RTL8723AS

User's Manual

Rev. 1.0
10 Jan. 2012

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USING THIS DOCUMENT

This document is intended for the software engineer's reference and provides detailed programming information.

Though every effort has been made to ensure that this document is current and accurate, more information may have become available subsequent to the production of this guide. In that event, please contact your Realtek representative for additional information that may help in the development process.

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1. General Description

1.1.

The Realtek is a highly integrated single-chip for 802.11n Wireless LAN and Bluetooth 2.1/3.0/4.0.It was composed of MAC, baseband, and RF, providing a complete solution for a high-performance integrated WLAN and BT. There are two kind of interface operation: one is SDIO for WLAN and UART for BT. The other one is USB for both WLAN and BT.(USB multi-function)

The integration provides better coordination between 802.11 and Bluetooth, and with sophisticated dynamic power control and packet traffic arbitration, is able to provide the best coexistence performance.

also integrates RF/PA/LNA for both of 802.11n and Bluetooth, so the external part numbers is reduced to minimum.

The 802.11 part supports 150Mbps PHY rate and delivers reliable throughput from an extended distance.

The Bluetooth part supports latest 3.0+HS/4.0+LE operation and provides smooth user experience under all usage scenarios. Optimized RF architecture and baseband algorithms provide superb performance and lowest power consumption.

2. Features

2.1 General

- 68-pin QFN
- CMOS MAC, Baseband PHY, and RF in a single chip for IEEE 802.11b/g/n compatible WLAN
- Complete 802.11n solution for 2.4GHz band
- 72.2Mbps receive PHY rate and 72.2Mbps transmit PHY rate using 20MHz bandwidth
- 150Mbps receive PHY rate and 150Mbps transmit PHY rate using 40MHz bandwidth
- Compatible with 802.11n specification
- Backward compatible with 802.11b/g devices while operating in 802.11n mode
- Qualified Bluetooth v2.1+EDR and v3.0+HS Systems
- Support for v4.0 Bluetooth Low Energy
- Integrated class1, class2, and class3 PA and modem in Bluetooth Controller

Standards Supported

- IEEE 802.11b/g/n compatible WLAN
- IEEE 802.11e QoS Enhancement (WMM)
- IEEE 802.11h TPC, Spectrum Measurement
- 802.11i (WPA, WPA2). Open, shared key, and pair-wise key authentication services
- Cisco Compatible Extensions (CCX) for WLAN devices

Host Interface

- SDIO for WLAN / UART for BT
- Multi-function USB for WLAN and BT

WLAN MAC Features

- Frame aggregation for increased MAC efficiency (A-MSDU, A-MPDU)
- Low latency immediate High-Throughput Block Acknowledgement (HT-BA)
- Long NAV for media reservation with CF-End for NAV release
- PHY-level spoofing to enhance legacy compatibility
- Power saving mechanism
- Channel management and co-existence
- Multiple BSSID feature allows the RTL8723AS to assume multiple MAC identities when used as a wireless bridge
- Transmit Opportunity (TXOP) Short Inter-Frame Space (SIFS) bursting for higher multimedia bandwidth

WLAN PHY Features

- IEEE 802.11n OFDM
- One Transmit and one Receive path (1T1R)
- 20MHz and 40MHz bandwidth transmission
- Short Guard Interval (400ns)

- DSSS with DBPSK and DQPSK, CCK modulation with long and short preamble
- OFDM with BPSK, QPSK, 16QAM, and 640QAM modulation. Convolutional Coding Rate: 1/2, 2/3, 3/4, and 5/6
- Maximum data rate 54Mbps in 802.11g and 150Mbps in 802.11n
- Switch diversity for DSSS/CCK
- Hardware antenna diversity
- Selectable receiver FIR filters
- Programmable scaling in transmitter and receiver to trade quantization noise against increased probability of clipping
- Fast receiver Automatic Gain Control (AGC)
- On-chip ADC and DAC

BT Controller

- Integrated MCU to execute Bluetooth protocol stack
- Support 3 SCO links simultaneously
- Support 3 scatternets
- Enhanced BT/WIFI Coexistence Control to improve transmission quality in different profiles
- Bluetooth Low Energy Dual Mode support

Bluetooth Transceiver Features

- Fast AGC control to improve receiving dynamic range
- Support AFH to dynamically detect channel quality to improve transmission quality
- Integrated internal class1, class2, and class3 PA
- Bluetooth 3.0 compliant
- Bluetooth Low Energy supported
- Integrated 32K oscillator

Peripheral Interfaces

- General Purpose Input/Output (11 pins)

- 4-wire EEPROM control interface (93C46)
- Three configurable LED pins
- Configurable Bluetooth Coexistence Interface

1.2. Environmental

1.2.1. Operating

Operating Temperature: 0 to 70 °C
Relative Humidity: 5-90% (non-condensing)

1.2.2. Storage

Temperature: -55 to 125 °C
Relevant Humidity: 5-95% (non-condensing)

1.3. Functional Specifications

Table 1. Functional Specifications

Standards	***WiFi:*** IEEE 802.11b, IEEE 802.11g, Draft IEEE 802.11n, IEEE 802.11d, IEEE 802.11e, IEEE 802.11h, IEEE 802.11i ***BT:*** BT v3.0, v4.0
Bus Interface	SDIO for WiFi and UART for BT Multi-function USB for WiFi and BT
Form Factor	Half Size Mini Card
Data Rate	**802.11b:** 11, 5.5, 2, 1 Mbps; **802.11g:** 54, 48, 36, 24, 18, 12, 9, 6 Mbps **802.11n:** MCS 0 to 7 for HT20MHz; MCS 0 to 7 for HT40MHz **BT:** 1/2/3 Mbps
Media Access Control	***WiFi:*** CSMA/CA with ACK ***WiFi* + BT:** AFH, Time Division
Modulation Techniques	***802.11b***: CCK, DQPSK, DBPSK ***802.11g***: 64 QAM, 16 QAM, QPSK, BPSK ***802.11n***: BPSK, QPSK, 16-QAM, 64-QAM ***BT***: GFSK, π/4 DQPSK, 8DPSK
Network Architecture	***WiFi***: Ad-hoc mode (Peer-to-Peer) Infrastructure mode

Operating Channel	***WiFi 2.4GHz:*** 11: (Ch. 1-11) – United States 13: (Ch. 1-13) – Europe 13: (Ch. 1-14) – Japan ***BT 2.4GHz:*** Ch. 0 ~78
Frequency Range	2.400GHz ~ 2.4835 GHz
Security	***WiFi*** : WPA, WPA-PSK, WPA2, WPA2-PSK, WEP 64bit & 128bit, IEEE 802.11x, IEEE 802.11i ***BT:*** Simple Paring
Operating Voltage	3.3 V ±9% I/O supply voltage

1.4. Warning

4.5.1 Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

IMPORTANT NOTE:
FCC Radiation Exposure Statement:
This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.
This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

IEEE 802.11b or 802.11g operation of this product in the U.S.A. is firmware-limited to channels 1 through 11.

This device is intended only for OEM integrators under the following conditions:
1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2) The transmitter module may not be co-located with any other transmitter or antenna,
3) For all products market in US, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change.

As long as 3 conditions above are met, further transmitter test will not be required. However, the OEM

integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling
This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains FCC ID: TX2-RTL8723AS”.

Manual Information To the End User
The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user’s manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as show in this manual.

4.5.2 Industry Canada Statement

This device complies with RSS-210 of the Industry Canada Rules. Operation is subject to the following two conditions:
1) this device may not cause interference and
2) this device must accept any interference, including interference that may cause undesired operation of the device

French translation:
Ce dispositif est conforme à la norme CNR-210 d'Industrie Canada applicable aux appareils radio exempts de licence. Son fonctionnement est sujet aux deux conditions suivantes: (1) le dispositif ne doit pas produire de brouillage préjudiciable, et (2) ce dispositif doit accepter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

This device has been designed to operate with an antenna having a maximum gain of 5dBi.
Antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms.
To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the EIRP is not more than required for successful communication.

French translation:
Ce dispositif a été conçu pour fonctionner avec une antenne ayant un gain maximum de 5 dBi. Une antenne à gain plus élevé est strictement interdite par les règlements d'Industrie Canada. L'impédance d'antenne

This radio transmitter (identify the device by certification number, or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.
Le présent émetteur radio (identifier le dispositif par son numéro de certification ou son numéro de modèle s'il fait partie du matériel de catégorie I) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

requise est de 50 ohms.
Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peutfonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pourl'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectriqueà l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que lapuissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire àl'établissement d'une communication satisfaisante.

IMPORTANT NOTE:

IC Radiation Exposure Statement:

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

French translation:

NOTE IMPORTANTE: (Pour l'utilisation de dispositifs mobiles)
Déclaration d'exposition aux radiations:
Cet équipement est conforme aux limites d'exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

This device is intended only for OEM integrators under the following conditions:

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and

2) The transmitter module may not be co-located with any other transmitter or antenna,

3) For all products market in Canada, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change.

As long as 3 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

French translation :

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)

1) L'antenne doit être installée de telle sorte qu'une distance de 20 cm est respectée entre l'antenne et les utilisateurs, et
2) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne,
3) Pour tous les produits vendus au Canada, OEM doit limiter les fréquences de fonctionnement CH1 à CH11 pour bandes de fréquences 2.4G grâce aux outils de microprogrammation fournis. OEM ne doit pas

fournir d'outil ou d'informations à l'utilisateur final en ce qui concerne le changement de réglementation de domaine.

Tant que les 3 conditions ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the IC authorization is no longer considered valid and the IC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate IC authorization.

French translation:

NOTE IMPORTANTE:
Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains IC: 6317A-RTL8723AS”.

French translation:

Plaque signalétique du produit final
Ce module émetteur est autorisé uniquement pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte qu'une distance de 20cm peut être maintenue entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 6317A-RTL8723AS ".

Manual Information To The End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user’s manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

French translation:

Manuel d'information à l'utilisateur final
L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.
Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

4.5.3 NCC 警語

經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

本模組於取得認證後將依規定於模組本體標示審合格籤。
系統廠商應於平台上標示「本產品內含射頻模組：  XXXyyyLPDzzzz-x (NCC ID) 」字樣。

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Antenna List

Table for Filed Antenna

No.	Brand	Ant. Type	Con. Type	Peak Gain (dBi)	Model No.
01	LYNwave	PIFA	IPEX	3.5	ALA110-222050-300010
02	JOYMAX	Dipole	IPEX	3.0	TWF-614XMPXX-500
03	ACON	PIFA	IPEX	TX 1: -0.19 TX 2: -0.99	AWP6P
04	Yageo	PIFA	IPEX	TX 1: -0.11 TX 2: 0.07	TX 1: CAN4313ZP0648WXA1 TX 2: CAN4313ZP0648WXA2
05	WNC	PIFA	IPEX	TX 1: 1.32 TX 2: 1.50	TX 1: 81.EJT15.GVM TX 2: 81.EJT15.GVN
06	Foxconn	PIFA	IPEX	TX 1: 1.47 TX 2: 1.38	WDAN-T1WM
07	Hitachi	PIFA	IPEX	Main: 2.19 Aux.: -0.33	HBY07
08	Hitachi	PIFA	IPEX	Main: 2.91 Aux.: 2.82	HBY051
09	Hitachi	PIFA	IPEX	TX 1: 0.27 TX 2: 0.02	HBY052
10	Hitachi	PIFA	IPEX	TX 1: 1.30 TX 2: 2.42	HBY061
11	Hitachi	PIFA	IPEX	TX 1: -1.04 TX 2: -1.19	HBY062
12	Hitachi	PIFA	IPEX	TX 1: -1.74 TX 2: 1.16	HFT65
13	Hitachi	PIFA	IPEX	TX 1: 0.87 TX 2: 1.94	HCT01
14	Hitachi	PIFA	IPEX	TX 1: 0.58 TX 2: 1.12	HFT40
15	Hitachi	PIFA	IPEX	TX 1: -1.65 TX 2: -0.92	HFT60
16	FOXCONN	PIFA	IPEX	TX 1: -0.43 TX 2: -0.7	WDAN-TQ
17	WNC	PIFA	IPEX	TX 1: 0.54 TX 2: 0.58	TX 1: 25.90AAP.011 TX 2: 25.90AAO.011
18	WNC	PIFA	IPEX	Main: 0.42 Aux.: 0.79 MIMO: 0.14	81.EJZ
19	WNC	PIFA	IPEX	Main: 0.96 Aux.: -0.08	81.EJT

20	ETHERTRONICS	PIFA	IPEX	TX 1: 0.12 TX 2: -3.87	TX 1: 5002011-1 TX 2: 5002012-1
21	ETHERTRONICS	PIFA	IPEX	TX 1: 0.76 TX 2: 0.59	TX 1: 5002015-1 TX 2: 5002016-1
22	ETHERTRONICS	PIFA	IPEX	TX 1: -1.76 TX 2: -2.61	TX 1: 5010011-1 TX 2: 5010012-1
23	ETHERTRONICS	PIFA	IPEX	TX 1: -0.84 TX 2: -2.07	TX 1: 5010015-1 TX 2: 50100161
24	ACON	PIFA	IPEX	TX 1: 0.00 TX 2: 1.89	AMP6P
25	WNC	PIFA	IPEX	Main: -1.08 Aux.: -0.62	81.EJZ15.G52
26	WNC	PIFA	IPEX	Main: -0.58 Aux.: -1.26	81.EJT15.GJC
27	WNC	PIFA	IPEX	Main: 0.52 Aux.: 0.77	81.EJT15.GGW
28	WNC	PIFA	IPEX	Main: -0.78 Aux.: -2.14	81.EJZ15.G53
29	QUANTA	PIFA	IPEX	TX 1: -0.7 TX 2: -1.9	TX 1: AN-070-G(R) TX 2: AN-070-G(L)
30	QUANTA	PIFA	IPEX	TX 1: -0.3 TX 2: -1.9	TX 1: AN-070-G(R) TX 2: AN-070-G(L)
31	QUANTA	PIFA	IPEX	TX 1: -0.4 TX 2: -0.3	TX 1: AN-120-F(R) TX 2: AN-120-F(L)
32	QUANTA	PIFA	IPEX	TX 1: -1.8 TX 2: -4.4	TX 1: AN-120-F(R) TX 2: AN-120-F(L)
33	JEM	PIFA	IPEX	Main: 1.27 Aux.: -1.27	Main: IA-100193 Aux.: IA-100194
34	Tyco (20-D1130002D)	PIFA	IPEX	TX1: -0.10 TX2: -0.92 TX 3: 0.56	TBN008
35	Smart Approach	PIFA	IPEX	TX 1: 1.51 TX 2: 1.56	03-FR021-026
36	Hitachi Cable	PIFA	IPEX	TX 1: -0.42 TX 2: 0.59 TX 3: 1.24	HBY17
37	Hitachi	PIFA	IPEX	TX 1: 2.97 TX 2: 0.90	HFT60
38	WNC	PIFA	IPEX	TX 1: 0.30 TX 2: 0.94	TX 1: 25.90AAN.011 TX 2: 25.90AAM.011

39	Smart Approach	PIFA	IPEX	TX 1: 1.66 TX 2: 1.83	03-FR021-020
40	WHAYU	PIFA	IPEX	Main: -2.12 Aux.: -2.49	MSA-00005A
41	Toshiba	PIFA	IPEX	-0.80	HFS23
42	Toshiba	PIFA	IPEX	0.64	HFS40
43	TYCO (20238740-1)	PIFA	IPEX	TX 1: 0.47 TX 2: 0.06 TX 3: 1.65	TBN008
44	TYCO (2023750-1)	PIFA	IPEX	TX 1: 0.47 TX 2: 0.06	TBN008
45	TYCO (2023772-1)	PIFA	IPEX	TX 1: -2.60 TX 2: -0.26 TX 3: -0.91	TBN008
46	TYCO	PIFA	IPEX	TX 1: 1.98 TX 2: 1.97 TX 3: -0.88	TBN007
47	TYCO	PIFA	IPEX	TX 1: 0.22 TX 2: 0.33 TX 3: 2.20	TBN009
48	TYCO	PIFA	IPEX	TX 1: 1.68 TX 2: 1.45 TX 3: 0.29	TBN010
49	Smart Approach	PIFA	IPEX	TX 1: 2.37 TX 2: 1.59	03-FR021-016
50	Foxconn	PIFA	IPEX	TX 1: 2.58 TX 2: 1.39	TX 1: WDAN-T1AM1001-DH TX 2: WDAN-T1AM1002-DH
51	WNC	PIFA	IPEX	Main: -2.76 Aux.: -3.64	WNC005
52	TYCO (20238740-1)	PIFA	IPEX	TX 1: 0.47 TX 2: 0.06 TX 3: 1.65	TBN008
53	Toshiba	PIFA	IPEX	TX 1: 0.28 TX 2: -0.83	TBN004
54	WNC	PIFA	IPEX	Main: -1.10 Aux.: 1.76	WNC001
55	WNC	PIFA	IPEX	Main: 1.18 Aux. 1.75	WNC002
56	Tyco	PIFA	IPEX	Main: -1.11 Aux.: -1.11	TBN003

				MIMO: -0.95	
57	WNC	PIFA	IPEX	Main: 2.40 Aux.: 1.50	WNC004
58	WNC	PIFA	IPEX	Main: 1.19 Aux.: 0.28	WNC001
59	WNC	PIFA	IPEX	Main: 0.52 Aux.: 1.07	WNC003
60	Quanta	PIFA	IPEX	TX 1: 1.0 TX 2: 0.2	3ASP8AATP20
61	Quanta	PIFA	IPEX	TX 1: -0.5 TX 2: -1.9	AS-070-F
62	Tyco	PIFA	IPEX	Main: 3.45 Aux: 2.41 MIMO: 1.04	TBN001
63	Well Green	PIFA	IPEX	TX 1: 1.79 TX 2: 0.66	TX 1: SK81WMPB01+A TX 2: SK81WMPB02+A
64	Tyco	PIFA	IPEX	-1.11	TBN005 & TBN006
65	Well Green	PIFA	IPEX	TX 1: -1.07 TX 2: -0.64	SKW31WMPB01+A
66	FVC	PIFA	IPEX	WiMAX-1: 1.58 WiMAX2: 1.75	K05007012102
67	FVC	PIFA	IPEX	WiMAX-1: 2.7 WiMAX-2: 2.19	K05007013402
68	Well Green	PIFA	IPEX	TX 1: -1.84 TX 2: -2.93	TX 1: SKM11WMPB03+A TX 2: SKM11WMPB02+D
69	FVC	PIFA	IPEX	WiMAX-1: 1.84 WiMAX-2:1.8	N01001218001
70	Well Green	PIFA	IPEX	TX 1: -1.63 TX 2: -0.99	SKW24WMPB01
71	FVC	PIFA	IPEX	TX 1: 2.05 TX 2: 1.88 TX 3: 3.04	TX 1: N01001199001 TX 2: N01001199001 TX 3: N01001182002
72	FVC	PIFA	IPEX	TX1: 3.11 TX2: 0.55	TX1: N01001193001 TX2: N01001193001
73	WNC	PIFA	IPEX	TX1: -0.61 TX2: 1.91	TX1: 25.90AAL.001 TX2: 25.90AAK.001
74	TE Connectivity	PIFA	IPEX	TX1: 1.29 TX2: 0.04	TX1: 25.90AAL.011 TX2: 25.90AAK.011
75	TE Connectivity	PIFA	IPEX	TX1: -0.01 TX2: 0.39	TX1: 25.90AAN.001 TX2: 25.90AAM.001

76	TE Connectivity	PIFA	IPEX	TX1: 1.20 TX2: 0.65	TX1: 25.90AAP.001 TX2: 25.90AAO.001
77	Quanta	PIFA	IPEX	TX1: 0.70 TX2: -1.40	35AX6AATP10
78	Quanta	PIFA	IPEX	TX1: 1.80 TX2: -0.30	37LX6AATP00
79	Quanta	PIFA	IPEX	TX1: 0.30 TX2: 1.70	37LX7AATP00
80	WNC	PIFA	IPEX	TX1: -0.10 TX2: 2.30	WNC003
81	WNC	PIFA	IPEX	TX1: 2.72 TX2: 2.66	TX1: 81.EJZ15.G94 TX2: 81.EJZ15.G95
82	WNC	PIFA	IPEX	TX1: 1.33 TX2: 1.95	TX1: 81.EJZ15.G98 TX2: 81.EJZ15.G99
83	WNC	PIFA	IPEX	TX1: 1.84 TX2: 1.64	81.EJZ15.GTP
84	WNC	PIFA	IPEX	TX1: 2.36 TX2: 1.13	TX1: 81.EK515.G15 TX2: 81.EK515.G16
85	WNC	PIFA	IPEX	TX1: 1.15 TX2: 0.59	TX1: DC33000YV20 TX2: DC33000YV30
86	WNC	PIFA	IPEX	TX1: 0.79 TX2: -0.32	TX1: DC33000YV60 TX2: DC33000YV70
87	HONGLIN	PIFA	IPEX	TX1: 1.85 TX2: 1.77	260-23249
88	Yageo	PIFA	IPEX	TX1: -2.69 TX2: -1.09	TX1: 6036B0086801 TX2: 6036B0087101
89	WNC	PIFA	IPEX	TX1: -1.30 TX2: -0.49	TX1: 6036B0086802 (81.EHC15.G63) TX2: 6036B0087102 (81.EHC15.G64)
90	WNC	PIFA	IPEX	TX1: 1.21 TX2: -0.07	TX1: 6036B0088203 TX2: 6036B0088303
91	WNC	PIFA	IPEX	TX1: 2.34 TX2: 1.28	TX1: 6036B0087303 TX2: 6036B0087203
92	WNC	PIFA	IPEX	TX1: 0.50 TX2: 0.12	TX1: 6036B0088203 TX2: 6036B0088303
93	Yageo	PIFA	IPEX	TX1: 0.61 TX2: 0.71	TX1: 6036B0088401 TX2: 6036B0088501
94	Yageo	PIFA	IPEX	TX1: 1.46 TX2: 0.95	TX1: 6036B0088901 TX2: 6036B0089001
95	WNC	PIFA	IPEX	TX1: -1.11 TX2: -0.95	TX1: 6036B0091201 TX2: 6036B0091401

96	Yageo	PIFA	IPEX	TX1: 0.80 TX2: 0.25	TX1: 6036B0091202 TX2: 6036B0091402
97	TE Connectivity	PIFA	IPEX	TX1: -0.23 TX2: -0.49	TX1: 1556465-1 TX2: 1556466-1
98	TE Connectivity	PIFA	IPEX	TX1: 1.29 TX2: 0.04	TX1: 1556495-1 TX2: 1556496-1
99	TE Connectivity	PIFA	IPEX	TX1: -0.87 TX2: -1.24	TX1: 1556505-1 TX2: 1556506-1
100	ACON	PIFA	IPEX	TX1: 1.96 TX2: 1.91	TX1: AMP8P-700186 TX2: AMP8P-700187
101	ACON	PIFA	IPEX	TX1: 2.79 TX2: 0.74	TX1: APM8P-700016 TX2: APM8P-700017
102	ACON	PIFA	IPEX	TX1: 2.66 TX2: 2.27	TX1: APM8P-700018 TX2: APM8P-700019
103	ACON	PIFA	IPEX	TX1: 1.10 TX2: 1.99	TX1: APP8P-700341 TX2: APP8P-700342
104	Wha Yu	PIFA	IPEX	TX1: -0.18 TX2: 2.58	TX1: C107-520757-A TX2: C107-520756-A
105	Wellshine	PIFA	IPEX	TX1: 1.17 TX2: -0.06	DQ67KJQUT33
106	Wha Yu	PIFA	IPEX	TX1: 1.74 TX2: 1.41	TX1: C435-520023-A TX2: C435-520024-A
107	Wha Yu	PIFA	IPEX	TX1: 1.92 TX2: -1.03	TX1: C680-520278-A TX2: C680-520277-A
108	Wha Yu	PIFA	IPEX	TX1: 1.09 TX2: -0.55	C680-520279-A
109	Yageo	PIFA	IPEX	TX1: 0.59 TX2: 0.90	TX1: CAN4313LC0613WLA3 TX2: CAN4313LC0613WLA4
110	Yageo	PIFA	IPEX	TX1: 0.97 TX2: 0.59	TX1: CAN4313LC0630WLA3 TX2: CAN4313LC0630WLA4
111	Yageo	PIFA	IPEX	TX1: 2.32 TX2: 1.85	TX1: CAN4313WICO03241 TX2: CAN4313WICO03242
112	Yageo	PIFA	IPEX	TX1: 0.23 TX2: 1.53	TX1: CAN43130WIFO04921 TX2: CAN43130WIFO04922
113	WNC	PIFA	IPEX	TX1: 0.18 TX2: 0.60	TX1: 81.EKG15.G38 TX2: 81.EKG15.G37
114	WNC	PIFA	IPEX	TX1: 0.54 TX2: -0.03	TX1: 81.EKG15.G41 TX2: 81.EKY15.G42
115	Jess-Link	PIFA	IPEX	TX1: 1.89 TX2: 1.56	TX1: PANT11A00008-1 TX2: PANT11A00009-1

116	Jess-Link	PIFA	IPEX	TX1: 1.84 TX2: 1.98	TX1: PANT11A00026-1 TX2: PANT11A00027-1
117	ACON	PIFA	IPEX	TX1: -0.70 TX2: -0.29	DQ60APM6P02
118	ACON	PIFA	IPEX	TX1: -0.60 TX2: -1.02	DQ60APM6P03
119	Well Shine (QUA)	PIFA	IPEX	TX1: 1.66 TX2: 0.05	TX1: DQ67KJQUT35 TX2: DQ67KJQUT36
120	Amphenol	PIFA	IPEX	TX1: -1.41 TX2: -0.77	FL5202-11-001-C
121	MAG. LAYERS	PIFA	IPEX	1.77	FPA-2423-25GC1-A1
122	Amphenol	PIFA	IPEX	TX1: 0.76 TX2: -2.11	TX1: FX5170-15-004-C TX2: FX5170-15-001-C
123	Amphenol	PIFA	IPEX	TX1: 0.55 TX2: 0.31	TX1: IV5218-11-002-C TX2: IV5218-11-001-C
124	Amphenol	PIFA	IPEX	TX1: 0.54 TX2: -0.53	TX1: IV5233-15-003-C TX2: IV5233-15-002-C
125	FVC	PIFA	IPEX	TX1: 2.85 TX2: 1.29	K05007014701
126	FAVORTRON	PIFA	IPEX	TX1: 2.81 TX2: 1.97	TX1: N01001205001 TX2: N01001206001
127	MAG. LAYERS	PIFA	IPEX	2.17	PCA-2111-25GC1-A1
128	Wha Yu	PIFA	IPEX	TX1: 2.43 TX2: -0.41	PSAM-002
129	Quanta	PIFA	IPEX	TX1: 1.6 TX2: 0.3	R12_AN-090-A/B
130	Quanta	PIFA	IPEX	TX1: 0.8 TX2: 0.4	R15_AN-090-A/B
131	Quanta	PIFA	IPEX	TX1: 1.5 TX2: 0.5	R18_AN-090-A/B
132	Smart Approach	PIFA	IPEX	TX1: 1.70 TX2: 1.53	SE-ECFKA-001
133	Smart Approach	PIFA	IPEX	TX1: 2.53 TX2: 2.92	TX1: SE-ECLA1-001 TX2: SE-ECLA1-002
134	Tyco (2023770-1)	PIFA	IPEX	TX1: -2.60 TX2: -0.26	TBN008
135	Tyco (2023772-1)	PIFA	IPEX	TX1: -2.60 TX2: -0.26	TBN008
136	Foxconn	PIFA	IPEX	TX1: -0.99 TX2: -0.09	TX1: WDAN-HMCH1401-DH TX2: WDAN-HMCH1402-DH

137	Foxconn	PIFA	IPEX	TX1: -0.35 TX2: 0.38	TX1: WDAN-HMCH1501-DH TX2: WDAN-HMCH1502-DH
138	Foxconn	PIFA	IPEX	TX1: -1.85 TX2: 1.33	WDAN-HMEDW005-DH
139	Tyco	PIFA	IPEX	TX1: -0.38 TX2: 1.04	TX1: 25.90A2G.021 TX2: 25.90A2H.021
140	WNC	PIFA	IPEX	TX1: 1.23 TX2: 0.29	TX1: 25.90A2G.001 TX2: 25.90A2H.001
141	Yageo	PIFA	IPEX	TX1: 0.48 TX2: -1.37	TX1: 25.90A2G.011 TX2: 25.90A2H.011
142	Quanta	PIFA	IPEX	TX1: 0.40 TX2: -1.00	TX1: QADCGC5_WL_M TX2: QADCGC5_WL_A
143	Quanta	PIFA	IPEX	TX1: 0.10 TX2: -0.40	TX1: DQ6GC200100 TX2: DQ6GC200200
144	Quanta	PIFA	IPEX	TX1: -1.30 TX2: 0.70	TX1: DQ6GC300100 TX2: DQ6GC300200
145	Quanta	PIFA	IPEX	TX1: 0.7 TX2: 1.2	TX1: QADCGC6_WL_M TX2: QADCGC6_WL_A
146	ACON	PIFA	IPEX	TX1: 1.84 TX2: 0.07	TX1: APP8P-700188 TX2: APP8P-700187
147	ACON	PIFA	IPEX	TX1: 1.84 TX2: 0.07	TX1: APP8P-700186 TX2: APP8P-700185
148	Wha Yu	PIFA	IPEX	TX1: 1.96 TX2: 1.97	TX1: C435-520044-A TX2: C435-520043-A
149	Wha Yu	PIFA	IPEX	TX1: 1.91 TX2: 1.88	TX1: C435-520042-A TX2: C435-520045-A
150	ACON	PIFA	IPEX	TX1: -0.96 TX2: -0.86	TX1: APM6P-700033 TX2: APM6P-700034
151	Amphenol	PIFA	IPEX	TX1: -1.85 TX2: -1.60	TX1: 14G152168231LV TX2: 14G152168131LV
152	ACON	PIFA	IPEX	TX1: -1.32 TX2: -0.23	TX1: APM6P-700027 TX2: APM6P-700029
153	Tyco	PIFA	IPEX	TX1: -2.39 TX2: 1.52	TX1: 2023940-1 TX2: 2023944-1
154	ACON	PIFA	IPEX	TX1: -1.16 TX2: -0.74	TX1: APM6P-700028 TX2: APM6P-700030
155	Tyco	PIFA	IPEX	TX1: -0.58 TX2: -0.11	TX1: 2023946-1 TX2: 2023950-1
156	Amphenol	PIFA	IPEX	TX1: 1.61 TX2: 1.57	TX1: LX-0980-11-000-R TX2: LX-0983-11-000-R

157	NISSEI	PIFA	IPEX	TX1: 1.35 TX2: 1.99	TX1: 3172525 TX2: 3172566
158	ACON	PIFA	IPEX	TX1: -0.39 TX2: 0.64	TX1: 25.90675.001 TX2: 25.90676.001
159	WNC	PIFA	IPEX	TX1: -1.53 TX2: 1.32	TX1: 25.90669.001 TX2: 25.90670.001
160	WNC	PIFA	IPEX	TX1: 1.94 TX2: -0.85	TX1: 25.90A1E.001 TX2: 25.90A1F.001
161	WNC	PIFA	IPEX	TX1: 1.89 TX2: -0.90	TX1: 25.90A1E.001 TX2: 25.90A1F.001
162	Yageo	PIFA	IPEX	TX1: 1.94 TX2: 1.78	TX1: 25.90A1E.011 TX2: 25.90A1F.011
163	WNC	PIFA	IPEX	TX1: 0.51 TX2: 1.73	TX1: 25.91370.021 TX2: 25.91371.021
164	Yageo	PIFA	IPEX	TX1: 1.06 TX2: 0.16	TX1: 25.91370.011 TX2: 25.91371.011
165	Tyco	PIFA	IPEX	TX1: 0.06 TX2: 0.18	TX1: 25.90A4C.021 TX2: 25.90A4D.021
166	WNC	PIFA	IPEX	TX1: 1.52 TX2: -0.60	TX1: 25.90A4C.001 TX2: 25.90A4D.001
167	Yageo	PIFA	IPEX	TX1: 0.93 TX2: -0.17	TX1: 25.90A4C.011 TX2: 25.90A4D.011
168	NISSEI	PIFA	IPEX	TX1: 1.88 TX2: 1.26	TX1: 3209970 TX2: 3210002
169	ACON	PIFA	IPEX	TX1: -0.04 TX2: 1.16	TX1: 25.90929.001 TX2: 25.90930.001
170	Ethertronics	PIFA	IPEX	TX1: 0.60 TX2: -0.59	TX1: 25.90934.001 TX2: 25.90935.001
171	WNC	PIFA	IPEX	TX1: 0.87 TX2: -0.93	TX1: 25.90919.001 TX2: 25.90920.001
172	WNC	PIFA	IPEX	TX1: 0.60 TX2: -0.59	TX1: 25.90934.001 TX2: 25.90935.001
173	Quanta	PIFA	IPEX	TX1: 0.10 TX2: -0.30	TX1: QADC FL8_WL_M TX2: QADC FL8_WL_A
174	Quanta	PIFA	IPEX	TX1: -0.1 TX2: -0.1	TX1: QADCFL3_WL_M TX2: QADCFL3_WL_A
175	Amphenol	PIFA	IPEX	TX1: 1.47 TX2: 1.68	TX1: LX0970-11-000-R TX2: LX0968-11-000-R
176	FOXCONN	PIFA	IPEX	TX1: -0.40 TX2: 1.10	TX1: WDAN-L1ML3001-DF TX2: WDAN-L1ML3002-DF

177	NISSEI	PIFA	IPEX	TX1: 0.54 TX2: 1.80	TX1: 3172467 TX2: 3172509
178	ACON	PIFA	IPEX	TX1: 1.17 TX2: 1.04	TX1: 25.90598.001 TX2: 25.90597.001
179	WNC	PIFA	IPEX	TX1: 1.94 TX2: 0.59	TX1: 25.90587.001 TX2: 25.90586.001
180	WNC	PIFA	IPEX	TX1: -1.21 TX2: 1.27	TX1: 25.90700.001 TX2: 25.90702.001
181	ACON	PIFA	IPEX	TX1: 1.37 TX2: 1.21	TX1: 25.90800.001 TX2: 25.90802.001
182	Yageo	PIFA	IPEX	TX1: 0.07 TX2: -0.06	TX1: 25.90A4W.001 TX2: 25.90A4V.001
183	FOXLINK	PIFA	IPEX	TX1: 1.98 TX2: 1.97	TX1: 25.90A4W.011 TX2: 25.90A4V.011
184	Amphenol	PIFA	IPEX	TX1: -0.37 TX2: -2.64	TX1: C-1334-11-000-26 TX2: C-1335-11-000-26
185	WNC	PIFA	IPEX	TX1: 0.77 TX2: 0.74	TX1: 25.90979.001 TX2: 25.90980.001
186	Amphenol	PIFA	IPEX	TX1: 0.35 TX2: -1.20	TX1: C-1952-11-000-26 TX2: C-1953-11-000-26
187	Amphenol	PIFA	IPEX	TX1: -1.31 TX2: -3.09	TX1: C-2238-11-000-26 TX2: C-2239-11-000-26
188	Foxconn	PIFA	IPEX	TX1: 1.14 TX2: 0.61	TX1: WDAN-LFNZ3001-DH TX2: WDAN-LFNZ3002-DH
189	Amphenol	PIFA	IPEX	TX1: 0.35 TX2: -1.20	TX1: C-3033-11-000-26 TX2: C-3034-11-000-26
190	Amphenol	PIFA	IPEX	TX1: -1.31 TX2: -3.09	TX1: C-3068-11-000-26 TX2: C-3069-11-000-26
191	Foxconn	PIFA	IPEX	TX1: -0.11 TX2: 0.35	TX1: WDAN-L1NZ4003-DH TX2: WDAN-L1NZ4004-DH
192	Foxconn	PIFA	IPEX	TX1: -0.11 TX2: 0.35	TX1: WDAN-L1NZ4001-DH TX2: WDAN-L1NZ4002-DH
193	Tyco	PIFA	IPEX	TX1: 0.64 TX2: -0.92	TX1: 1556219-1 TX2: 1556220-1
194	ACON	PIFA	IPEX	TX1: 2.00 TX2: 0.13	TX1: APP8P-700191 TX2: APP8P-700192
195	ACON	PIFA	IPEX	TX1: 2.00 TX2: 0.13	TX1: APP8P-700189 TX2: APP8P-700190
196	Tyco	PIFA	IPEX	TX1: 0.64 TX2: -0.92	TX1: 1556216-1 TX2: 1556215-1

197	ACON	PIFA	IPEX	TX1: -0.42 TX2: -0.13	TX1: 25.90653.001 TX2: 25.90654.001
198	WNC	PIFA	IPEX	TX1: -0.52 TX2: 0.31	TX1: 25.90649.001 TX2: 25.90650.001
199	Quanta	PIFA	IPEX	TX1: -0.10 TX2: 0.00	TX1: QADC PS3_WL_M TX2: QADC PS3_WL_A
200	Foxconn	PIFA	IPEX	TX1: 1.16 TX2: -0.88	TX1: 024-01F0-2242 TX2: 024-01F0-2243
201	NISSEI	PIFA	IPEX	TX1: -0.83 TX2: -0.61	TX1: 3176658 TX2: 3176674
202	Amphenol	PIFA	IPEX	TX1: -1.54 TX2: -2.93	TX1: C-2381-11-000-26 TX2: C-2382-11-000-26
203	Foxconn	PIFA	IPEX	TX1: 0.87 TX2: 0.49	TX1: WDAN-LWSN3001-DH TX2: WDAN-LWSN3002-DH
204	Foxconn	PIFA	IPEX	TX1: 1.71 TX2: 1.43	TX1: WDAN-L1WK1001-DF TX2: WDAN-L1WK1002-DF
205	Hitachi	PIFA	IPEX	TX1: 1.82 TX2: 1.54	TX1: HMT14-MAIN TX2: HMT14-AUX
206	ACON	PIFA	IPEX	TX1: -1.21 TX2: 1.27	TX1: 25.90700.001 TX2: 25.90702.001
207	ACON	PIFA	IPEX	TX1: 1.37 TX2: 1.21	TX1: 25.90800.001 TX2: 25.90802.001
208	Quanta	PIFA	IPEX	TX1: -0.5 TX2: -1.4	TX1: QADCPS1_WL_M TX2: QADCPS1_WL_A
209	WNC	PIFA	IPEX	TX1: 0.30 TX2: 0.39	TX1: 81.EK515.G13 TX2: 81.EK515.G14
210	ZTX	PIFA	IPEX	TX1: 2.01 TX2: 1.69	ZTX-A162-Q18000-00