peripheral device, a wrist watch, a clock, etc. Further, the electronic devices can include unfinished products.

Conclusion

[0102] Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." The word "coupled", as generally used herein, refers to two or more elements that may be either directly connected, or connected by way of one or more intermediate elements. Likewise, the word "connected", as generally used herein, refers to two or more elements that may be either directly connected, or connected by way of one or more intermediate elements. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or" in reference to a list of two or more items, that word covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

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[0103] Moreover, conditional language used herein, such as, among others, "can," "could," "might," "can," "e.g.," "for example," "such as" and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements and/or states. Thus, such conditional language is not generally intended to imply that features, elements and/or states are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without author input or prompting, whether these features, elements and/or states are included or are to be performed in any particular embodiment.

[0104] The above detailed description of embodiments of the invention is not intended to be exhaustive or to limit the invention to the precise form disclosed above. While specific embodiments of, and examples for, the invention are described above for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. For example, while processes or blocks are presented in a given order, alternative embodiments may perform routines having steps, or employ systems having blocks, in a different order, and some processes or blocks may be deleted, moved, added, subdivided, combined, and/or modified. Each of these processes or blocks may be implemented in a variety of different ways. Also, while processes or blocks are at times shown as being performed in series, these processes or blocks may instead be performed in parallel, or may be performed at different times.

[0105] The teachings of the invention provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

[0106] While certain embodiments of the inventions have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosure. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the disclosure. The accompanying claims and their equivalents

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are intended to cover such forms or modifications as would fall within the scope and spirit of the disclosure.

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WHAT IS CLAIMED IS:

1. A mobile device comprising:

a transceiver configured to generate a radio frequency signal and a power amplifier enable signal;

a power amplifier configured to provide amplification to the radio frequency signal, the power amplifier configured to receive a bias signal that biases the power amplifier; and

a bias circuit configured to receive the power amplifier enable signal and to generate the bias signal, the bias circuit including a gain correction circuit configured to generate a correction current in response to activation of the power amplifier enable signal, and a primary biasing circuit configured to generate the bias signal based on the correction current and the power amplifier enable signal.

2. The mobile device of claim 1 wherein the primary bias circuit includes a first transistor, the correction current configured to change a current flowing through the first transistor.

3. The mobile device of claim 2 wherein the primary bias circuit further includes a resistor, the first transistor configured to receive the power amplifier enable signal via the resistor.

4. The mobile device of claim 2 wherein the primary bias circuit further includes a second transistor electrically coupled to the first transistor and configured to provide the bias signal to the power amplifier.

5. The mobile device of claim 1 wherein the power amplifier includes an output configured to provide a wireless local area network signal, the power amplifier enable signal operable to pulse the output of the power amplifier.

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6. The mobile device of claim 1 wherein the gain correction circuit includes a time-dependent signal generator configured to generate a control current in response to activation of the power amplifier enable signal, and a current amplifier configured to generate the correction current by amplifying the control current.

7. The mobile device of claim 6 wherein the current amplifier includes a current mirror configured to generate the correction current by mirroring the control current.

8. The mobile device of claim 6 wherein the current amplifier is configured to receive the power amplifier enable signal.

9. The mobile device of claim 6 wherein the time-dependent signal generator receives the power amplifier enable signal at an input and generates the control current at an output, the time-dependent signal generator including a capacitor and a first resistor electrically connected in a first electrical path from the input to the output.

10. The mobile device of claim 9 wherein the time-dependent signal generator further includes a second resistor electrically connected in a second electrical path from the input to the output.

11. A method of power amplifier biasing, the method comprising:

generating a radio frequency signal and a power amplifier enable signal using a transceiver;

providing amplification to the radio frequency signal using a power amplifier;

generating a correction current in response to activation of the power amplifier enable signal using a gain correction circuit;

generating a bias signal based on the correction current and the power amplifier enable signal using a primary biasing circuit; and

biasing the power amplifier using the bias signal.

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12. The method of claim 11 wherein generating the correction current includes generating a control current in response to activation of the power amplifier enable signal using a time-dependent signal generator, and amplifying the control current to generate the correction current using a current amplifier.

13. The method of claim 12 wherein amplifying the control current includes mirroring the control current to generate the correction current using a current mirror.

14. A packaged module comprising:

a package substrate; and

an integrated circuit attached to the package substrate and including a power amplifier configured to provide amplification to a radio frequency signal and a bias circuit configured to receive a power amplifier enable signal and to generate a bias signal that biases the power amplifier, the bias circuit including a gain correction circuit configured to generate a correction current in response to activation of the power amplifier enable signal, and a primary biasing circuit configured to generate the bias signal based on the correction current and the power amplifier enable signal.

15. The packaged module of claim 14 wherein the primary bias circuit includes a first transistor, the correction current configured to change a current flowing through the first transistor.

16. The packaged module of claim 15 wherein the primary bias circuit further includes a resistor, the first transistor configured to receive the power amplifier enable signal via the resistor.

17. The packaged module of claim 14 wherein the gain correction circuit includes a time-dependent signal generator configured to generate a control current in response to activation of the power amplifier enable signal, and a current amplifier configured to generate the correction current by amplifying the control current.

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18. The packaged module of claim 17 wherein the current amplifier includes a current mirror configured to generate the correction current by mirroring the control current.

19. The packaged module of claim 17 wherein the time-dependent signal generator receives the power amplifier enable signal at an input and generates the correction current at an output, the time-dependent signal generator including a capacitor and a first resistor electrically connected in a first electrical path from the input to the output.

20. The packaged module of claim 19 wherein the time-dependent signal generator further includes a second resistor electrically connected in a second electrical path from the input to the output.

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ABSTRACT OF THE DISCLOSURE

Apparatus and methods for biasing of power amplifiers are disclosed. In one embodiment, a mobile device includes a transceiver that generates a radio frequency signal and a power amplifier enable signal, a power amplifier that provides amplification to the radio frequency signal and that is biased by a bias signal, and a bias circuit that receives the power amplifier enable signal and generates the bias signal. The bias circuit includes a gain correction circuit that generates a correction current in response to activation of the power amplifier enable signal, and a primary biasing circuit that generates the bias signal based on the correction current and the power amplifier enable signal.

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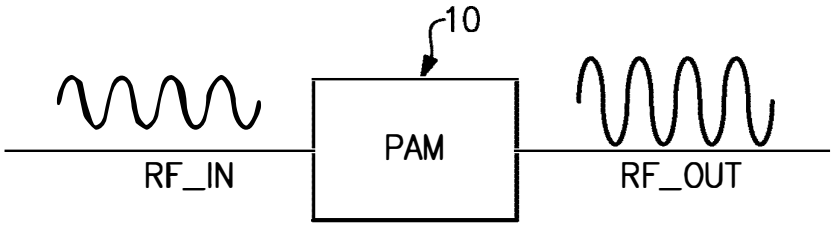

10
PAM
RF_IN
RF_OUT

FIG.1

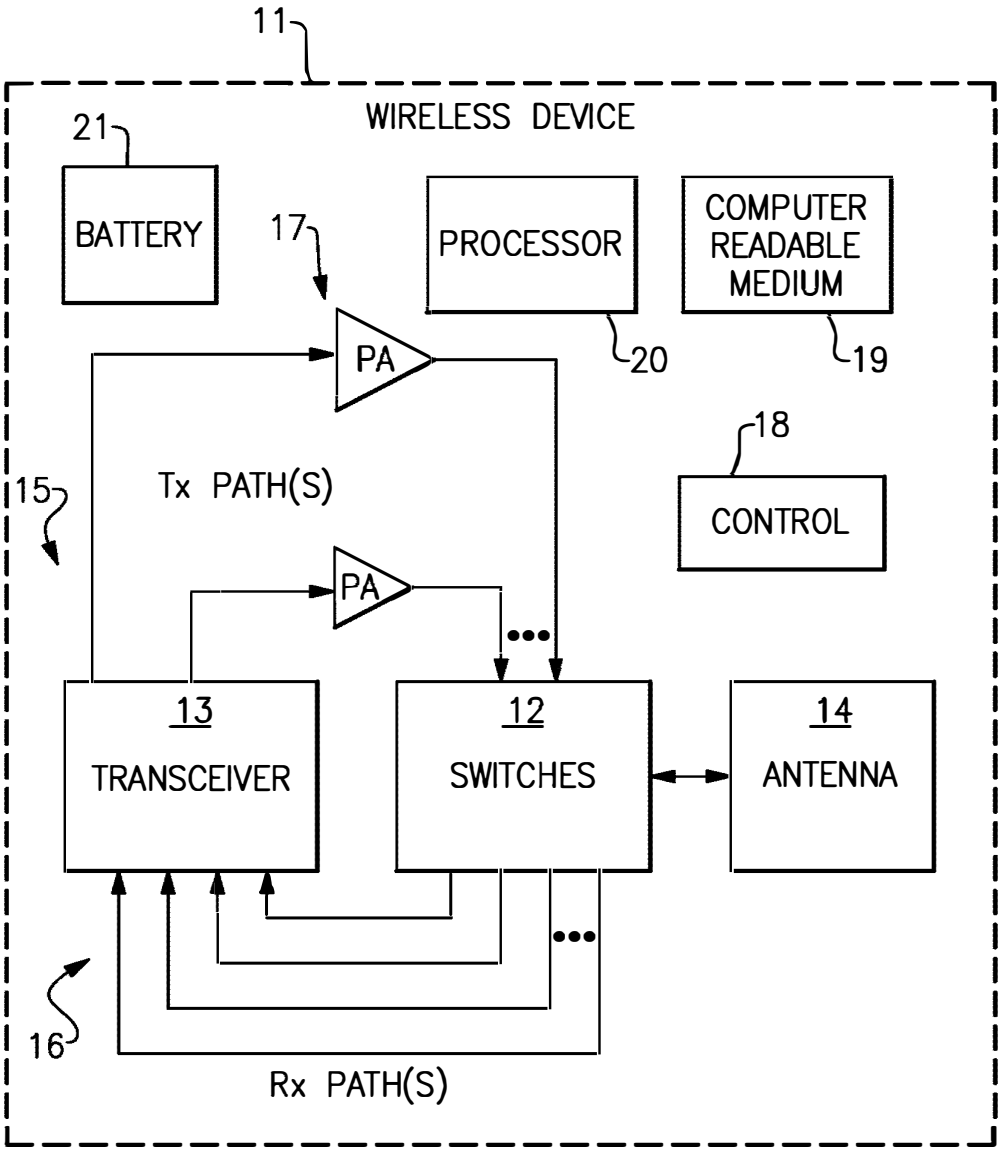

11
WIRELESS DEVICE
21
BATTERY
17
PROCESSOR
COMPUTER READABLE MEDIUM
20
19
PA
18
CONTROL
15
Tx PATH(S)
PA
13
TRANSCEIVER
12
SWITCHES
14
ANTENNA
16
Rx PATH(S)

FIG.2

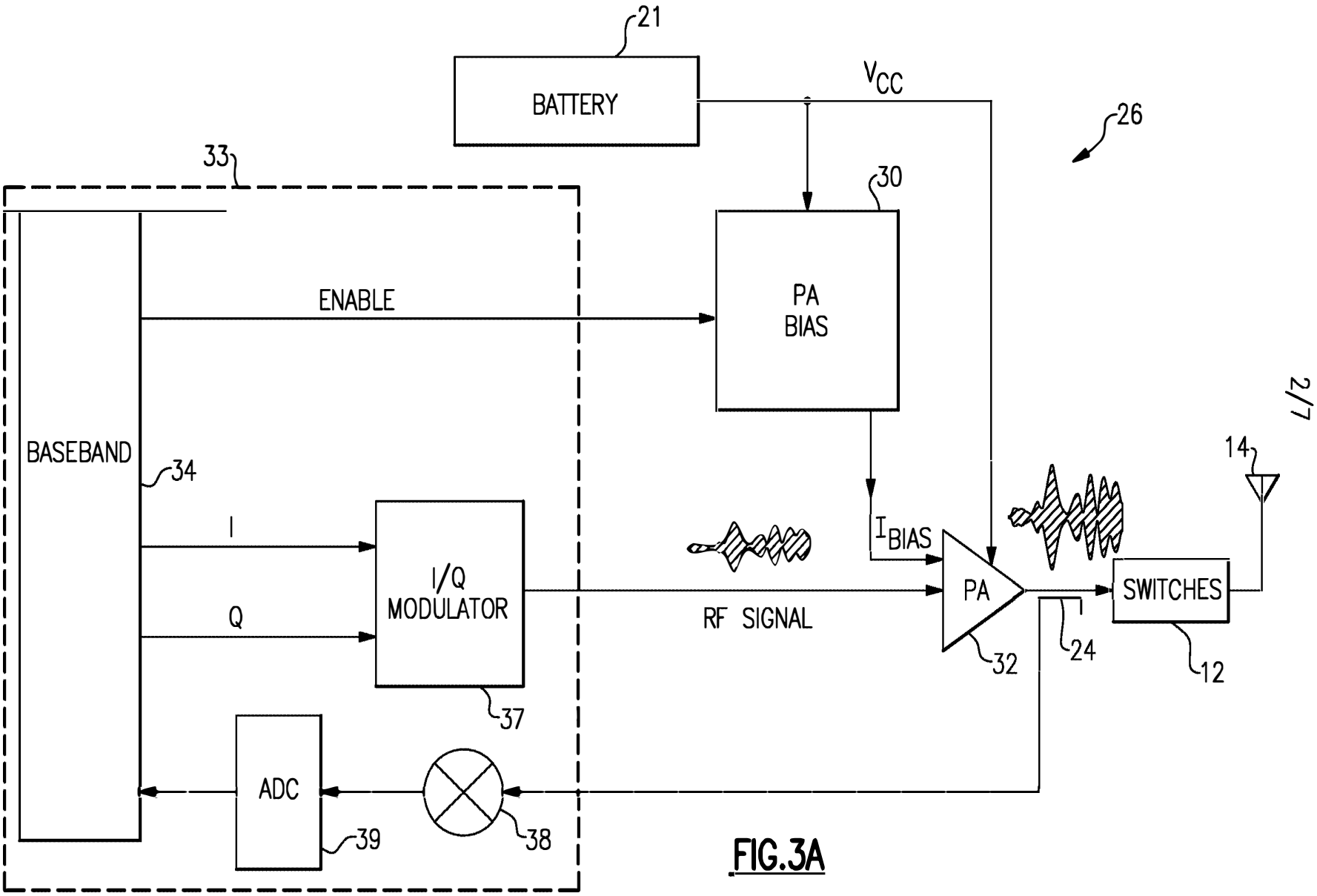

21
BATTERY
V_{CC}
26
33
30
ENABLE
PA
BIAS
BASEBAND
34
14
I
Q
I/Q
MODULATOR
I_{BIAS}
RF SIGNAL
PA
SWITCHES
32
24
12
37
ADC
39
38

FIG.3A

2/7

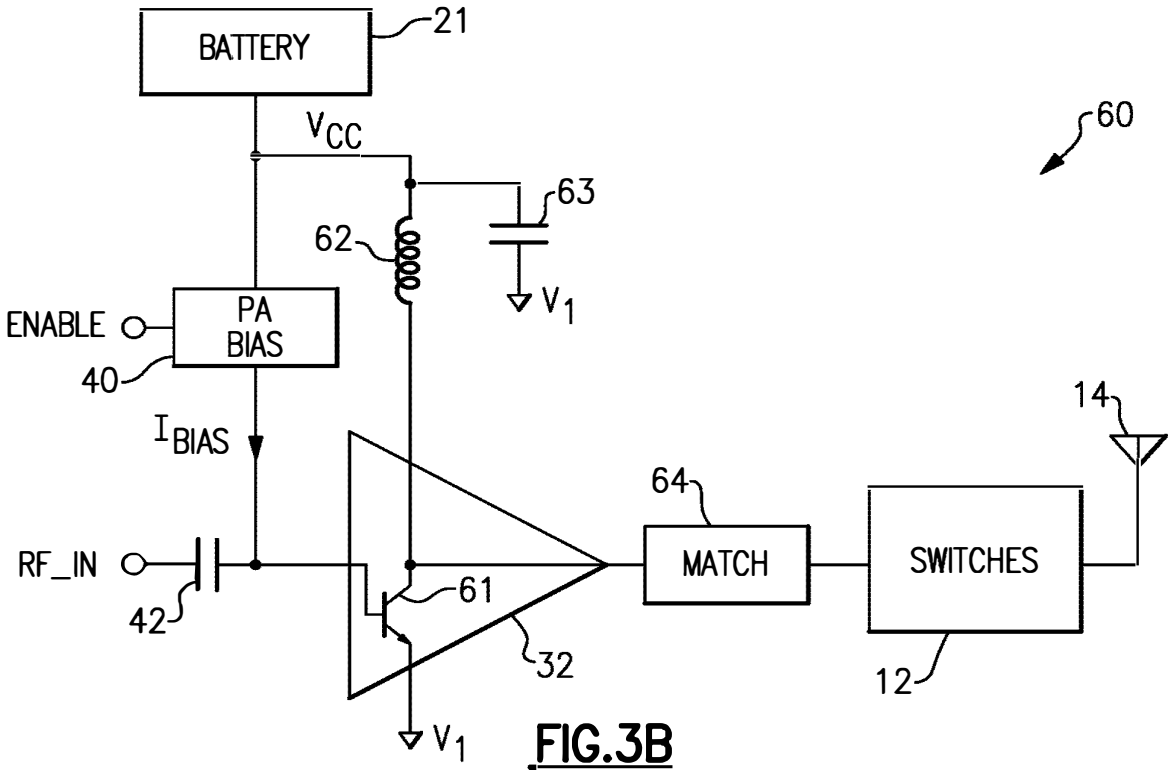

BATTERY
21
V_{CC}
60
63
62
V_1
ENABLE
PA BIAS
40
I_{BIAS}
14
64
RF_IN
42
61
MATCH
SWITCHES
32
12
V_1

FIG.3B

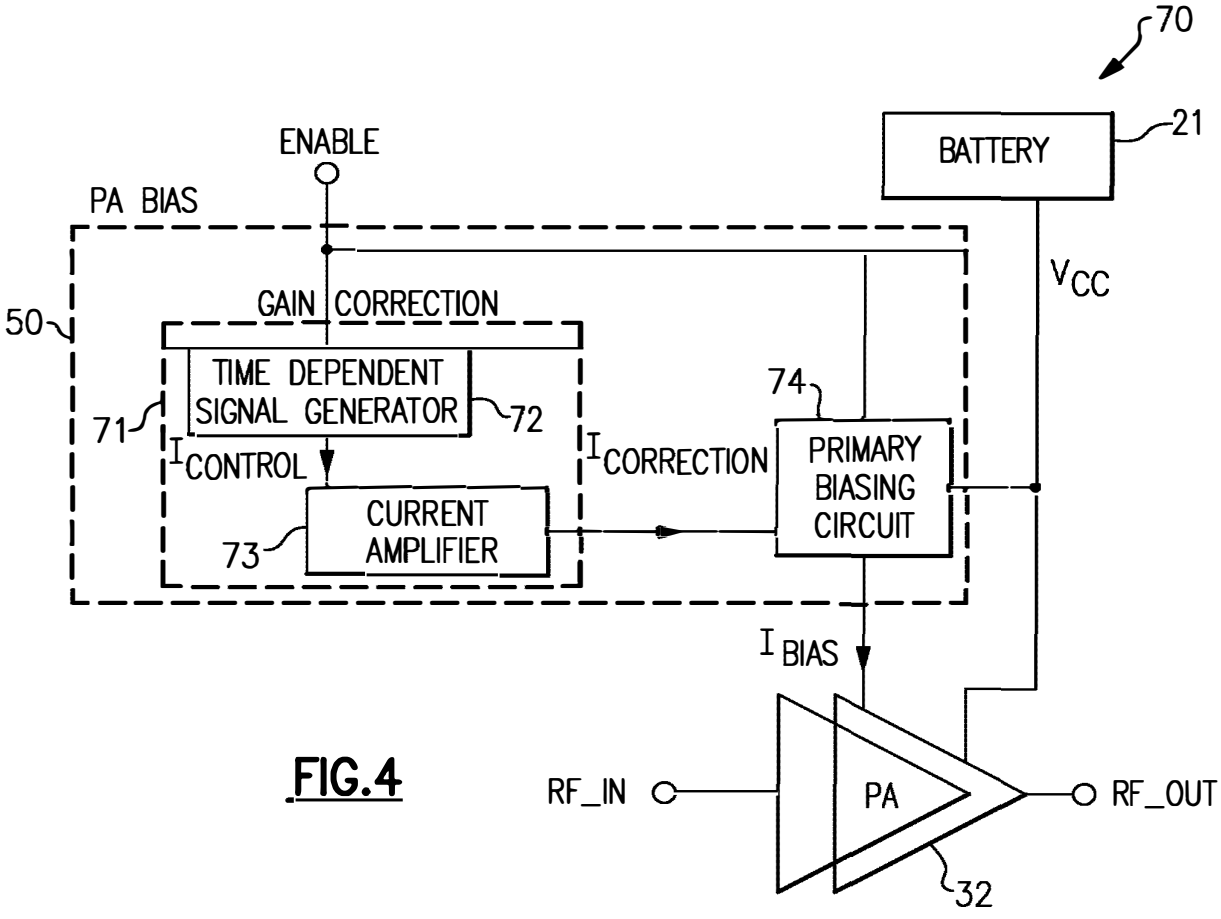

70
ENABLE
BATTERY
21
PA BIAS
V_{CC}
50
GAIN CORRECTION
TIME DEPENDENT SIGNAL GENERATOR
71
72
74
$I_{CONTROL}$
$I_{CORRECTION}$
PRIMARY BIASING CIRCUIT
CURRENT AMPLIFIER
73
I_{BIAS}
RF_IN
PA
RF_OUT
32

FIG.4

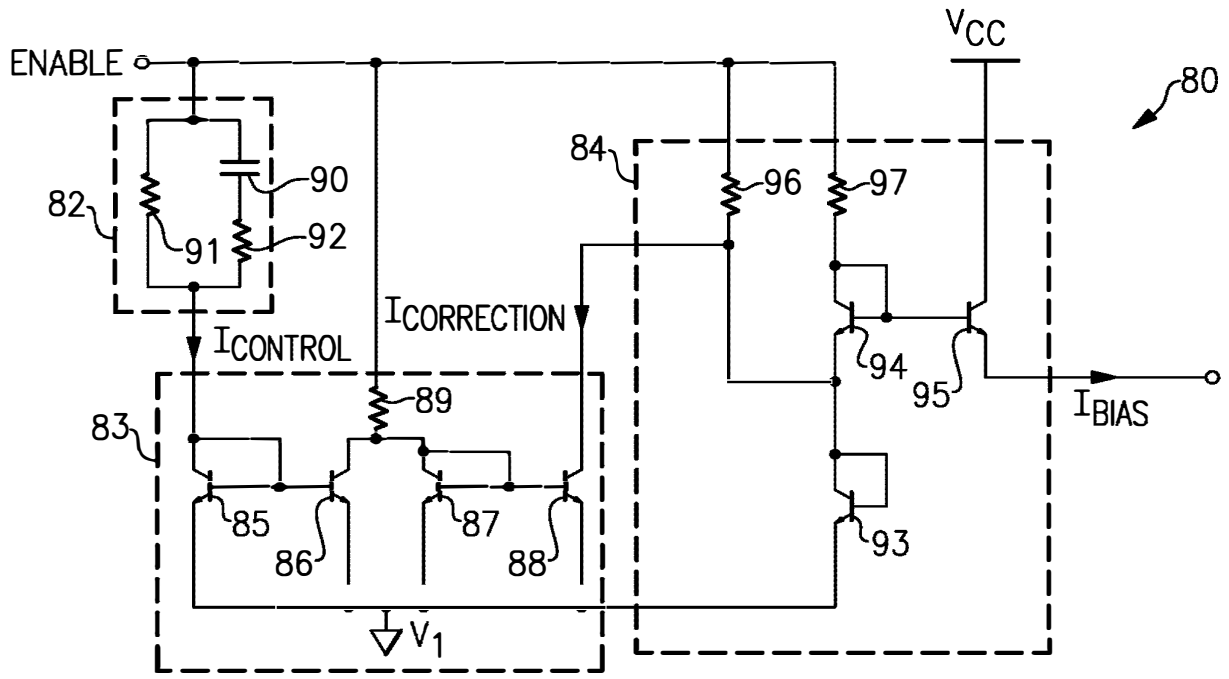

ENABLE
V_{CC}
80
84
82
90
91
92
96
97
$I_{CORRECTION}$
$I_{CONTROL}$
94
95
I_{BIAS}
89
83
85
86
87
88
93
V_1

FIG.5

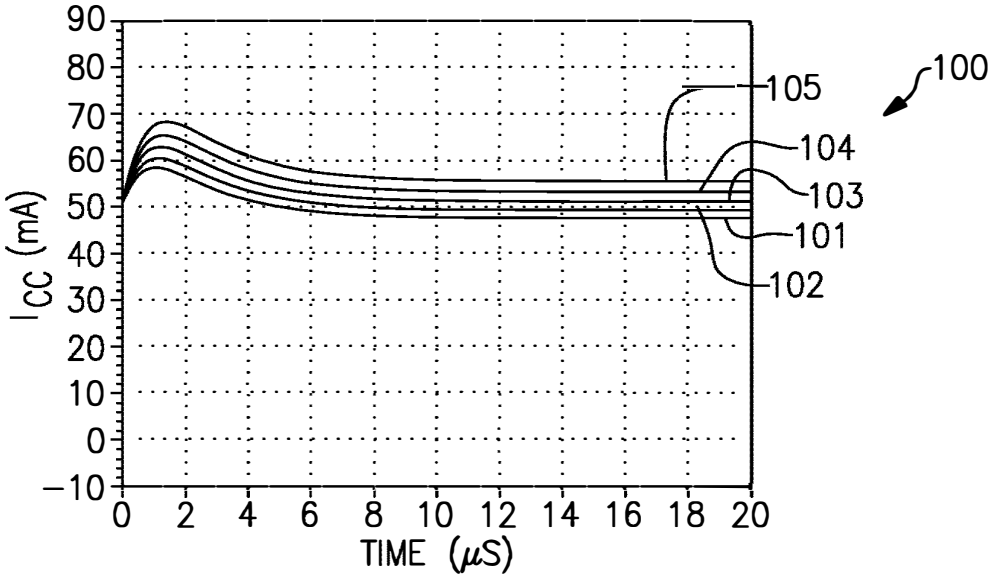

90
80
70
60
50
40
30
20
10
0
−10
I_{CC} (mA)
0 2 4 6 8 10 12 14 16 18 20
TIME (μS)
100
105
104
103
101
102

FIG.6

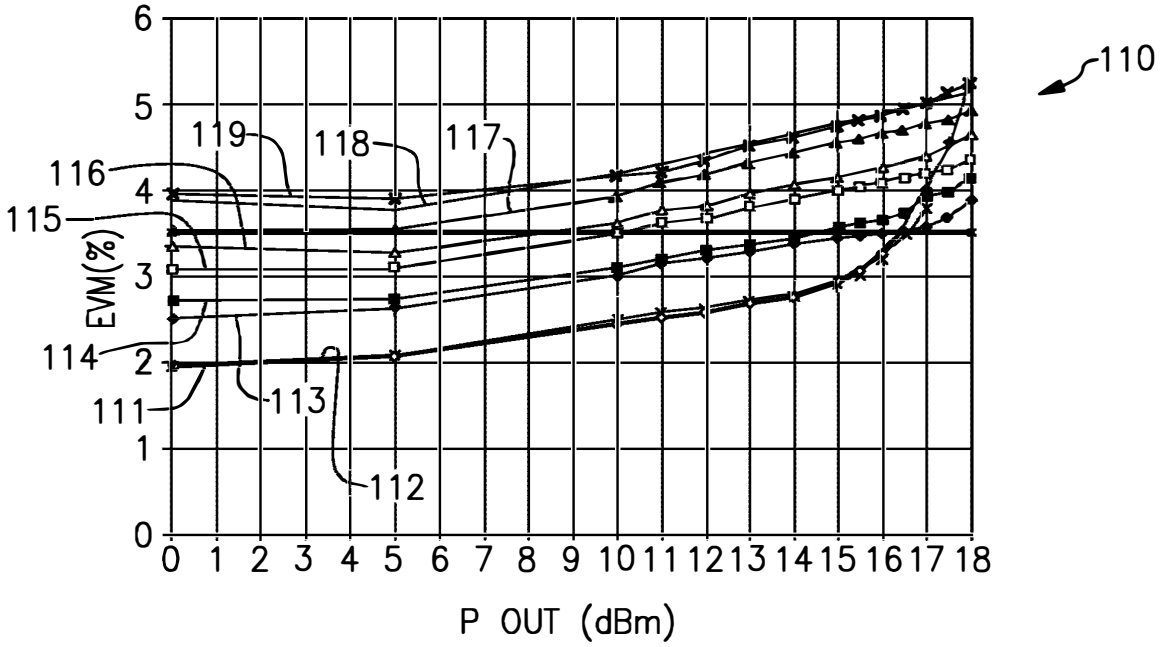

110
119
118
117
116
115
114
111
113
112
EVM(%)
P OUT (dBm)

FIG.7A

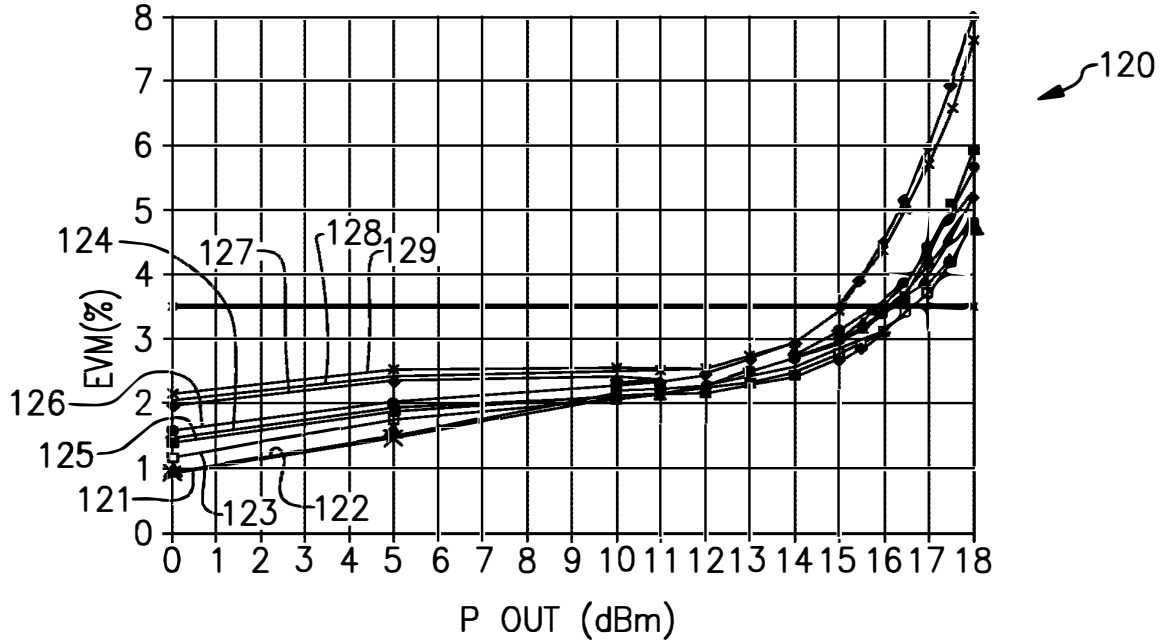

120
124
127
128
129
126
125
121
123
122
EVM(%)
P OUT (dBm)

FIG.7B

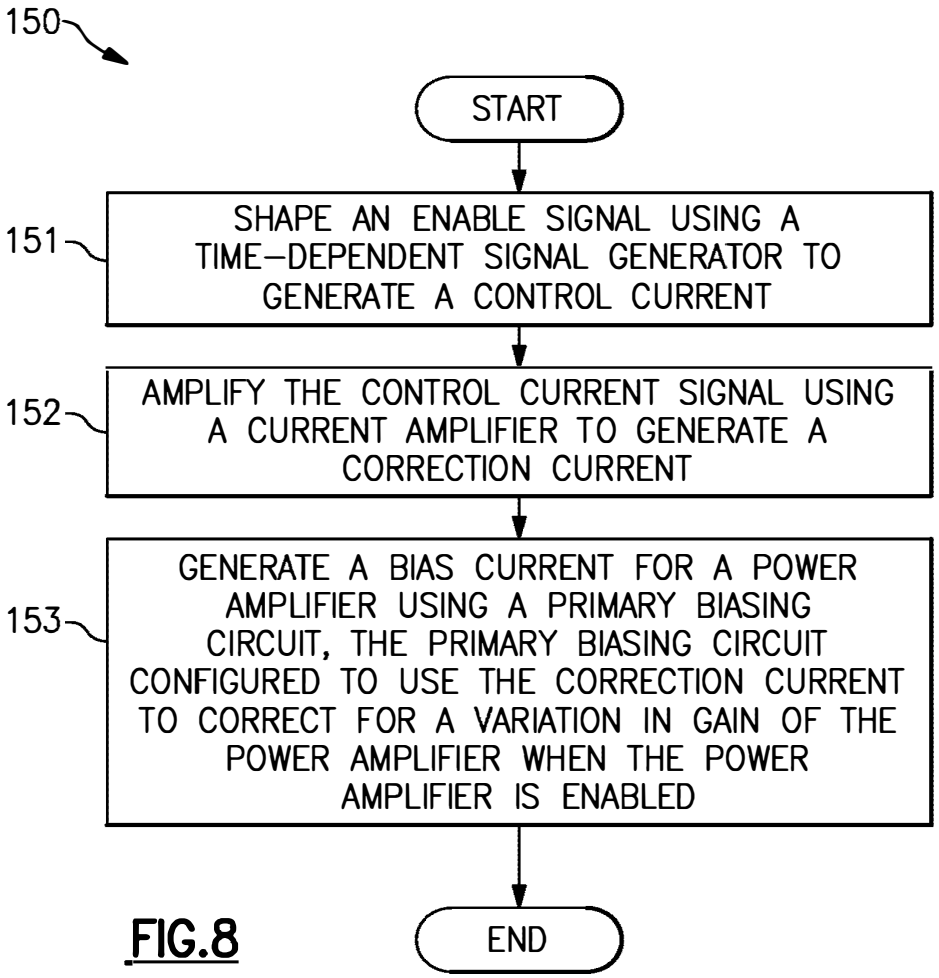

150
START
151
SHAPE AN ENABLE SIGNAL USING A TIME-DEPENDENT SIGNAL GENERATOR TO GENERATE A CONTROL CURRENT
152
AMPLIFY THE CONTROL CURRENT SIGNAL USING A CURRENT AMPLIFIER TO GENERATE A CORRECTION CURRENT
153
GENERATE A BIAS CURRENT FOR A POWER AMPLIFIER USING A PRIMARY BIASING CIRCUIT, THE PRIMARY BIASING CIRCUIT CONFIGURED TO USE THE CORRECTION CURRENT TO CORRECT FOR A VARIATION IN GAIN OF THE POWER AMPLIFIER WHEN THE POWER AMPLIFIER IS ENABLED
END

FIG.8

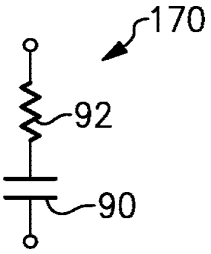

170
92
90

FIG.9

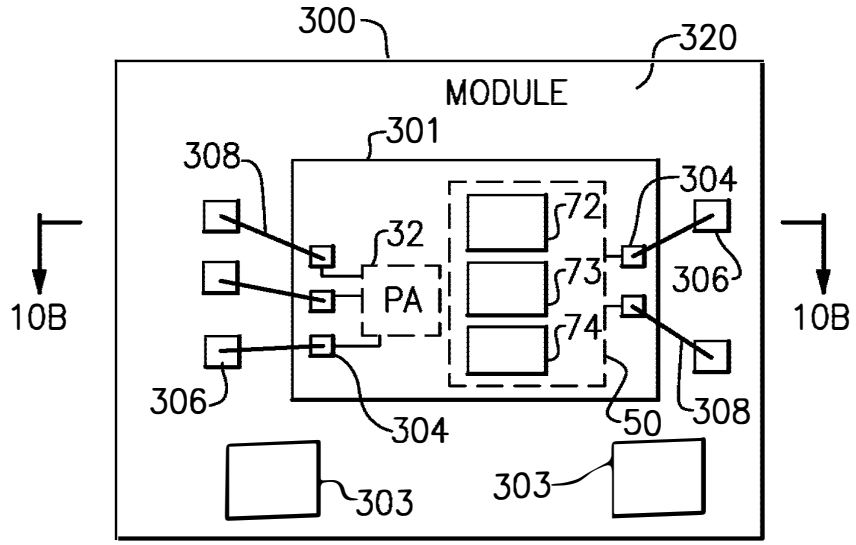


FIG.10A

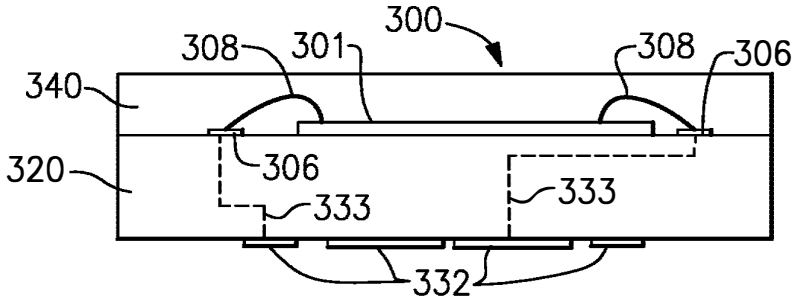


FIG.10B

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
First Named Inventor/Applicant Name:	Ping Li
Filer:	David R. Trossen/Alanna Wai
Attorney Docket Number:	SKYWRKS.280C3

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	280	280
UTILITY SEARCH FEE	1111	1	600	600
UTILITY EXAMINATION FEE	1311	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1600**

Electronic Acknowledgement Receipt

EFS ID:	27782276
Application Number:	15377842
International Application Number:	
Confirmation Number:	1052
Title of Invention:	APPARATUS AND METHODS FOR BIASING OF POWER AMPLIFIERS
First Named Inventor/Applicant Name:	Ping Li
Customer Number:	20995
Filer:	David R. Trossen/Angel Zehnder
Filer Authorized By:	David R. Trossen
Attorney Docket Number:	SKYWRKS.280C3
Receipt Date:	13-DEC-2016
Filing Date:	
Time Stamp:	18:53:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1600
RAM confirmation Number	121416INTEFSW18544500
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	ADS_SKYWRKS-280C3.pdf	1823612 e0b8f775e9249f665a7af2281f73772b5f85e47f	no	9
Warnings:					
Information:					
2	Oath or Declaration filed	Declaration_SKYWRKS-280C3.pdf	626205 97dfd61aa48768f57dcb3de8b8b4c579690e3640	no	3
Warnings:					
Information:					
3		Specification_SKYWRKS-280C3.pdf	138685 d8296ef8c5fe203284e14c6ca9ff47d8f8e1af1c	yes	30

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	25
Claims	26	29
Abstract	30	30

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4	Drawings-only black and white line drawings	Figures_SKYWRKS-280C3.pdf	94508 6ac43b68707c3addf790050a035893d1ab88795f	no	7
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5	Fee Worksheet (SB06)	fee-info.pdf	34745 280d58234c73a5af184cfa80c41139035479 69be	no	2

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.