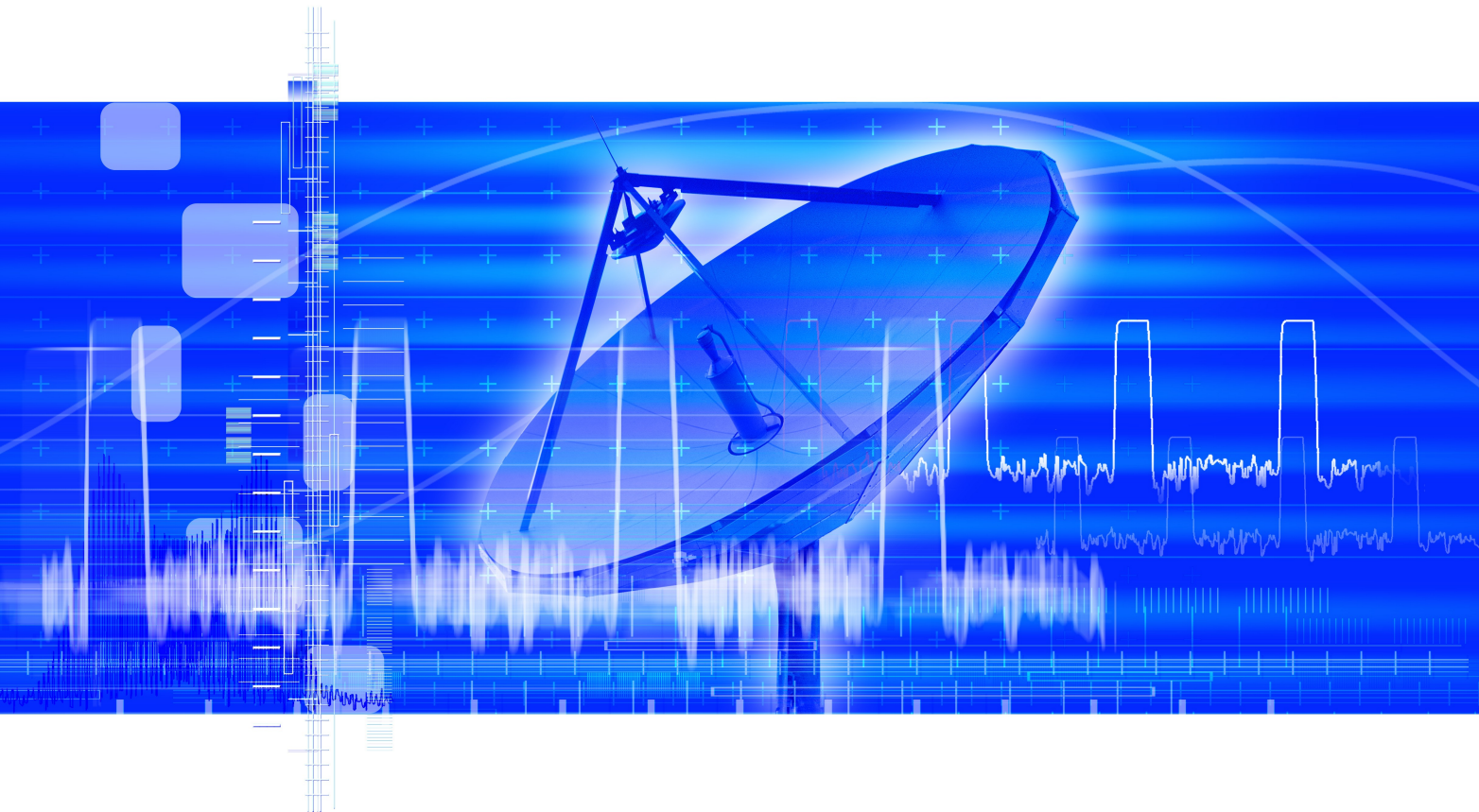


Software Manual



Pulse Sequencer Software **DFS Signal Generation**

V 3.1

Printed in Germany



ROHDE & SCHWARZ

Dear Customer,

R&S® is a registered trademark of Rohde & Schwarz GmbH & Co. KG. Throughout this manual, the R&S® SMU-K6, R&S® SMJ-K6, R&S® SMATE-K6, R&S® AFQ-K6, R&S® AMU-K6 is abbreviated as R&S Pulse Sequencer.

Trade names are trademarks of the owners.

Basic Safety Instructions

Always read through and comply with the following safety instructions!









All plants and locations of the Rohde & Schwarz group of companies make every effort to keep the safety standards of our products up to date and to offer our customers the highest possible degree of safety. Our products and the auxiliary equipment they require are designed, built and tested in accordance with the safety standards that apply in each case. Compliance with these standards is continuously monitored by our quality assurance system. The product described here has been designed, built and tested in accordance with the attached EC Certificate of Conformity and has left the manufacturer's plant in a condition fully complying with safety standards. To maintain this condition and to ensure safe operation, you must observe all instructions and warnings provided in this manual. If you have any questions regarding these safety instructions, the Rohde & Schwarz group of companies will be happy to answer them.







Furthermore, it is your responsibility to use the product in an appropriate manner. This product is designed for use solely in industrial and laboratory environments or, if expressly permitted, also in the field and must not be used in any way that may cause personal injury or property damage. You are responsible if the product is used for any intention other than its designated purpose or in disregard of the manufacturer's instructions. The manufacturer shall assume no responsibility for such use of the product.

The product is used for its designated purpose if it is used in accordance with its product documentation and within its performance limits (see data sheet, documentation, the following safety instructions). Using the product requires technical skills and a basic knowledge of English. It is therefore essential that only skilled and specialized staff or thoroughly trained personnel with the required skills be allowed to use the product. If personal safety gear is required for using Rohde & Schwarz products, this will be indicated at the appropriate place in the product documentation. Keep the basic safety instructions and the product documentation in a safe place and pass them on to the subsequent users.

Observing the safety instructions will help prevent personal injury or damage of any kind caused by dangerous situations. Therefore, carefully read through and adhere to the following safety instructions before and when using the product. It is also absolutely essential to observe the additional safety instructions on personal safety, for example, that appear in relevant parts of the product documentation. In these safety instructions, the word "product" refers to all merchandise sold and distributed by the Rohde & Schwarz group of companies, including instruments, systems and all accessories.

Symbols and safety labels

							
Notice, general danger location Observe product documentation	Caution when handling heavy equipment	Danger of electric shock	Warning! Hot surface	PE terminal	Ground	Ground terminal	Be careful when handling electrostatic sensitive devices

					
ON/OFF supply voltage	Standby indication	Direct current (DC)	Alternating current (AC)	Direct/alternating current (DC/AC)	Device fully protected by double (reinforced) insulation

Tags and their meaning

The following signal words are used in the product documentation in order to warn the reader about risks and dangers.



indicates a hazardous situation which, if not avoided, will result in death or serious injury.



indicates a hazardous situation which, if not avoided, could result in death or serious injury.



indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.



indicates the possibility of incorrect operation which can result in damage to the product.

In the product documentation, the word ATTENTION is used synonymously.

These tags are in accordance with the standard definition for civil applications in the European Economic Area. Definitions that deviate from the standard definition may also exist in other economic areas or military applications. It is therefore essential to make sure that the tags described here are always used only in connection with the related product documentation and the related product. The use of tags in connection with unrelated products or documentation can result in misinterpretation and in personal injury or material damage.

Operating states and operating positions

The product may be operated only under the operating conditions and in the positions specified by the manufacturer, without the product's ventilation being obstructed. If the manufacturer's specifications are not observed, this can result in electric shock, fire and/or serious personal injury or death. Applicable local or national safety regulations and rules for the prevention of accidents must be observed in all work performed.

1. Unless otherwise specified, the following requirements apply to Rohde & Schwarz products: predefined operating position is always with the housing floor facing down, IP protection 2X, pollution severity 2, overvoltage category 2, use only indoors, max. operating altitude 2000 m above sea level, max. transport altitude 4500 m above sea level. A tolerance of $\pm 10\%$ shall apply to the nominal voltage and $\pm 5\%$ to the nominal frequency.
2. Do not place the product on surfaces, vehicles, cabinets or tables that for reasons of weight or stability are unsuitable for this purpose. Always follow the manufacturer's installation instructions when installing the product and fastening it to objects or structures (e.g. walls and shelves). An installation that is not carried out as described in the product documentation could result in personal injury or death.
3. Do not place the product on heat-generating devices such as radiators or fan heaters. The ambient temperature must not exceed the maximum temperature specified in the product documentation or in the data sheet. Product overheating can cause electric shock, fire and/or serious personal injury or death.

Electrical safety

If the information on electrical safety is not observed either at all to the extent necessary, electric shock, fire and/or serious personal injury or death may occur.

1. Prior to switching on the product, always ensure that the nominal voltage setting on the product matches the nominal voltage of the AC supply network. If a different voltage is to be set, the power fuse of the product may have to be changed accordingly.
2. In the case of products of safety class I with movable power cord and connector, operation is permitted only on sockets with an earthing contact and protective earth connection.
3. Intentionally breaking the protective earth connection either in the feed line or in the product itself is not permitted. Doing so can result in the danger of an electric shock from the product. If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
4. If the product does not have a power switch for disconnection from the AC supply network, the plug of the connecting cable is regarded as the disconnecting device. In such cases, always ensure that the power plug is easily reachable and accessible at all times (corresponding to the length of connecting cable, approx. 2 m). Functional or electronic switches are not suitable for providing disconnection from the AC supply network. If products without power switches are integrated into racks or systems, a disconnecting device must be provided at the system level.
5. Never use the product if the power cable is damaged. Check the power cable on a regular basis to ensure that it is in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, you can ensure that the cable will not be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.
6. The product may be operated only from TN/TT supply networks fused with max. 16 A (higher fuse only after consulting with the Rohde & Schwarz group of companies).
7. Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise, sparks that result in fire and/or injuries may occur.
8. Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
9. For measurements in circuits with voltages $V_{\text{rms}} > 30 \text{ V}$, suitable measures (e.g. appropriate measuring equipment, fusing, current limiting, electrical separation, insulation) should be taken to avoid any hazards.
10. Ensure that the connections with information technology equipment, e.g. PCs or other industrial computers, comply with the IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards that apply in each case.
11. Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
12. If a product is to be permanently installed, the connection between the PE terminal on site and the product's PE conductor must be made first before any other connection is made. The product may be installed and connected only by a licensed electrician.
13. For permanently installed equipment without built-in fuses, circuit breakers or similar protective devices, the supply circuit must be fused in such a way that anyone who has access to the product, as well as the product itself, is adequately protected from injury or damage.

14. Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
15. Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.
16. Unless specified otherwise, products are not liquid-proof (see also section "Operating states and operating positions", item 1. Therefore, the equipment must be protected against penetration by liquids. If the necessary precautions are not taken, the user may suffer electric shock or the product itself may be damaged, which can also lead to personal injury.
17. Never use the product under conditions in which condensation has formed or can form in or on the product, e.g. if the product has been moved from a cold to a warm environment. Penetration by water increases the risk of electric shock.
18. Prior to cleaning the product, disconnect it completely from the power supply (e.g. AC supply network or battery). Use a soft, non-linting cloth to clean the product. Never use chemical cleaning agents such as alcohol, acetone or diluents for cellulose lacquers.

Operation

1. Operating the products requires special training and intense concentration. Make sure that persons who use the products are physically, mentally and emotionally fit enough to do so; otherwise, injuries or material damage may occur. It is the responsibility of the employer/operator to select suitable personnel for operating the products.
2. Before you move or transport the product, read and observe the section titled "Transport".
3. As with all industrially manufactured goods, the use of substances that induce an allergic reaction (allergens) such as nickel cannot be generally excluded. If you develop an allergic reaction (such as a skin rash, frequent sneezing, red eyes or respiratory difficulties) when using a Rohde & Schwarz product, consult a physician immediately to determine the cause and to prevent health problems or stress.
4. Before you start processing the product mechanically and/or thermally, or before you take it apart, be sure to read and pay special attention to the section titled "Waste disposal", item 1.
5. Depending on the function, certain products such as RF radio equipment can produce an elevated level of electromagnetic radiation. Considering that unborn babies require increased protection, pregnant women must be protected by appropriate measures. Persons with pacemakers may also be exposed to risks from electromagnetic radiation. The employer/operator must evaluate workplaces where there is a special risk of exposure to radiation and, if necessary, take measures to avert the potential danger.
6. Should a fire occur, the product may release hazardous substances (gases, fluids, etc.) that can cause health problems. Therefore, suitable measures must be taken, e.g. protective masks and protective clothing must be worn.
7. If a laser product (e.g. a CD/DVD drive) is integrated into a Rohde & Schwarz product, absolutely no other settings or functions may be used as described in the product documentation. The objective is to prevent personal injury (e.g. due to laser beams).

Repair and service

1. The product may be opened only by authorized, specially trained personnel. Before any work is performed on the product or before the product is opened, it must be disconnected from the AC supply network. Otherwise, personnel will be exposed to the risk of an electric shock.
2. Adjustments, replacement of parts, maintenance and repair may be performed only by electrical experts authorized by Rohde & Schwarz. Only original parts may be used for replacing parts relevant to safety (e.g. power switches, power transformers, fuses). A safety test must always be performed after parts relevant to safety have been replaced (visual inspection, PE conductor test, insulation resistance measurement, leakage current measurement, functional test). This helps ensure the continued safety of the product.

Batteries and rechargeable batteries/cells

If the information regarding batteries and rechargeable batteries/cells is not observed either at all or to the extent necessary, product users may be exposed to the risk of explosions, fire and/or serious personal injury, and, in some cases, death. Batteries and rechargeable batteries with alkaline electrolytes (e.g. lithium cells) must be handled in accordance with the EN 62133 standard.

1. Cells must not be taken apart or crushed.
2. Cells or batteries must not be exposed to heat or fire. Storage in direct sunlight must be avoided. Keep cells and batteries clean and dry. Clean soiled connectors using a dry, clean cloth.
3. Cells or batteries must not be short-circuited. Cells or batteries must not be stored in a box or in a drawer where they can short-circuit each other, or where they can be short-circuited by other conductive materials. Cells and batteries must not be removed from their original packaging until they are ready to be used.
4. Keep cells and batteries out of the hands of children. If a cell or a battery has been swallowed, seek medical aid immediately.
5. Cells and batteries must not be exposed to any mechanical shocks that are stronger than permitted.
6. If a cell develops a leak, the fluid must not be allowed to come into contact with the skin or eyes. If contact occurs, wash the affected area with plenty of water and seek medical aid.
7. Improperly replacing or charging cells or batteries that contain alkaline electrolytes (e.g. lithium cells) can cause explosions. Replace cells or batteries only with the matching Rohde & Schwarz type (see parts list) in order to ensure the safety of the product.
8. Cells and batteries must be recycled and kept separate from residual waste. Rechargeable batteries and normal batteries that contain lead, mercury or cadmium are hazardous waste. Observe the national regulations regarding waste disposal and recycling.

Transport

1. The product may be very heavy. Therefore, the product must be handled with care. In some cases, the user may require a suitable means of lifting or moving the product (e.g. with a lift-truck) to avoid back or other physical injuries.

2. Handles on the products are designed exclusively to enable personnel to transport the product. It is therefore not permissible to use handles to fasten the product to or on transport equipment such as cranes, fork lifts, wagons, etc. The user is responsible for securely fastening the products to or on the means of transport or lifting. Observe the safety regulations of the manufacturer of the means of transport or lifting. Noncompliance can result in personal injury or material damage.
3. If you use the product in a vehicle, it is the sole responsibility of the driver to drive the vehicle safely and properly. The manufacturer assumes no responsibility for accidents or collisions. Never use the product in a moving vehicle if doing so could distract the driver of the vehicle. Adequately secure the product in the vehicle to prevent injuries or other damage in the event of an accident.

Waste disposal

1. If products or their components are mechanically and/or thermally processed in a manner that goes beyond their intended use, hazardous substances (heavy-metal dust such as lead, beryllium, nickel) may be released. For this reason, the product may only be disassembled by specially trained personnel. Improper disassembly may be hazardous to your health. National waste disposal regulations must be observed.
2. If handling the product releases hazardous substances or fuels that must be disposed of in a special way, e.g. coolants or engine oils that must be replenished regularly, the safety instructions of the manufacturer of the hazardous substances or fuels and the applicable regional waste disposal regulations must be observed. Also observe the relevant safety instructions in the product documentation. The improper disposal of hazardous substances or fuels can cause health problems and lead to environmental damage.

Informaciones elementales de seguridad

Es imprescindible leer y observar las siguientes instrucciones e informaciones de seguridad!









El principio del grupo de empresas Rohde & Schwarz consiste en tener nuestros productos siempre al día con los estándares de seguridad y de ofrecer a nuestros clientes el máximo grado de seguridad. Nuestros productos y todos los equipos adicionales son siempre fabricados y examinados según las normas de seguridad vigentes. Nuestro sistema de garantía de calidad controla constantemente que sean cumplidas estas normas. El presente producto ha sido fabricado y examinado según el certificado de conformidad adjunto de la UE y ha salido de nuestra planta en estado impecable según los estándares técnicos de seguridad. Para poder preservar este estado y garantizar un funcionamiento libre de peligros, el usuario deberá atenerse a todas las indicaciones, informaciones de seguridad y notas de alerta. El grupo de empresas Rohde & Schwarz está siempre a su disposición en caso de que tengan preguntas referentes a estas informaciones de seguridad.







Además queda en la responsabilidad del usuario utilizar el producto en la forma debida. Este producto está destinado exclusivamente al uso en la industria y el laboratorio o, si ha sido expresamente autorizado, para aplicaciones de campo y de ninguna manera deberá ser utilizado de modo que alguna persona/cosa pueda sufrir daño. El uso del producto fuera de sus fines definidos o sin tener en cuenta las instrucciones del fabricante queda en la responsabilidad del usuario. El fabricante no se hace en ninguna forma responsable de consecuencias a causa del mal uso del producto.

Se parte del uso correcto del producto para los fines definidos si el producto es utilizado conforme a las indicaciones de la correspondiente documentación del producto y dentro del margen de rendimiento definido (ver hoja de datos, documentación, informaciones de seguridad que siguen). El uso del producto hace necesarios conocimientos técnicos y ciertos conocimientos del idioma inglés. Por eso se debe tener en cuenta que el producto solo pueda ser operado por personal especializado o personas instruidas en profundidad con las capacidades correspondientes. Si fuera necesaria indumentaria de seguridad para el uso de productos de Rohde & Schwarz, encontraría la información debida en la documentación del producto en el capítulo correspondiente. Guarde bien las informaciones de seguridad elementales, así como la documentación del producto, y entréguelas a usuarios posteriores.

Tener en cuenta las informaciones de seguridad sirve para evitar en lo posible lesiones o daños por peligros de toda clase. Por eso es imprescindible leer detalladamente y comprender por completo las siguientes informaciones de seguridad antes de usar el producto, y respetarlas durante el uso del producto. Deberán tenerse en cuenta todas las demás informaciones de seguridad, como p. ej. las referentes a la protección de personas, que encontrarán en el capítulo correspondiente de la documentación del producto y que también son de obligado cumplimiento. En las presentes informaciones de seguridad se recogen todos los objetos que distribuye el grupo de empresas Rohde & Schwarz bajo la denominación de "producto", entre ellos también aparatos, instalaciones así como toda clase de accesorios.

Símbolos y definiciones de seguridad

							
Aviso: punto de peligro general Observar la documentación del producto	Atención en el manejo de dispositivos de peso elevado	Peligro de choque eléctrico	Advertencia: superficie caliente	Conexión a conductor de protección	Conexión a tierra	Conexión a masa	Aviso: Cuidado en el manejo de dispositivos sensibles a la electrostática (ESD)

					
Tensión de alimentación de PUESTA EN MARCHA / PARADA	Indicación de estado de espera (Standby)	Corriente continua (DC)	Corriente alterna (AC)	Corriente continua / Corriente alterna (DC/AC)	El aparato está protegido en su totalidad por un aislamiento doble (reforzado)

Palabras de señal y su significado

En la documentación del producto se utilizan las siguientes palabras de señal con el fin de advertir contra riesgos y peligros.



PELIGRO identifica un peligro inminente con riesgo elevado que provocará muerte o lesiones graves si no se evita.



ADVERTENCIA identifica un posible peligro con riesgo medio de provocar muerte o lesiones (graves) si no se evita.



ATENCIÓN identifica un peligro con riesgo reducido de provocar lesiones leves o moderadas si no se evita.



AVISO indica la posibilidad de utilizar mal el producto y, como consecuencia, dañarlo.

En la documentación del producto se emplea de forma sinónima el término CUIDADO.

Las palabras de señal corresponden a la definición habitual para aplicaciones civiles en el área económica europea. Pueden existir definiciones diferentes a esta definición en otras áreas económicas o en aplicaciones militares. Por eso se deberá tener en cuenta que las palabras de señal aquí descritas sean utilizadas siempre solamente en combinación con la correspondiente documentación del producto y solamente en combinación con el producto correspondiente. La utilización de las palabras de señal en combinación con productos o documentaciones que no les correspondan puede llevar a interpretaciones equivocadas y tener por consecuencia daños en personas u objetos.

Estados operativos y posiciones de funcionamiento

El producto solamente debe ser utilizado según lo indicado por el fabricante respecto a los estados operativos y posiciones de funcionamiento sin que se obstruya la ventilación. Si no se siguen las indicaciones del fabricante, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte. En todos los trabajos deberán ser tenidas en cuenta las normas nacionales y locales de seguridad del trabajo y de prevención de accidentes.

1. Si no se convino de otra manera, es para los productos Rohde & Schwarz válido lo que sigue: como posición de funcionamiento se define por principio la posición con el suelo de la caja para abajo, modo de protección IP 2X, grado de suciedad 2, categoría de sobrecarga eléctrica 2, uso solamente en estancias interiores, utilización hasta 2000 m sobre el nivel del mar, transporte hasta 4500 m sobre el nivel del mar. Se aplicará una tolerancia de $\pm 10\%$ sobre el voltaje nominal y de $\pm 5\%$ sobre la frecuencia nominal.
2. No sitúe el producto encima de superficies, vehículos, estantes o mesas, que por sus características de peso o de estabilidad no sean aptos para él. Siga siempre las instrucciones de instalación del fabricante cuando instale y asegure el producto en objetos o estructuras (p. ej. paredes y estantes). Si se realiza la instalación de modo distinto al indicado en la documentación del producto, pueden causarse lesiones o incluso la muerte.
3. No ponga el producto sobre aparatos que generen calor (p. ej. radiadores o calefactores). La temperatura ambiente no debe superar la temperatura máxima especificada en la documentación del producto o en la hoja de datos. En caso de sobrecalentamiento del producto, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.

Seguridad eléctrica

Si no se siguen (o se siguen de modo insuficiente) las indicaciones del fabricante en cuanto a seguridad eléctrica, pueden producirse choques eléctricos, incendios y/o lesiones graves con posible consecuencia de muerte.

1. Antes de la puesta en marcha del producto se deberá comprobar siempre que la tensión preseleccionada en el producto coincida con la de la red de alimentación eléctrica. Si es necesario modificar el ajuste de tensión, también se deberán cambiar en caso dado los fusibles correspondientes del producto.
2. Los productos de la clase de protección I con alimentación móvil y enchufe individual solamente podrán enchufarse a tomas de corriente con contacto de seguridad y con conductor de protección conectado.
3. Queda prohibida la interrupción intencionada del conductor de protección, tanto en la toma de corriente como en el mismo producto. La interrupción puede tener como consecuencia el riesgo de que el producto sea fuente de choques eléctricos. Si se utilizan cables alargadores o regletas de enchufe, deberá garantizarse la realización de un examen regular de los mismos en cuanto a su estado técnico de seguridad.
4. Si el producto no está equipado con un interruptor para desconectarlo de la red, se deberá considerar el enchufe del cable de conexión como interruptor. En estos casos se deberá asegurar que el enchufe siempre sea de fácil acceso (de acuerdo con la longitud del cable de conexión, aproximadamente 2 m). Los interruptores de función o electrónicos no son aptos para el corte de la red eléctrica. Si los productos sin interruptor están integrados en bastidores o instalaciones, se deberá colocar el interruptor en el nivel de la instalación.
5. No utilice nunca el producto si está dañado el cable de conexión a red. Compruebe regularmente el correcto estado de los cables de conexión a red. Asegúrese, mediante las medidas de protección y de instalación adecuadas, de que el cable de conexión a red no pueda ser dañado o de que nadie pueda ser dañado por él, p. ej. al tropezar o por un choque eléctrico.
6. Solamente está permitido el funcionamiento en redes de alimentación TN/TT aseguradas con fusibles de 16 A como máximo (utilización de fusibles de mayor amperaje solo previa consulta con el grupo de empresas Rohde & Schwarz).
7. Nunca conecte el enchufe en tomas de corriente sucias o llenas de polvo. Introduzca el enchufe por completo y fuertemente en la toma de corriente. La no observación de estas medidas puede provocar chispas, fuego y/o lesiones.
8. No sobrecargue las tomas de corriente, los cables alargadores o las regletas de enchufe ya que esto podría causar fuego o choques eléctricos.
9. En las mediciones en circuitos de corriente con una tensión $U_{\text{eff}} > 30 \text{ V}$ se deberán tomar las medidas apropiadas para impedir cualquier peligro (p. ej. medios de medición adecuados, seguros, limitación de tensión, corte protector, aislamiento etc.).
10. Para la conexión con dispositivos informáticos como un PC o un ordenador industrial, debe comprobarse que éstos cumplan los estándares IEC60950-1/EN60950-1 o IEC61010-1/EN 61010-1 válidos en cada caso.
11. A menos que esté permitido expresamente, no retire nunca la tapa ni componentes de la carcasa mientras el producto esté en servicio. Esto pone a descubierto los cables y componentes eléctricos y puede causar lesiones, fuego o daños en el producto.

12. Si un producto se instala en un lugar fijo, se deberá primero conectar el conductor de protección fijo con el conductor de protección del producto antes de hacer cualquier otra conexión. La instalación y la conexión deberán ser efectuadas por un electricista especializado.
13. En el caso de dispositivos fijos que no estén provistos de fusibles, interruptor automático ni otros mecanismos de seguridad similares, el circuito de alimentación debe estar protegido de modo que todas las personas que puedan acceder al producto, así como el producto mismo, estén a salvo de posibles daños.
14. Todo producto debe estar protegido contra sobretensión (debida p. ej. a una caída del rayo) mediante los correspondientes sistemas de protección. Si no, el personal que lo utilice quedará expuesto al peligro de choque eléctrico.
15. No debe introducirse en los orificios de la caja del aparato ningún objeto que no esté destinado a ello. Esto puede producir cortocircuitos en el producto y/o puede causar choques eléctricos, fuego o lesiones.
16. Salvo indicación contraria, los productos no están impermeabilizados (ver también el capítulo "Estados operativos y posiciones de funcionamiento", punto 1). Por eso es necesario tomar las medidas necesarias para evitar la entrada de líquidos. En caso contrario, existe peligro de choque eléctrico para el usuario o de daños en el producto, que también pueden redundar en peligro para las personas.
17. No utilice el producto en condiciones en las que pueda producirse o ya se hayan producido condensaciones sobre el producto o en el interior de éste, como p. ej. al desplazarlo de un lugar frío a otro caliente. La entrada de agua aumenta el riesgo de choque eléctrico.
18. Antes de la limpieza, desconecte por completo el producto de la alimentación de tensión (p. ej. red de alimentación o batería). Realice la limpieza de los aparatos con un paño suave, que no se deshilache. No utilice bajo ningún concepto productos de limpieza químicos como alcohol, acetona o diluyentes para lacas nitrocelulósicas.

Funcionamiento

1. El uso del producto requiere instrucciones especiales y una alta concentración durante el manejo. Debe asegurarse que las personas que manejen el producto estén a la altura de los requerimientos necesarios en cuanto a aptitudes físicas, psíquicas y emocionales, ya que de otra manera no se pueden excluir lesiones o daños de objetos. El empresario u operador es responsable de seleccionar el personal usuario apto para el manejo del producto.
2. Antes de desplazar o transportar el producto, lea y tenga en cuenta el capítulo "Transporte".
3. Como con todo producto de fabricación industrial no puede quedar excluida en general la posibilidad de que se produzcan alergias provocadas por algunos materiales empleados, los llamados alérgenos (p. ej. el níquel). Si durante el manejo de productos Rohde & Schwarz se producen reacciones alérgicas, como p. ej. irritaciones cutáneas, estornudos continuos, enrojecimiento de la conjuntiva o dificultades respiratorias, debe avisarse inmediatamente a un médico para investigar las causas y evitar cualquier molestia o daño a la salud.
4. Antes de la manipulación mecánica y/o térmica o el desmontaje del producto, debe tenerse en cuenta imprescindiblemente el capítulo "Eliminación", punto 1.

5. Ciertos productos, como p. ej. las instalaciones de radiocomunicación RF, pueden a causa de su función natural, emitir una radiación electromagnética aumentada. Deben tomarse todas las medidas necesarias para la protección de las mujeres embarazadas. También las personas con marcapasos pueden correr peligro a causa de la radiación electromagnética. El empresario/operador tiene la obligación de evaluar y señalizar las áreas de trabajo en las que exista un riesgo elevado de exposición a radiaciones.
6. Tenga en cuenta que en caso de incendio pueden desprenderse del producto sustancias tóxicas (gases, líquidos etc.) que pueden generar daños a la salud. Por eso, en caso de incendio deben usarse medidas adecuadas, como p. ej. máscaras antigás e indumentaria de protección.
7. En caso de que un producto Rohde & Schwarz contenga un producto láser (p. ej. un lector de CD/DVD), no debe usarse ninguna otra configuración o función aparte de las descritas en la documentación del producto, a fin de evitar lesiones (p. ej. debidas a irradiación láser).

Reparación y mantenimiento

1. El producto solamente debe ser abierto por personal especializado con autorización para ello. Antes de manipular el producto o abrirlo, es obligatorio desconectarlo de la tensión de alimentación, para evitar toda posibilidad de choque eléctrico.
2. El ajuste, el cambio de partes, el mantenimiento y la reparación deberán ser efectuadas solamente por electricistas autorizados por Rohde & Schwarz. Si se reponen partes con importancia para los aspectos de seguridad (p. ej. el enchufe, los transformadores o los fusibles), solamente podrán ser sustituidos por partes originales. Después de cada cambio de partes relevantes para la seguridad deberá realizarse un control de seguridad (control a primera vista, control del conductor de protección, medición de resistencia de aislamiento, medición de la corriente de fuga, control de funcionamiento). Con esto queda garantizada la seguridad del producto.

Baterías y acumuladores o celdas

Si no se siguen (o se siguen de modo insuficiente) las indicaciones en cuanto a las baterías y acumuladores o celdas, pueden producirse explosiones, incendios y/o lesiones graves con posible consecuencia de muerte. El manejo de baterías y acumuladores con electrolitos alcalinos (p. ej. celdas de litio) debe seguir el estándar EN 62133.

1. No deben desmontarse, abrirse ni triturarse las celdas.
2. Las celdas o baterías no deben someterse a calor ni fuego. Debe evitarse el almacenamiento a la luz directa del sol. Las celdas y baterías deben mantenerse limpias y secas. Limpiar las conexiones sucias con un paño seco y limpio.
3. Las celdas o baterías no deben cortocircuitarse. Es peligroso almacenar las celdas o baterías en estuches o cajones en cuyo interior puedan cortocircuitarse por contacto recíproco o por contacto con otros materiales conductores. No deben extraerse las celdas o baterías de sus embalajes originales hasta el momento en que vayan a utilizarse.
4. Mantener baterías y celdas fuera del alcance de los niños. En caso de ingestión de una celda o batería, avisar inmediatamente a un médico.
5. Las celdas o baterías no deben someterse a impactos mecánicos fuertes indebidos.

6. En caso de falta de estanqueidad de una celda, el líquido vertido no debe entrar en contacto con la piel ni los ojos. Si se produce contacto, lavar con agua abundante la zona afectada y avisar a un médico.
7. En caso de cambio o recarga inadecuados, las celdas o baterías que contienen electrolitos alcalinos (p. ej. las celdas de litio) pueden explotar. Para garantizar la seguridad del producto, las celdas o baterías solo deben ser sustituidas por el tipo Rohde & Schwarz correspondiente (ver lista de recambios).
8. Las baterías y celdas deben reciclarse y no deben tirarse a la basura doméstica. Las baterías o acumuladores que contienen plomo, mercurio o cadmio deben tratarse como residuos especiales. Respete en esta relación las normas nacionales de eliminación y reciclaje.

Transporte

1. El producto puede tener un peso elevado. Por eso es necesario desplazarlo o transportarlo con precaución y, si es necesario, usando un sistema de elevación adecuado (p. ej. una carretilla elevadora), a fin de evitar lesiones en la espalda u otros daños personales.
2. Las asas instaladas en los productos sirven solamente de ayuda para el transporte del producto por personas. Por eso no está permitido utilizar las asas para la sujeción en o sobre medios de transporte como p. ej. grúas, carretillas elevadoras de horquilla, carros etc. Es responsabilidad suya fijar los productos de manera segura a los medios de transporte o elevación. Para evitar daños personales o daños en el producto, siga las instrucciones de seguridad del fabricante del medio de transporte o elevación utilizado.
3. Si se utiliza el producto dentro de un vehículo, recae de manera exclusiva en el conductor la responsabilidad de conducir el vehículo de manera segura y adecuada. El fabricante no asumirá ninguna responsabilidad por accidentes o colisiones. No utilice nunca el producto dentro de un vehículo en movimiento si esto pudiera distraer al conductor. Asegure el producto dentro del vehículo debidamente para evitar, en caso de un accidente, lesiones u otra clase de daños.

Eliminación

1. Si se trabaja de manera mecánica y/o térmica cualquier producto o componente más allá del funcionamiento previsto, pueden liberarse sustancias peligrosas (povos con contenido de metales pesados como p. ej. plomo, berilio o níquel). Por eso el producto solo debe ser desmontado por personal especializado con formación adecuada. Un desmontaje inadecuado puede ocasionar daños para la salud. Se deben tener en cuenta las directivas nacionales referentes a la eliminación de residuos.
2. En caso de que durante el trato del producto se formen sustancias peligrosas o combustibles que deban tratarse como residuos especiales (p. ej. refrigerantes o aceites de motor con intervalos de cambio definidos), deben tenerse en cuenta las indicaciones de seguridad del fabricante de dichas sustancias y las normas regionales de eliminación de residuos. Tenga en cuenta también en caso necesario las indicaciones de seguridad especiales contenidas en la documentación del producto. La eliminación incorrecta de sustancias peligrosas o combustibles puede causar daños a la salud o daños al medio ambiente.

Qualitätszertifikat

Certificate of quality

Certificat de qualité

Certified Quality System
ISO 9001

Certified Environmental System
ISO 14001

Sehr geehrter Kunde,

Sie haben sich für den Kauf eines Rohde&Schwarz-Produktes entschieden. Hiermit erhalten Sie ein nach modernsten Fertigungsmethoden hergestelltes Produkt. Es wurde nach den Regeln unseres Qualitätsmanagementsystems entwickelt, gefertigt und geprüft. Das Rohde&Schwarz-Qualitätsmanagementsystem ist u.a. nach ISO 9001 und ISO 14001 zertifiziert.

Der Umwelt verpflichtet

- ▮ Energie-effiziente, RoHS-konforme Produkte
- ▮ Kontinuierliche Weiterentwicklung nachhaltiger Umweltkonzepte
- ▮ ISO 14001-zertifiziertes Umweltmanagementsystem

Dear Customer,

You have decided to buy a Rohde&Schwarz product. You are thus assured of receiving a product that is manufactured using the most modern methods available. This product was developed, manufactured and tested in compliance with our quality management system standards. The Rohde&Schwarz quality management system is certified according to standards such as ISO 9001 and ISO 14001.

Environmental commitment

- ▮ Energy-efficient products
- ▮ Continuous improvement in environmental sustainability
- ▮ ISO 14001-certified environmental management system

Cher client,

Vous avez choisi d'acheter un produit Rohde&Schwarz. Vous disposez donc d'un produit fabriqué d'après les méthodes les plus avancées. Le développement, la fabrication et les tests respectent nos normes de gestion qualité. Le système de gestion qualité de Rohde&Schwarz a été homologué, entre autres, conformément aux normes ISO 9001 et ISO 14001.

Engagement écologique

- ▮ Produits à efficience énergétique
- ▮ Amélioration continue de la durabilité environnementale
- ▮ Système de gestion de l'environnement certifié selon ISO 14001

Customer Support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and will work with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz equipment.

Up-to-date information and upgrades

To keep your instrument up-to-date and to be informed about new application notes related to your instrument, please send an e-mail to the Customer Support Center stating your instrument and your wish. We will take care that you will get the right information.

USA & Canada

Monday to Friday (except US public holidays)
8:00 AM – 8:00 PM Eastern Standard Time (EST)

Tel. from USA 888-test-rsa (888-837-8772) (opt 2)
From outside USA +1 410 910 7800 (opt 2)
Fax +1 410 910 7801

E-mail CustomerSupport@rohde-schwarz.com

East Asia

Monday to Friday (except Singaporean public holidays)
8:30 AM – 6:00 PM Singapore Time (SGT)

Tel. +65 6 513 0488
Fax +65 6 846 1090

E-mail CustomerSupport@rohde-schwarz.com

Rest of the World

Monday to Friday (except German public holidays)
08:00 – 17:00 Central European Time (CET)

Tel. +49 89 4129 13774
Fax +49 (0) 89 41 29 637 78

E-mail CustomerSupport@rohde-schwarz.com



Contents

Introduction.....	5
Normative References.....	6
Instrument Requirements.....	7
ARB Memory Considerations.....	8
Instrument Options.....	9
Firmware Requirements.....	10
Additional Information.....	11
Test Setup Example.....	12
General Instrument Configuration.....	14
Test Measurement during Level or Frequency Change.....	14
Signal Blanking In List Mode.....	15
Triggering Waveforms by External Trigger.....	16
Signal Level.....	17
Connecting to the Instrument.....	18
Loading a DFS Project File.....	19
Controlling Multi Segment Waveforms.....	21
ETSI 301 893, ETSI 302 502.....	22
Waveform Requirements 301893 V 1.3.1 (2005-08).....	22
Waveform Requirements 301893 V 1.4.1 (2007-07).....	22
Waveform Requirements 301893 V 1.5.1 (2008-12).....	23
Waveform Requirements 302502 V 1.2.1 (2008-02).....	24
Instrument Setup.....	25
Creating The Waveforms.....	26
Report Creation.....	27
Conducting The Trials.....	28
FCC 06-96.....	30
Waveform Requirements.....	30
Type 1 - 4.....	30
Type 5.....	31

Type 6.....	31
Instrument Setup.....	32
Type 1 - 4.....	32
Type 5.....	33
Type 6.....	34
Creating the Waveforms.....	36
Type 1 - 4.....	36
Type 5.....	37
Type 6.....	39
Report Creation.....	41
Conducting the Trials.....	42
Type 1 - 4.....	42
Type 5.....	45
Type 6.....	47
Report Generation Background.....	50
Waveform Verification.....	51
FCC 0696 Type 1 – One entire burst.....	51
FCC 0696 Type 1 – Single pulse with trigger.....	52
FCC 0696 Type 2 – one entire burst.....	53
FCC 0696 Type 2 – Single pulse with trigger.....	54
FCC 0696 Type 2 – Random variations for PRI and pulse width.....	55
FCC 0696 Type 5 – Burst starting time.....	56
FCC 0696 Type 5 – Pulse spacing.....	57
FCC 0696 Type 6 – One single burst.....	59
Jitter Statistics.....	60

Introduction

Worldwide, the two frequency bands 5.25 - 5.35 GHz and 5.47 - 5.725 GHz are used by various radar systems and in addition, are allocated to unlicensed WLAN devices. A requirement arising from this frequency band reuse is a method called DFS which stands for Dynamic Frequency Selection.

A system that requires DFS needs to be capable of avoiding interfering with radar systems. This is achieved by various methods.

- Verify that the channel is free of any radar signals before using it.
- Continuous monitoring for radar signals once a channel is in use. The channel needs to be vacated if a radar signal is detected.
- Blacklisting channels where a radar signal was detected.
- Using channels equally (Uniform Loading).
- Transmit only the required amount of power (Transmit Power Control).

Since the radar systems are used by the military the actual signatures are confidential. The representative test patterns therefore contain random variations. It also needs to be ensured that WLAN devices should not only detect a specific pattern but respond to a wider variety of signals.

Different standards documents exist worldwide that define requirements and test patterns. These standards are listed in the next section of this document.

This manual mainly deals with the requirements set in the ETSI and FCC standard. It describes how the test signals can be generated using a Rohde & Schwarz Vector Signal Generator (e.g. R&S SMU200A) with the R&S K6 Pulse Sequencer Software option.

The R&S Pulse Sequencer Software comes as a stand alone PC based software with preconfigured project files for DFS and other standards. It simplifies the generation of all required waveforms and offers a one box solution.

Normative References

This manual and the related DFS project files for the R&S Pulse Sequencer Software describe the generation of the test patterns required by the marked (bold letters) standards below.

US

- **FCC 06-96** APPENDIX “COMPLIANCE MEASUREMENT PROCEDURES FOR UNLICENSED NATIONAL INFORMATION INFRASTRUCTURE DEVICES OPERATING THE 5250-5350 MHz AND 5470-5725 MHz BANDS INCORPORATING DYNAMIC FREQUENCY SELECTION”.

Europe

- ETSI EN 301 893 V1.3.1 (2005-08)
Broadband Radio Access Networks (BRAN);
5 GHz high performance RLAN;
Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive
- **ETSI EN 301 893 V1.4.1 (2007-07)**
Broadband Radio Access Networks (BRAN);
5 GHz high performance RLAN;
Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive
- **ETSI EN 301 893 V1.5.1 (2008-12)**
Broadband Radio Access Networks (BRAN);
5 GHz high performance RLAN;
Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive
- **ETSI EN 302 502 V1.2.1 (2008-02)**
Broadband Radio Access Networks (BRAN);
5.8 GHz fixed broadband data transmitting systems;
Harmonized EN covering thee essential requirements of article 3.2 of the R&TTE Directive

Australia/New Zealand

- AS/NZS 4268:2008
Radio equipment and systems – Short range devices – Limits and methods of measurement

Canada

- RSS 210, Issue 7, June 2007
Low-power License-exempt Radiocommunication Devices (All Frequency Bands)
Category I Equipment

This document refers under section A9.4 (b) to the DFS test procedures published by the U.S. Federal Communication Commission (FCC).

Instrument Requirements

The instrument requirements mainly depend on the size of the generated waveforms. The table below lists typical waveform sizes for the different DFS test signals. The listed waveform sizes are the maximum number that needs to be expected based on a given ARB sampling rate and provided in mega-samples (1 Ms = 2^{20} samples). Higher ARB sampling rates generate signals with better pulse shaping but the waveform files increase in size. The examples below are a good compromise between signal quality and file size.

FCC 06-96		SMBV-B55 (256 Ms)	SMU-B10 (64 Ms)
Type 1	1.3 Ms (50 MHz, 1 trial, MSW)	•	•
Type 2	12 Ms (50 MHz, all 30 trials, MSW)	•	•
Type 3	16 Ms (50 MHz, all 30 trials, MSW)	•	•
Type 4	15 Ms (50 MHz, all trials, MSW)	•	•
Type 5	4 Ms (20 MHz, sequencer, one trial)	•	•
Type 6	29 Ms (100 MHz, used for all 30 trials)	•	•

ETSI EN 301 893 V1.4.1 (2007-07)		SMU-B10 (64 Ms)	SMBV-B55 (256 Ms)	SMU-B9 (128 Ms)
Signal 1	420 kS (20 MHz, 1 trial, MSW)	•	•	•
Signal 2	21 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 3	31 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 4	5 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 5	6 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 6	5 MS (20 MHz, 20 trials, MSW)	•	•	•

ETSI EN 301 893 V1.5.1 (2008-12)		SMU-B10 (64 Ms)	SMBV-B55 (256 Ms)	SMU-B9 (128 Ms)
Signal 1	36 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 2	36 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 3	5 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 4	4 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 5	71 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 6	54 MS (20 MHz, 20 trials, MSW)	•	•	•

ETSI EN 302 502 V1.2.1 (2008-02)		SMU-B10 (64 Ms)	SMBV-B55 (256 Ms)	SMU-B9 (128 Ms)
Signal 1	420 kS (20 MHz, 1 trial, MSW)	•	•	•
Signal 2	21 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 3	31 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 4	5MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 5	6 MS (20 MHz, 20 trials, MSW)	•	•	•
Signal 6	5 MS (20 MHz, 20 trials, MSW)	•	•	•
D.3.2, Sig. 1	80 MS (10 MHz, 30 trials, MSW)		•	•
D.3.2, Sig. 2	70 MS (10 MHz, 30 trials, MSW)		•	•

ARB Memory Considerations

The maximum duration of the FCC Type 1 waveform is almost 26 ms. If the maximum ARB sample rate of 100 MHz is chosen for best pulse performance a total number of 2 600 000 samples (2.48 Msamples) is required. If markers are used the instrument reserves additional space and the total memory requirement increases by a factor of 1.25. If all 30 test patterns (trials) are generated and assembled to a Multi Segment Waveform the instrument must reserve the total amount of memory including markers and for all segments.

Maximum Play Time		26 ms		
ARB Sample Rate	x	100 000 1/s	=	2 600 000 samples
Additional Marker	0.25 x	2 600 000	=	+ 650 000 samples

				3 250 000 samples
All 30 Trials		30 x 3 250 000	=	93 Msample

The final number of samples need to be taken into account for the comparison with the maximum available ARB memory specified in M samples (M sample = 1024*1024 samples).

In order to reduce the number of samples it is permissible to reduce the ARB sample rate but values below 10 MHz should be avoided for signal performance reasons.

Instrument Options

R&S SMBV100A

- | | | |
|-----------------|--------------|--|
| • R&S SMBV100A | 1407.6004.02 | Base Unit |
| • R&S SMBV-B106 | 1407.9703.02 | 9 kHz to 6 GHz |
| • R&S SMBV-B51 | 1407.9003.02 | Baseband Generator with ARB, 60 MHz BW
32 Msample |
| • R&S SMBV-B55 | 1407.9203.02 | Memory Extension for ARB to 256 Ms |
| • R&S SMBV-B92 | 1407.9403.02 | Removable Hard Disk |
| • R&S SMBV-K6 | 1415.8390.02 | Pulse Sequencer License |

R&S SMU200A Vector Signal Generator

- | | | |
|----------------|--------------|--------------------------------------|
| • R&S SMU200A | 1141.2005.02 | Base Unit |
| • R&S SMU-B106 | 1141.8803.02 | 100 kHz to 6 GHz (RF Path A) |
| • R&S SMU-B9 | 1161.0766.02 | Baseband Generator with ARB (128 Ms) |
| • R&S SMU-B10 | 1141.7007.02 | Baseband Generator with ARB (64 Ms) |
| • R&S SMU-B13 | 1141.8003.04 | Baseband Main Module |
| • R&S SMU-K6 | 1408.7662.02 | Pulse Sequencer License |

For the generation of DFS signals different instruments or instrument configurations may be used. This section briefly outlines these choices.

One SMU200A / SMJ100A Vector Signal Generator

A single SMU100A or SMJ100A instrument may be used for the DFS signal generation. Path A should be configured for 6 GHz and contain the baseband main module (B13) as well as the ARB memory option. The FCC Type 5 waveforms require an instrument firmware that supports the Multi-Segment waveform sequencer mode.

One SMBV100A Vector Signal Generator

A single SMBV100A instrument may be used for the DFS signal generation. It must be equipped with the ARB memory extension B55 which provides up to 256 Msamples. The FCC Type 5 waveforms require an instrument firmware that supports the Multi-Segment waveform sequencer mode.

Firmware Requirements

The following minimum firmware requirements should be met for the generation of the DFS signals.

SMBV100A	>= 02.15.85.81
SMU200A	>= 02.10.111.116

Additional Information

- Rohde & Schwarz Application Note
<http://www.rohde-schwarz.com>

1EF59: DFS Analysis Tool, Dynamic Frequency Selection in the 5 GHz Band
- FCC (Federal Communications Commission) Part 15, Subpart E
<http://www.fcc.gov>

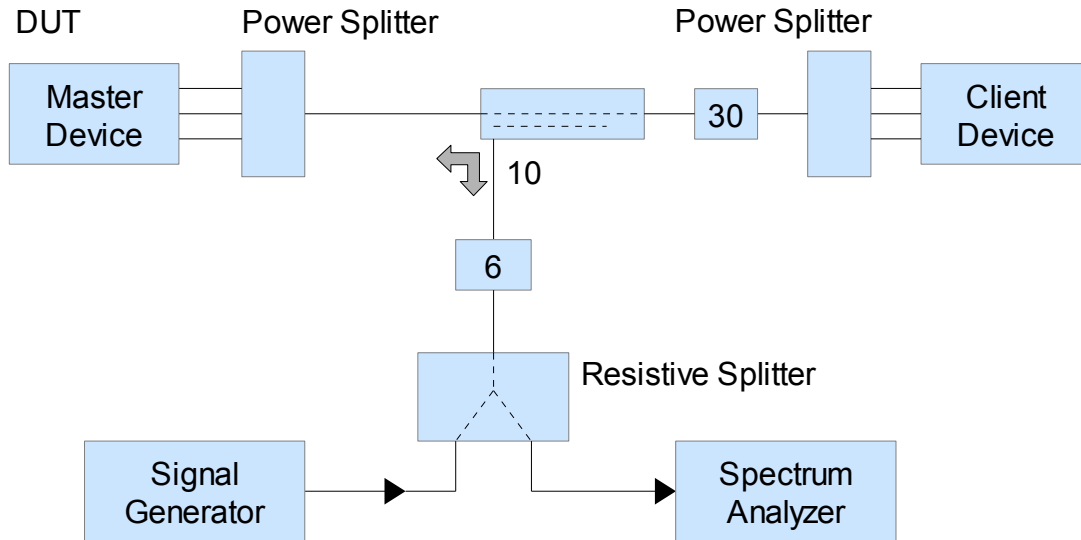
FCC-06-96A1.pdf
- ETSI (European Telecommunications Standards Institute) documents
<http://www.etsi.org>

en_301893v010501p.pdf
en_301893v010401p.pdf
en_302502v010201o.pdf
- NTIA (National Telecommunications And Information Administration) DFS information
<http://ntiacsd.ntia.doc.gov/dfs/>
- FCC search page for approved devices
<https://fjallfoss.fcc.gov/oetcf/eas/reports/GenericSearch.cfm>

Test Setup Example

This chapter briefly discusses DFS test setup fundamentals. The detailed requirements for the various standards can be found in the related standard documents.

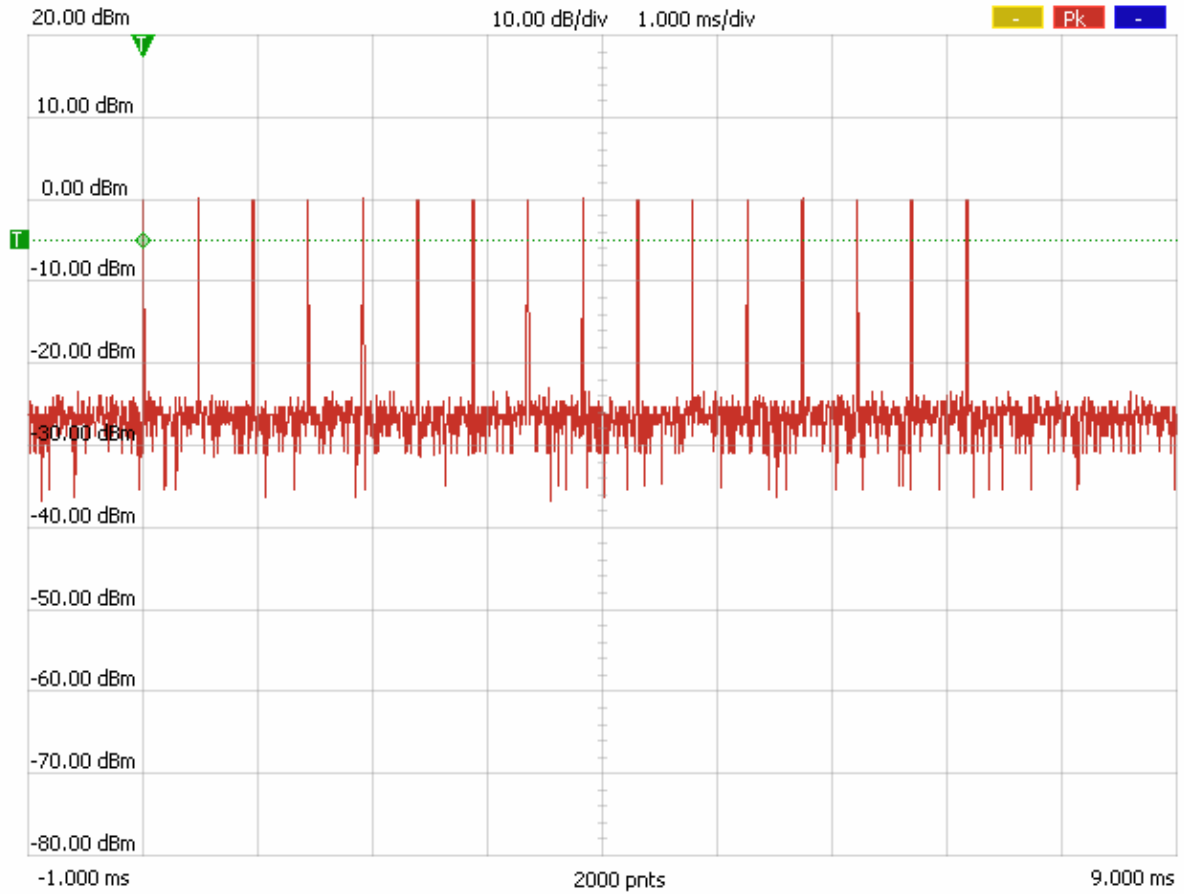
The figure below shows an example setup that can be utilized for conducted DFS tests. The setup uses a master device as DUT and a client device for the setup of the data link. The test signal is attenuated by an additional 30 dB in the RF path to the client device. This ensures that only the master device responds to the test signal.



The Vector Signal Generator injects the DFS test signal into the communication between the master and the client device. The Spectrum Analyzer is operated in zero span mode on the channel centre frequency. It monitors the traffic between the two devices as well as the injected radar pulses. Both, the Vector Signal Generator and the Spectrum Analyzer can be remote controlled by a PC software for test automation.

It is helpful to trigger the Spectrum Analyzer sweep when a new radar test signal is injected. This can be achieved by using one of the marker signals that are contained in the test signals generated with the R&S Pulse Sequencer Software.

If the signal levels are high enough an alternative method for the measurement of the RF test signals or the data traffic is the use of the R&S NRP-Z81 Power Sensor. The following screen shot measures a pulse train generated from a Vector Signal Generator.



General Instrument Configuration

The following paragraph contains detailed information about specific instrument functions that need to be paid special attention to during DFS testing. Each section also contains background information why these settings may need to be changed.

Test Measurement during Level or Frequency Change

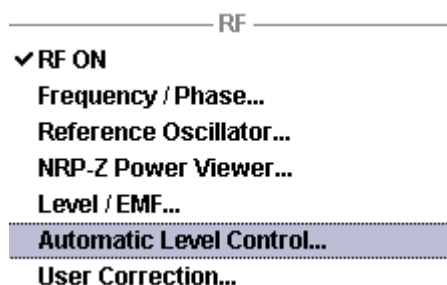
This paragraph is only relevant for the instruments SMJ100A, SMU200A and SMATE200A. The SMBV100A suppresses the RF signal during its internal measurement by 50 dB.

During manual testing it is mostly required to send a single DFS test signal, observe the response of the DUT and in case of successful detection change to a new channel frequency. This is because the DUT must blacklist the channel if radar signals were detected on this frequency. The testing is usually done in a signal generator mode where the baseband mode is set to a manual trigger that is issued via the user interface ('Execute Trigger' button).

In a mode where the baseband is waiting for a trigger event and the level or frequency is changed the Vector Signal Generator generates an internal test signal for correct levelling. This test signal also appears at the RF output for a short period of time and with the set frequency and level.

In case of DFS testing this test signal could be interpreted by the DUT as a radar pattern and cause another hop to the next available channel.

In order to suppress this test signal the R&S Vector Signal Generators offer an option that reduces the RF output by 40 dB below the set RF level. This should lead to a level well below the detection threshold of the DUT. By default this option is disabled and enabling the level suppression can be done in the *Automatic Level Control* dialog from the instruments RF section.



The check box '*Protect RF Output*' enables the additional attenuation.



Please Note:

Enabling this option slightly decreases the level accuracy because the temporary change of the internal attenuator has minor effects on the internal level sensor. This is the reason why this option is disabled by default. Since the effect is minor the degradation of level accuracy can be ignored for DFS testing.

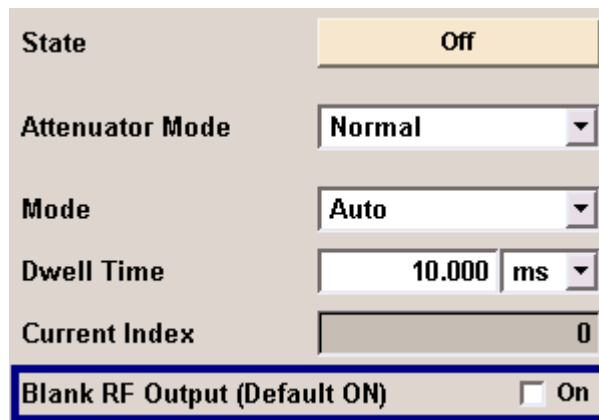
Signal Blanking In List Mode

The Type 6 waveform for the DFS testing according to FCC 06-96 rules require frequency hops across a wide frequency range. This hopping can simply be achieved by combining the ARB signal with the RF List Mode of the R&S Vector Signal Generator.

The hop intervals are given by the standards and allow for enough time to fit one burst into this interval. Special care must therefore be taken since changing the frequency requires the instrument to readjust the internal synthesizer and this takes a small amount of time. By default the instrument suppresses any RF output during this time period to protect devices from an undefined or unwanted signal. The signal is activated again once the new frequency has settled to the specified accuracy. For safety an additional margin is added to the blanking time.

For the DFS testing the default blanking time used by the instrument is slightly too long and the first pulse from the burst will be truncated. Shorter blanking times are sufficient because the frequency will settle well within the channel bandwidth at a much shorter time and the tough requirement to reach the instrument specification limits is not required in this case.

Disabling the blanking period is possible in the List Mode dialog in the instruments RF section.



By default the '*Blank RF Output*' option is enabled for safety. For DFS testing according to the FCC 06-96 rules this option must be disabled.

Triggering Waveforms by External Trigger

Whenever waveforms or Multi Segment Waveforms are triggered by an external event a small delay occurs between the physical trigger event and the start of the waveform. In the R&S Vector Signal Generators this delay depends on the sample rate used with the waveform. This is because an external trigger event starts the ARB but the signal chain also contains digital and analog filters that add an additional delay. In order to overcome this issue the instrument uses the following method to ensure that the signal output is synchronized with the external trigger event.

- The instrument calculates the internal processing time based on its settings.
- On an external trigger event the instrument skips this fraction of the signal at the beginning of the waveform.
- The playback starts after the skipped section.
- The remaining part of the waveform is perfectly synchronized with the external trigger event.

This method is desirable for most telecommunication applications where only initial triggering is required and an initially truncated data frame can be tolerated. For DFS testing no part of the waveform can be skipped because the radar test signals need to be played back entirely.

Trigger In	
Extended Trigger Mode	Next Segment
Mode	Single
	Stopped
Signal Duration Unit	Sequence Length (SL)
Signal Duration	1 SL
Source	External (TRIGGER 1)
External Delay	0.00 Samples
External Inhibit	0 Samples

The Pulse Sequencer project files take care on this issue and add a small amount of delay time at the beginning of each waveform (1 ms). This delay is substantially greater than the internal processing and therefore only a fraction of this initial blank period is truncated.

The initial blank period does not affect the testing because it simply delays the signal generation by a small amount of time.

Signal Level

Generally the level setting of the Vector Signal Generator relates to the average signal power. The Peak Envelope Power (PEP) depends on the signal and is automatically determined by the instrument. The figure below shows the settings for a 3GPP FDD signal at -10 dBm average power level.

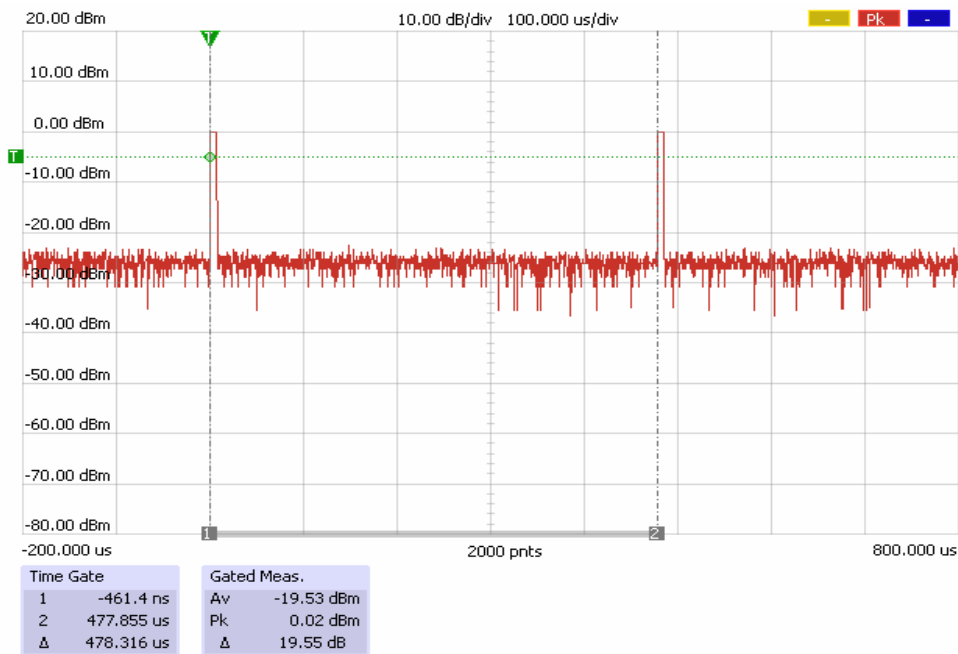


Setting the average power level is usually desirable in telecommunication systems but it is not in the case of radar signals. The radar signals typically exhibit large Peak-to-Average ratios because of their large on-off time ratios. In order to set the radar pulse peak power rather than an average power the Peak to Average ratio of the waveform needs to be forced to zero.



The Pulse Sequencer DFS project files take care on this issue and set the Peak-to-Average ratio to zero. The result is that equal power values are shown for the average and the PEP power on the instruments user interface.

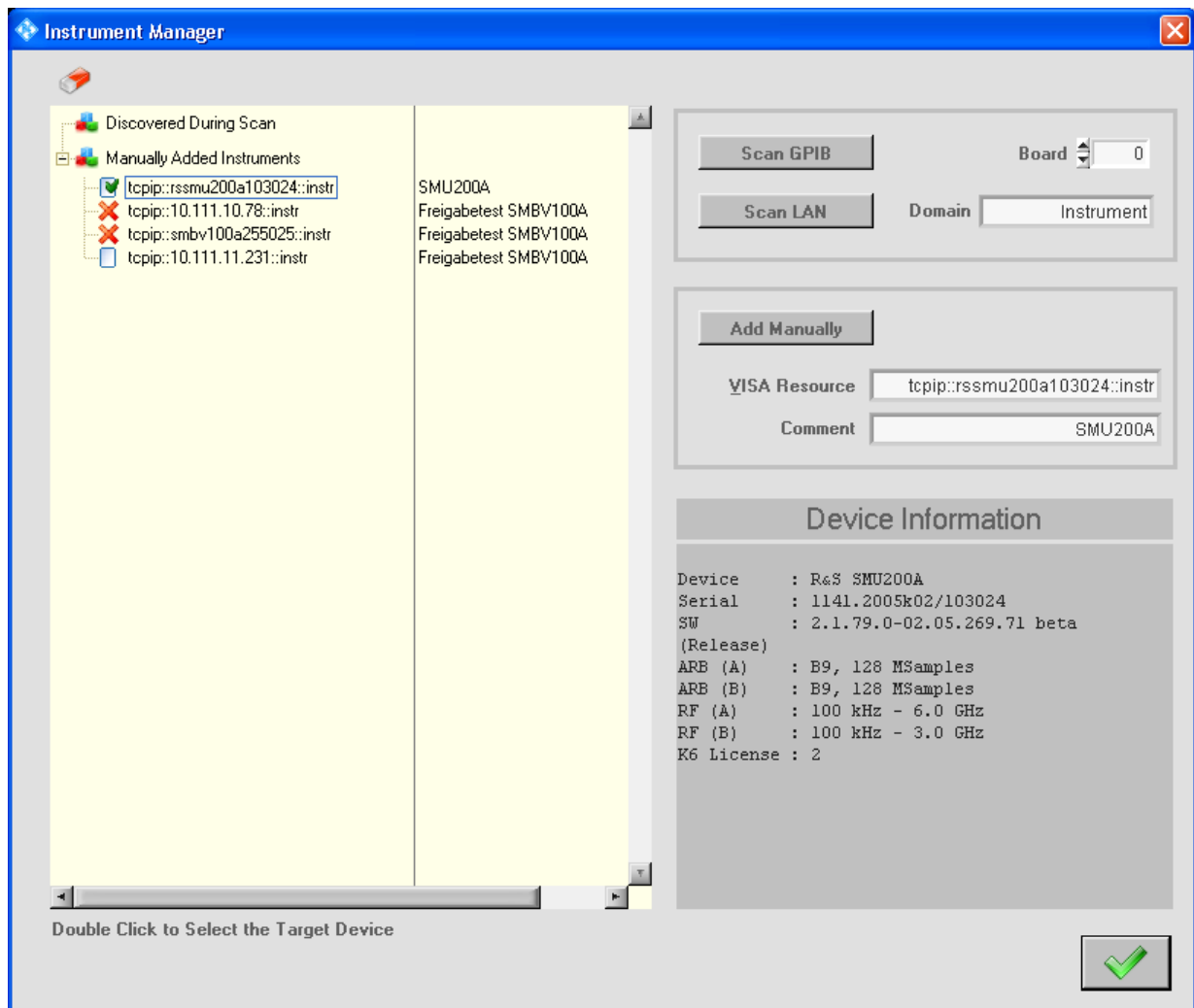
The instrument sets up its internal signal chain according to the peak power to ensure that clipping does not occur.



Connecting to the Instrument

The first step after a fresh installation of the Pulse Sequencer Software is to configure the instrument connection. The instrument connection is required for the creation of Multi Segment Waveforms and RF List files. In addition, the instrument capabilities (e.g. ARB memory or the availability of the second path) need to be considered when building the waveforms.

Setting up the instruments is done in the Instrument Manager panel which can be accessed from the main menu under '*Instrument* → *Manager*'. The screen shot below shows this panel with four instruments and one active connection.



A detailed discussion of the Instrument Manager panel can be found in the Pulse Sequencer Software manual.

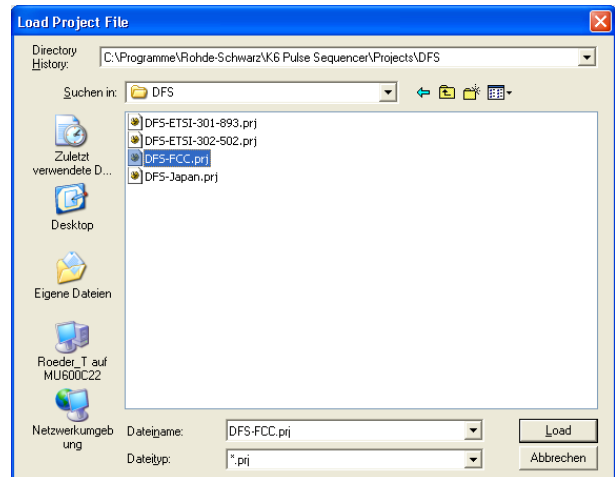
Loading a DFS Project File

The Pulse Sequencer software contains predefined project files for the different DFS standards. These project files can be found in the sub directory 'Projects\DFS' in the application directory.

The project files contain all pulse definitions, radar test signals, and frequency hopping lists that are required by the standard. In addition, waveform parameters that are used during the test signal creation are reported to Microsoft EXCEL spread sheets for later filing.

The project files cannot be edited directly but they configure the Pulse Sequencer Software for the generation of the various test signals. It is possible for the user to alter settings as needed and save the modified project file under a different name.

A project file can be loaded by selecting 'File → Load Project...' from the menu bar. Navigate to the subdirectory *Projects\DFS* in your application directory and load the appropriate file for the standard you are working with.



The following project files are available.

ETSI

ETSI-302-502-V121.prj	ETSI 302502 V 1.2.1
ETSI-301-893-V141.prj	ETSI 301893 V 1.4.1
ETSI-301-893-V151.prj	ETSI 301893 V 1.5.1

FCC

FCC0696-Type1-4.prj	FCC 0696	Type 1 – 4 waveforms
FCC0696-Type5-Sequencer.prj	FCC 0696	Type 5 waveforms using the sequencer mode
FCC0696-Type6.prj	FCC 0697	Type 6 waveform and RF lists

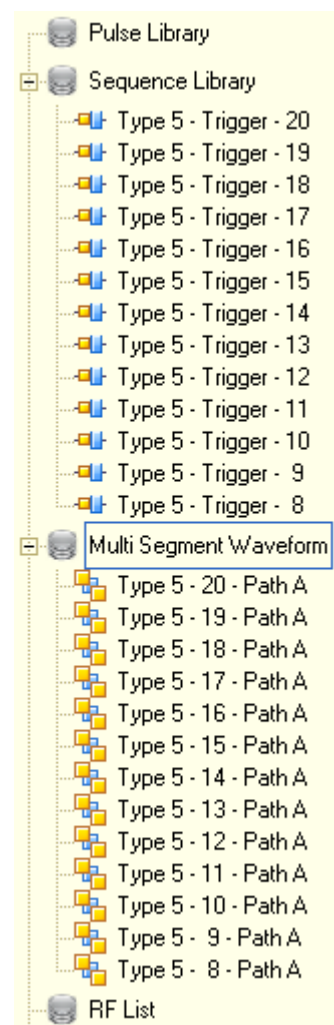
Other

Japan.prj

Once a project file is loaded the project tree on the left side of the main application window lists the entire project contents. The tree contains individual branches for pulses, sequences, Multi Segment Waveforms and RF Lists. The items located under these branches represent the contents of the project.

Project content can also be hidden from the user to reduce the number of items shown in the project tree. This is useful in DFS projects where the underlying pulse definitions do not need to be altered by the user unless parameters change with new versions of a standard. Items that are marked with a hidden flag can be made visible by deselecting the option '*Project* → *Hide Tree Entries*' from the main menu.

Selecting one of the tree items opens the associated editor panel on the right side of the main application window. This panel can be used to edit an item or in the case of a sequence, Multi Segment Waveform or RF List to build the file and transfer to the instrument.



Controlling Multi Segment Waveforms

Multi Segment Waveform contain multiple waveforms in one large file. Each waveform can be played individually or one after the other.

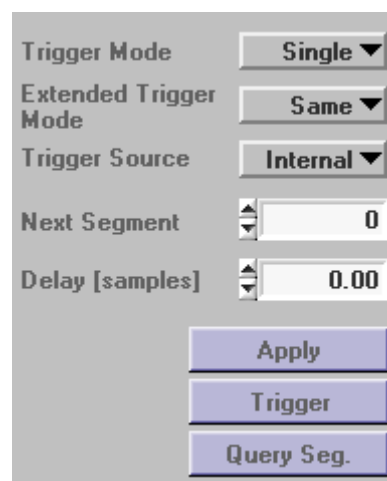
For DFS testing the Multi Segment Waveforms are utilized to hold all the required trials for each radar test signal. This simplifies the testing process dramatically because the Multi Segment Waveform is automatically build and all random parameters used during that build process are reported into a Microsoft EXCEL spread sheet. For testing of the DUT the individual waveforms (segments) can be activated via the instruments user interface of the Pulse Sequencer Software panel.

The next section describes how to control the Multi Segment Waveform playback via the Pulse Sequencer Software user interface.

Triggering the Multi Segment Waveform can be done by using the Pulse Sequencer controls on the Multi Segment Waveform editor panel. If the trigger mode is set to '**Single**' each waveform segment is only played back once. In combination with the extended trigger mode set to '**Next**' the trigger event switches the Multi Segment Waveform to the next item. The '**Internal**' trigger source setting allows for triggering the instrument via the remote control command sent from the Pulse Sequencer Software.

The '**Apply**' button can be used to select a specific segment and configure the instrument according to all settings. Subsequently pressing the '**Trigger**' button advances the Multi Segment Waveform to the next item.

The '**Query Seg**' button reads back the number of the currently active segment and highlights this entry in the segment editor table in blue.



The image shows a control panel for the Multi Segment Waveform editor. It features several settings and buttons:

- Trigger Mode:** A dropdown menu set to 'Single'.
- Extended Trigger Mode:** A dropdown menu set to 'Same'.
- Trigger Source:** A dropdown menu set to 'Internal'.
- Next Segment:** A numeric input field set to '0'.
- Delay [samples]:** A numeric input field set to '0.00'.
- Buttons:** Three buttons are located at the bottom: 'Apply', 'Trigger', and 'Query Seg.'.

ETSI 301 893, ETSI 302 502

This chapter discusses the generation of DFS test signals according to the various ETSI standards. A discussion of the FCC related waveforms follow in the next chapter.

Waveform Requirements 301893 V 1.3.1 (2005-08)

Please refer to the next section 'Waveform Requirements 301893 V 1.4.1'.

Waveform Requirements 301893 V 1.4.1 (2007-07)

The table below lists the waveform requirements from the standard document (Annex D, DFS parameters).

Radar Test Signal	Pulse Width [µs]	PRF [Hz]	Pulses per Burst
1	1	750	15
2	1, 2, 5	200, 300, 500, 800, 1000	10
3	10,15	200, 300, 500, 800, 1000	15
4	1, 2, 5, 10, 15	1200, 1500, 1600	15
5	1, 2, 5, 10, 15	2300, 3000, 3500, 4000	25
6	20,3	2000, 3000, 4000	20

The first test signal is a static pattern with fixed parameters whereas all other signals use random variations of the pulse width and the pulse repetition frequency. The radar test signal 6 additionally requires a linear chirp modulation from -2.5 MHz to +2.5 MHz within the pulse.

For the test signals 2 – 6 a total of 20 randomly generated test patterns are required.

Waveform Requirements 301893 V 1.5.1 (2008-12)

The table below lists the waveform requirements from the standard document (Annex D, DFS parameters).

Radar Test Signal	Pulse Width [μs]	PRF [Hz]	Pulses per Burst
1	0.8 - 5	200 - 1000	10, 18
2	0.8 - 15	200 - 1600	15, 18
3	0.8 - 15	2300 - 4000	25
4	20 - 30	2000 - 4000	20
5	0.8 - 2	300 - 400	10, 18
6	0.8 - 2	400 - 1200	15, 18

All test signals use random variations of the pulse width and the pulse repetition frequency. The radar test signal 6 additionally requires a linear chirp modulation from -2.5 MHz to +2.5 MHz within the pulse.

The test signals 5 and 6 use two or three different PRF values in a staggered configuration. An additional requirement exists that the difference between the PRF values is between 20 and 50 Hz for the type 5 signal and between 80 and 400 Hz for the type 6 signal.

For all test signals a total of 20 randomly generated test patterns are required.

Waveform Requirements 302502 V 1.2.1 (2008-02)

The table below lists the waveform requirements from the standard document (Annex D, DFS parameters, Table D.3.1).

Radar Test Signal	Pulse Width [μs]	PRF [Hz]	Pulses per Burst
1	1	750	15
2	1, 2, 5	200, 300, 500, 800, 1000	10
3	10,15	200, 300, 500, 800, 1000	15
4	1, 2, 5, 10, 15	1200, 1500, 1600	15
5	1, 2, 5, 10, 15	2300, 3000, 3500, 4000	25
6	20,3	2000, 3000, 4000	20

The first test signal is a static test pattern with fixed parameters whereas all other signals use random variations of the pulse width and the pulse repetition frequency. The radar test signal 6 additionally requires a linear chirp modulation from -2.5 MHz to +2.5 MHz within the pulse.

For the test signals 2 – 6 a total of 20 randomly generated test patterns are required.

This standard adds two more waveforms that simulate frequency hopping radar systems (Table D.3.2).

Radar Test Signal	Pulse Width [μs]	PRF [Hz]	Pulses per Burst	Burst Length [ms]	Bursts per Trial	Pulse Modulation
1	1	3000	9	3	8	-
2	20	4500	9	2	2	Chirp

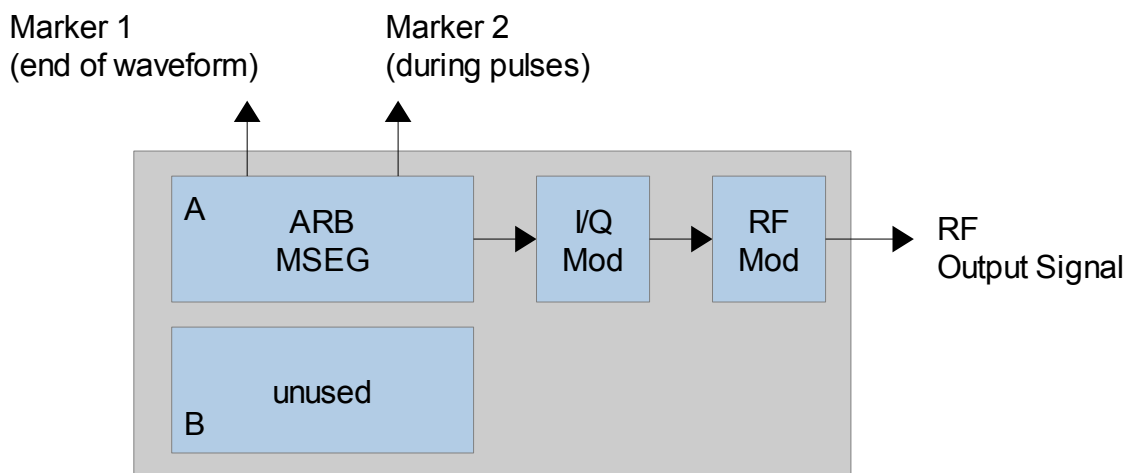
Both signals use bursts that contain 9 pulses with fixed pulse width and fixed PRF. The second signal additionally uses an intra pulse modulation of a linear FM chirp from -2.5 MHz to +2.5 MHz. In contrast to the other waveforms the spacing between the bursts is increased from trial to trial by a fixed step size.

Radar Test Signal	Trials	Min Spacing [ms]	Max Spacing [ms]	Step Size [ms]
1	29	1.25	37.5	1.25
2	29	5	150	5

Instrument Setup

All test signals are created as ARB Multi Segment Waveforms that fit into the SMU-B9 or SMBV-B55 ARB. Please see the instrument requirements section in this book for additional details on the required hardware options.

The ARB waveforms also contain marker information that is tied to the pulse timing. The marker signals are available as digital signals through BNC connectors and may be used for the triggering of a Spectrum Analyzer or a Power Meter.



Marker 1 becomes active for a short period of time at the end of the last pulse. The rising edge of this signal may be used to mark the beginning point for measurements, such as the Channel Move Time.

Marker 2 is active during each individual pulse and may be used to trigger a Spectrum Analyzer for the verification of the pulse train in zero span mode. Alternatively a R&S NRP-Z3 adapter may be utilized for the triggering of a R&S NRP-Z Power Sensor.

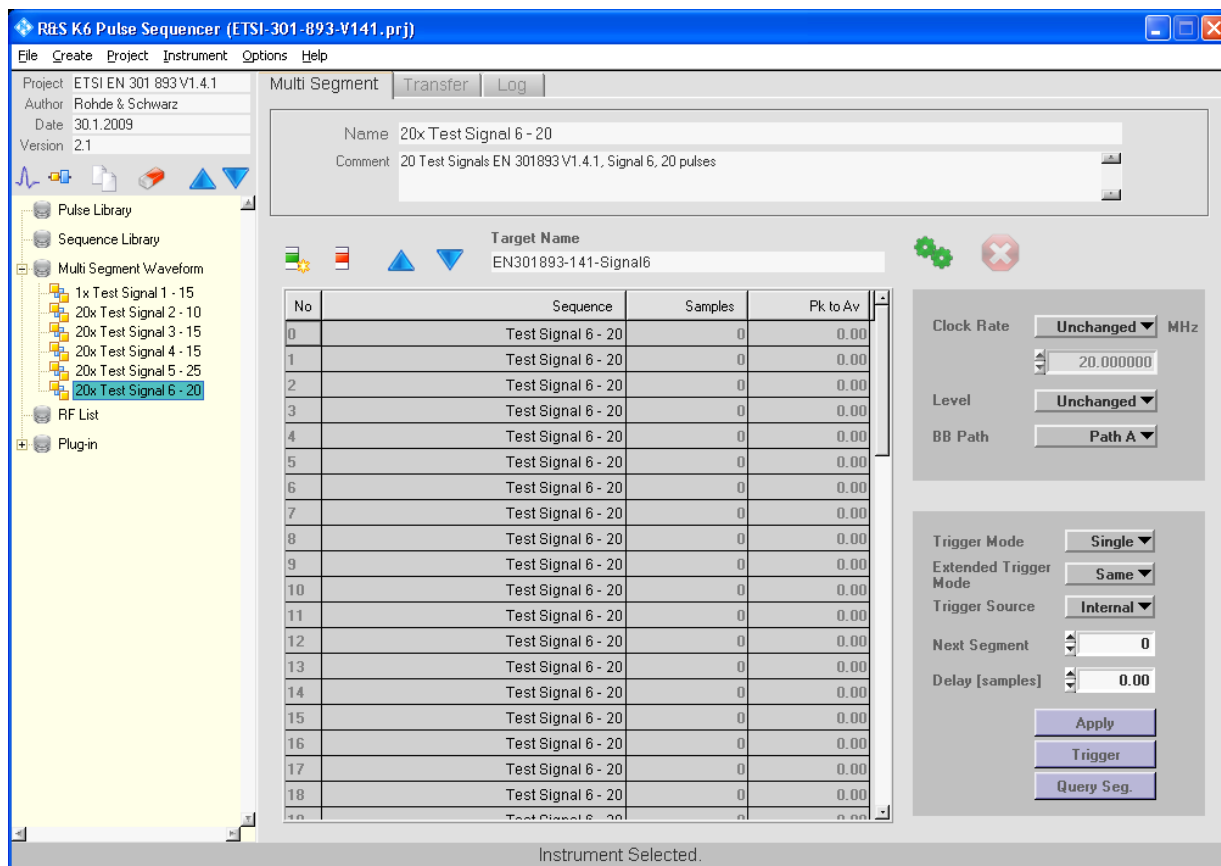
The instrument setup is relatively simple. The ARB is configured to the Multi Segment Waveform mode and contains all the required trials as waveform segments. During the testing procedure the user selects the next segment to be played back and issues a single trigger.

In case of a two-path instrument (SMU200A) the second path is not required for these waveforms and remains unused.

Creating The Waveforms

The project tree contains a Multi Segment Waveform entry for each test signal type listed in the standard document. Each Multi Segment Waveform contains all all the required trials.

The generation of the Multi Segment Waveform files is a fully automated process. Once an instrument is selected and the connection is established the 'Batch Build' button becomes active on the Multi Segment panel.



Pressing the 'Batch Build' button performs the following steps automatically.

- Open the Microsoft EXCEL spread sheet for reporting
- Create the individual waveforms and transfer to the instrument
- Close EXCEL spread sheet
- Assemble waveforms to Multi Segment Waveform file
- Start ARB with Multi Segment Waveform and configure according to settings

Report Creation

For the filing of test results it is important that the parameters are documented that were used during the waveform generation. For this purpose the DFS projects make use of a Microsoft EXCEL reporting plugin. This plugin receives pulse parameters during the waveform generation and fills in the spread sheets.

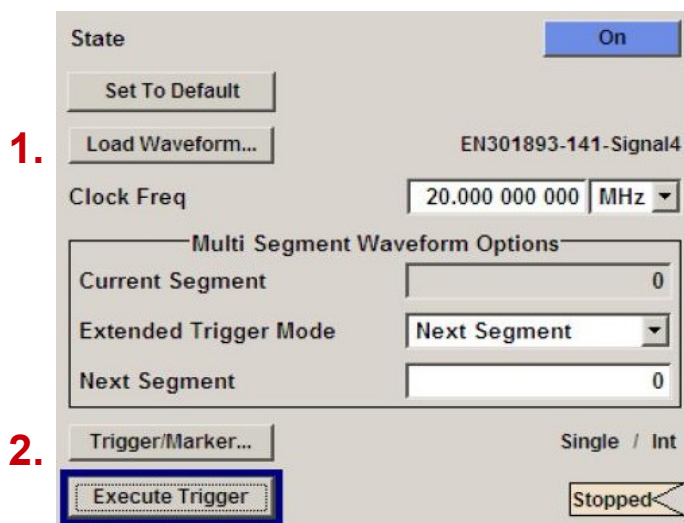
ETSI EN 301 893 V1.4.1 (2007-07)				Clear
Tester:				
Test Lab:				
Date:				
Device: Example Device				
Serial:				
Firmware:				
Manufacturer:				
Test: Idle, Ch 60, Germany, 20 MHz				
TEST SIGNAL 5				Rohde & Schwarz K6 Pulse Sequencer
Trial #	Number of Pulses per Burst	Pulse Width (µsec)	PRF (Hz)	Detection (yes/no)
1	25	1	3000	y
2	25	15	2300	n
3	25	1	2300	y
4	25	10	3500	y
5	25	2	4000	y
6	25	2	3000	y
7	25	10	3000	y
8	25	5	3000	y
9	25	5	4000	y
10	25	5	3500	y
11	25	1	4000	y
12	25	2	3000	y
13	25	2	2300	y
14	25	1	2300	y
15	25	5	3000	y
16	25	10	3000	y
17	25	5	3500	y
18	25	5	2300	y
19	25	10	3500	y
20	25	5	4000	y

The spread sheets may also be used to mark passed and failed tests.

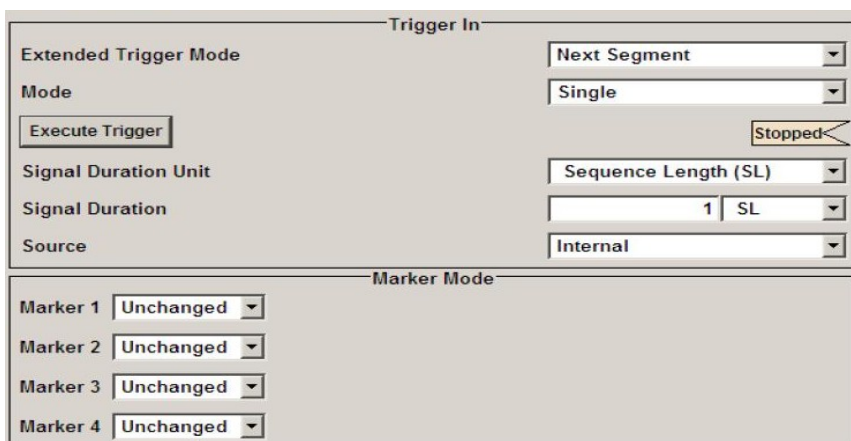
Conducting The Trials

After completion of the Multi Segment Waveform build process the file can be selected in the instruments ARB menu. This paragraph describes the process of selecting the waveform and playing the individual segments.

First, the waveform file must be set using the 'Load Waveform...' button from the instruments ARB panel. The Multi Segment Waveform contains all trials as individual segments and it is possible to execute each segment manually using the 'Execute Trigger' button. Before starting the tests it is required to configure the waveform trigger in the trigger settings dialog. This dialog can be opened using the 'Trigger/Marker' button.



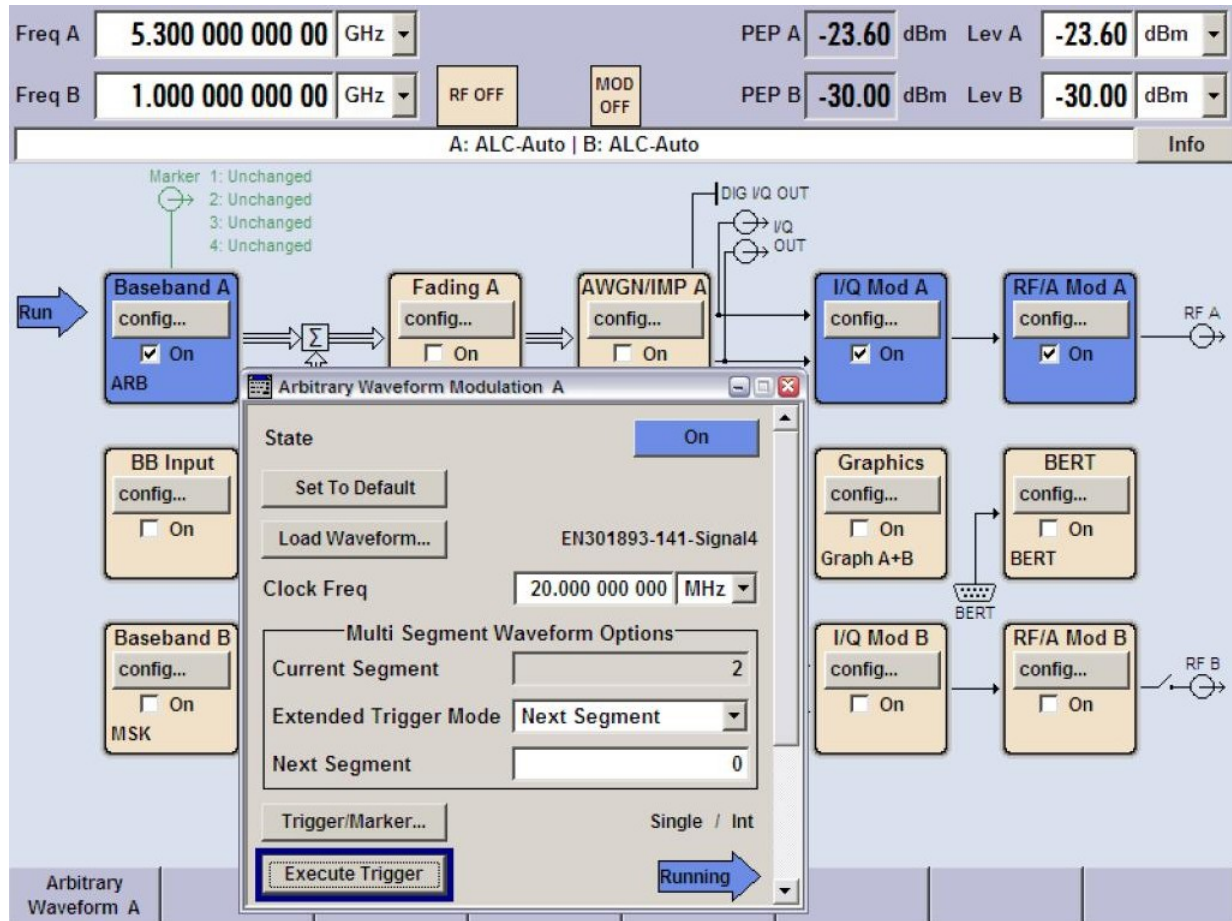
The first two sections in the trigger dialog are important. First, the operation mode should be configured as shown in the figure below. This sets the instrument to advance to the next waveform segment each time the 'Execute Trigger' button is pressed.



It is also required to leave all marker mode settings on 'Unchanged'. This instructs the instrument to use the marker definitions from the Multi Segment Waveform file.

The ARB system is now configured correctly and the next step is to set the RF level and frequency correctly.

Once all settings are made the instrument is ready to generate the radar test signals one after the other. The screen shot below shows a typical SMU200A setup.



The PEP (Peak Envelope Power) level is equal to the average level. This behaviour is forced by the waveform file because DFS testing requires to control the pulse power rather than an average signal power.

Every time the 'Execute Trigger' button is pressed the instrument generates the next radar test signal and subsequently increases the current segment count.

FCC 06-96

This chapter discusses the generation of the DFS related radar test signals defined in the FCC 06-96 standard document. This document lists various test waveforms in section 6.

- Chapter 6.1 Radar Type 1-4 Short Pulse Radar Waveforms
- Chapter 6.2 Radar Type 5 Long Pulse Radar Test Waveform
- Chapter 6.3 Radar Type 6 Frequency Hopping Radar Test Waveform

For each of these chapters a separate Pulse Sequencer project file exists that contains all relevant pulse definitions and creates Multi Segment Waveforms that contain all the required trials. In addition, the parameters used during waveform creation are sent to a Microsoft EXCEL reporting plugin. This plugin fills in report sheets that can be used for the FCC filing.

The next sections describe the waveform requirements, the instrument setup, the report generation, and the test execution for the various waveforms in more detail.

Waveform Requirements

Type 1 - 4

The following table lists the parameters for the waveforms of Type 1 - 4. These waveforms are referred to as the *Short Pulse Radar Test Waveforms*.

Radar Type	Pulse Width (0.1 us steps)	PRI [us] (1 us steps)	Pulses (step 1)
1	1	1428	18
2	1-5	150-230	23-29
3	6-10	200-500	16-18
4	11-20	200-500	12-16

The first waveform is static whereas the other waveforms use random variations of the pulse width, the pulse repetition interval and the number of pulses. With the exception of waveform Type 1 a minimum of 30 unique waveforms of each type are required.

Type 5

The FCC 06-96 Type 5 waveform is the most complex test pattern since it uses FM chirped bursts and randomly varies many pulse parameters. The following table shows the requirements set by the standard for this waveform. A total of 30 unique waveforms are required for the testing.

Radar Type	Pulse Width (0.1 us steps)	PRI [us] (1 us steps)	Pulses per Burst	Bursts	Chirp Deviation [MHz]
5	50 - 100	1000 - 2000	1 - 3	8 - 20	5 - 20

The overall duration of the waveform is always 12 seconds. This time is divided into equal durations depending on the number of bursts (N = 8 20) used in the waveform. Each burst is started at a random position within its time interval.

A burst may contain one, two, or three FM chirped pulses. The pulse width and FM chirp deviation are randomly selected for each burst and are the same for all pulses within one burst. The same applies for the PRI with the exception that bursts that contain three pulses also vary the PRI within the burst. This means that in case of three pulses the intra pulse spacing is different between pulse one and two as well as between pulse two and three.

Type 6

The following table lists the FCC requirements set for the Type 6 waveform.

Radar Type	Pulse Width [us]	PRI [us]	Waveform duration [ms]	Pulses per hop	Hop Rate [Hz]
6	1	333	300	9	333

This waveform generates 9 consecutive pulses on one frequency. This burst is referred to as the pulses per hop. After these 9 pulses have been played a new frequency is chosen and the next 9 pulses are generated. A total of 100 frequencies are taken from a range between 5.25 GHz and 5.724 GHz. It is not permissible to reuse a frequency. The frequency changes every 3 ms. It must be ensured that at least one of the random frequencies falls into the receiver bandwidth of the DUT.

Instrument Setup

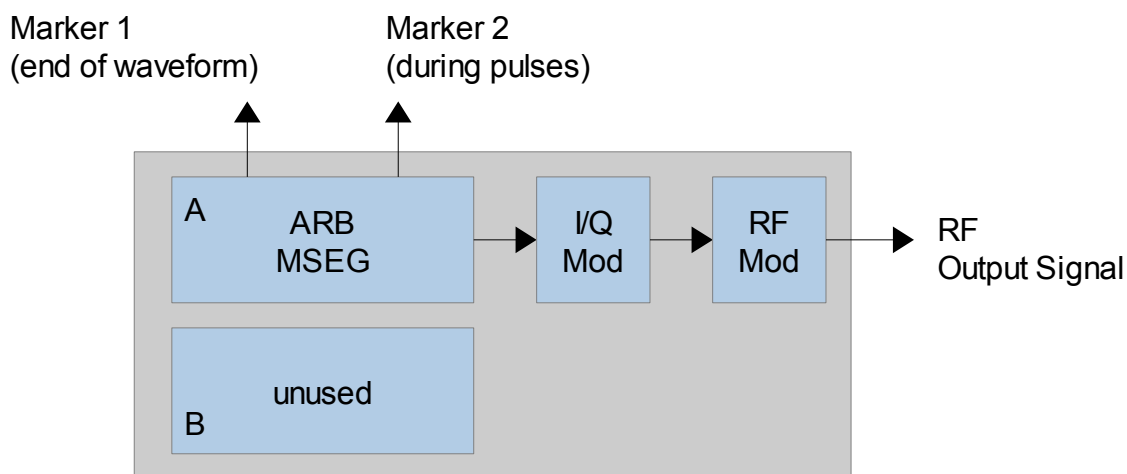
The instrument setup varies between the Type 1-4, Type 5 and Type 6 waveforms. This paragraph discusses the different setups.

Type 1 - 4

The Pulse Sequencer software creates 30 unique waveforms and assembles them to one Multi-Segment Waveform file. The build process is fully automated and the parameters used during the build process are documented in a Microsoft EXCEL spreadsheet. This spreadsheet can be used during testing and for filing purposes.

Once the Multi Segment Waveform is created the user can step through the waveforms using the instruments user interface and conduct the trials. The test itself is usually a manual process because it involves Spectrum Analyzer measurements and possibly resetting the DUT.

The following figure shows an instrument setup for the generation of the FCC Type 1 - 4 waveforms using the SMU200A Vector Signal Generator. The same setup is valid for single-path instruments, such as the SMJ100A and the SMBV100A.



The Marker 1 signal becomes active for a short period of time at the end of the last pulse. The rising edge of this signal may be used to mark the beginning point for measurements, such as the Channel Move Time.

The Marker 2 signal is active during each individual pulse and may be used to trigger a Spectrum Analyzer for the verification of the pulse train in zero span mode. Alternatively, the R&S NRP-Z3 adapter may be utilized for the triggering of a R&S NRP-Z Power Sensor.

The instrument setup is relatively simple. The ARB is configured to the Multi Segment Waveform mode and contains all the required trials as waveform segments. During the testing procedure the user selects the next segment to be played back and issues a single trigger.

In case of a two-path instrument (SMU200A) the second path is not required for these waveforms and remains unused.

Type 5

The FCC Type 5 waveform has a fixed duration of 12 seconds. The maximum chirp deviation is 20 MHz and is defined as a frequency sweep from $-f_{dev}/2$ to $+f_{dev}/2$. The maximum frequency distance to the carrier is therefore 10 MHz which requires at least 20 MHz of ARB sample rate (oversampling ratio of 2). Generating a single ARB waveform for the full 12 seconds of play time does require a total of $12 \cdot 20^6 = 240 \cdot 10^6$ samples. The use of markers further increases the memory requirement by a factor of 1.25 to a total of

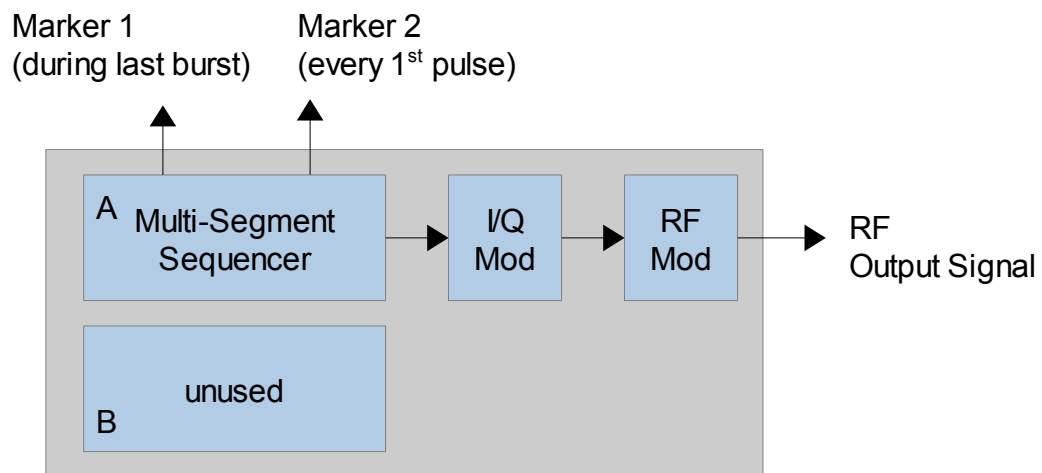
$$240 \cdot 10^6 \text{ samples} \cdot 1.25 \cdot 4 \text{ bytes/sample} = 1200 \cdot 10^6 \text{ bytes} = 1.12 \text{ Gbytes.}$$

A waveform of this size is inconvenient to handle and requires a long time to create.

The Multi-Segment waveform sequencer mode can be used to create the blank times from a short waveform and a larger repetition count. The result is a much shorter waveform scenario.

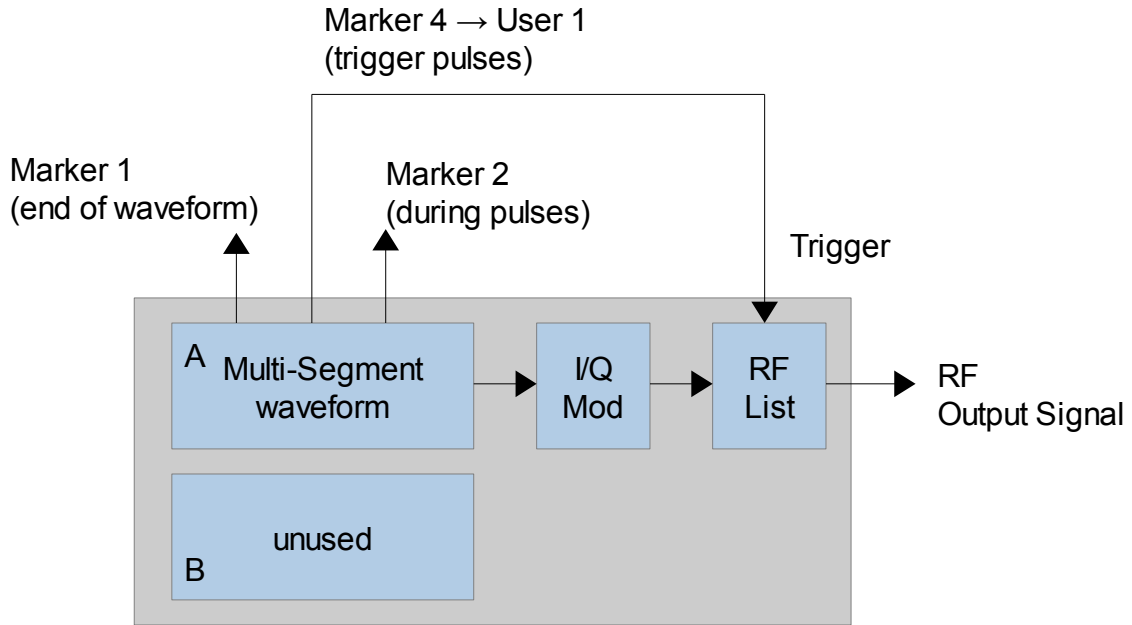
The Pulse Sequencer software automatically builds Multi-Segment waveforms including the sequencer data. This makes the creation of the Type 5 waveforms an easy task.

The following diagram shows the Type 5 configuration.



Type 6

The FCC Type 6 waveform uses a static waveform with 100 bursts in the instruments ARB. In addition, the RF list mode is operated with a list containing 100 frequencies from a randomly generated list. Each burst from the waveform file initiates a trigger pulse at the beginning that switches the RF list from one item to the next one.



The Marker signals 1 and 2 are used in the same way as in the other waveforms before. The Marker 4 signal needs to be mapped to the User 1 BNC connector and connected with the instruments trigger input (Instr. Trigger).

Mapping Configuration

Map Output Connector User 1 (BNC) To Marker 4 A

AUX I/O Connector: SMU Rear Panel

50: Not Used	44: Not Used	29-38: PARDATA 0-9
49: SYMB CLCK	43: MARKER 3 B	28: INST TRG B
48: User 2	42: MARKER 2 B	27: CW MODE
47: BIT CLK	41: MARKER 3	26: LEV ATT
46: EXT TUNE	40: User 4	1-25: GROUND
45: BURST	39: User 3	

For the external triggering of the RF list the operation mode must be set to 'Extern Step'. In addition the check box 'Blank RF Output' must be disabled to avoid the truncation of the very first pulse.

State	Off
Attenuator Mode	Normal
Mode	Extern Step
Dwell Time	10.000 ms
Current Index	0
Blank RF Output (Default ON)	<input type="checkbox"/> On

Creating the Waveforms

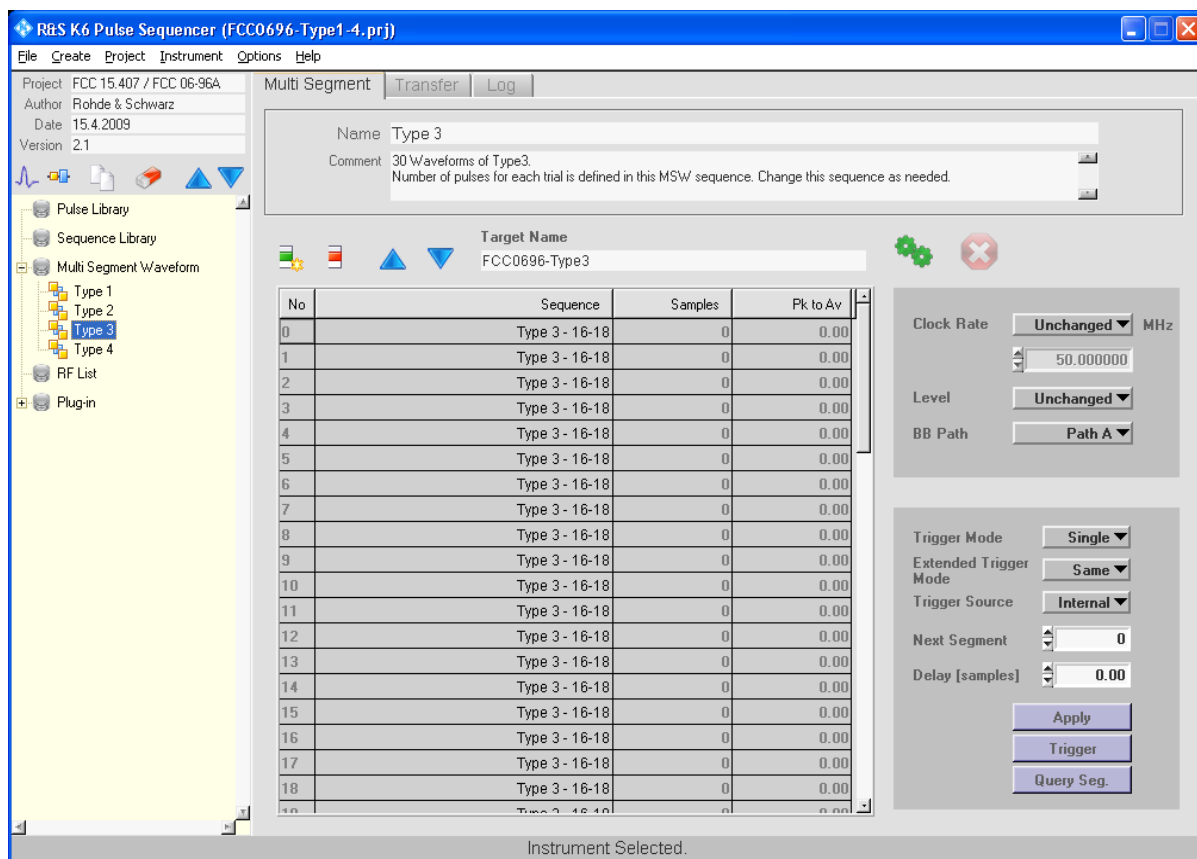
Creating the radar test waveforms is slightly different between the Type 1-4, Type 5 and Type 6 signals. This is due to the more complex nature of the Type 5 and 6 patterns. This section discusses how the radar test signals are generated using the R&S Pulse Sequencer Software.

It is advisable to create all signals before starting the manual tests. One of the main reasons for this procedure is that a series of Microsoft EXCEL spreadsheets are created that contain the waveform pulse parameters. These spreadsheets can be used during the test runs for marking passed or failed tests.

Type 1 - 4

The Type 1-4 waveforms are relatively simple to create since all required trials are contained in one single Multi Segment Waveform file.


The project tree contains the Radar Type 1 - 4 entries under the 'Multi Segment Waveform' branch. Selecting one of these Multi Segment Waveforms opens the edit- and creation panel on the right side of the applications workspace.



The Pulse Sequencer Software creates a Microsoft EXCEL report during the waveform generation. This report contains all relevant parameters that were used for the pulses and may be used for the FCC filing.

This Multi Segment Waveform is automatically created by the Pulse Sequencer Software. The creation process is the same for all instruments.

The following steps need to be executed in order to build one Multi Segment Waveform file and send it to the instrument.

1. Ensure that Microsoft EXCEL is installed on your PC
2. Start the K6 Pulse Sequencer Software
3. Setup the instrument connection
2. Load the project 'FCC0696-Type1-4.prj'
3. Select one of the Multi Segment Waveforms from the project tree
4.  Press the '**Batch Build**' button

Please Note:

The waveform creation fails if Microsoft EXCEL is not installed on the system. In this case the reporting must be deactivated or plain text file reporting be used. Details can be found in the report background information chapter in this manual.

The Multi Segment Waveforms are assembled by the instrument firmware. With the exception of the AFQ models all vector signal generators support this feature.

Depending on the instrument and waveform size the Multi Segment Waveform generation may take up to a few minutes. During this time the instrument and the Pulse Sequencer Software display a progress bar. Do not interrupt this process or execute other actions while the waveform is assembled.

Type 5

The Type 5 waveform runs for a total duration of 12 seconds and requires the Multi-Segment waveform sequencer mode. For each trial a single Multi-Segment waveform is created.

For the reporting to the Microsoft EXCEL spread sheet the Pulse Sequencer Software evaluates the trial number from the Multi-Segment waveform file name. It must therefore be ensured that a valid trial number suffix is provided as part of the file name:


FCC0696-T5-<bursts>-TRIAL-<number>

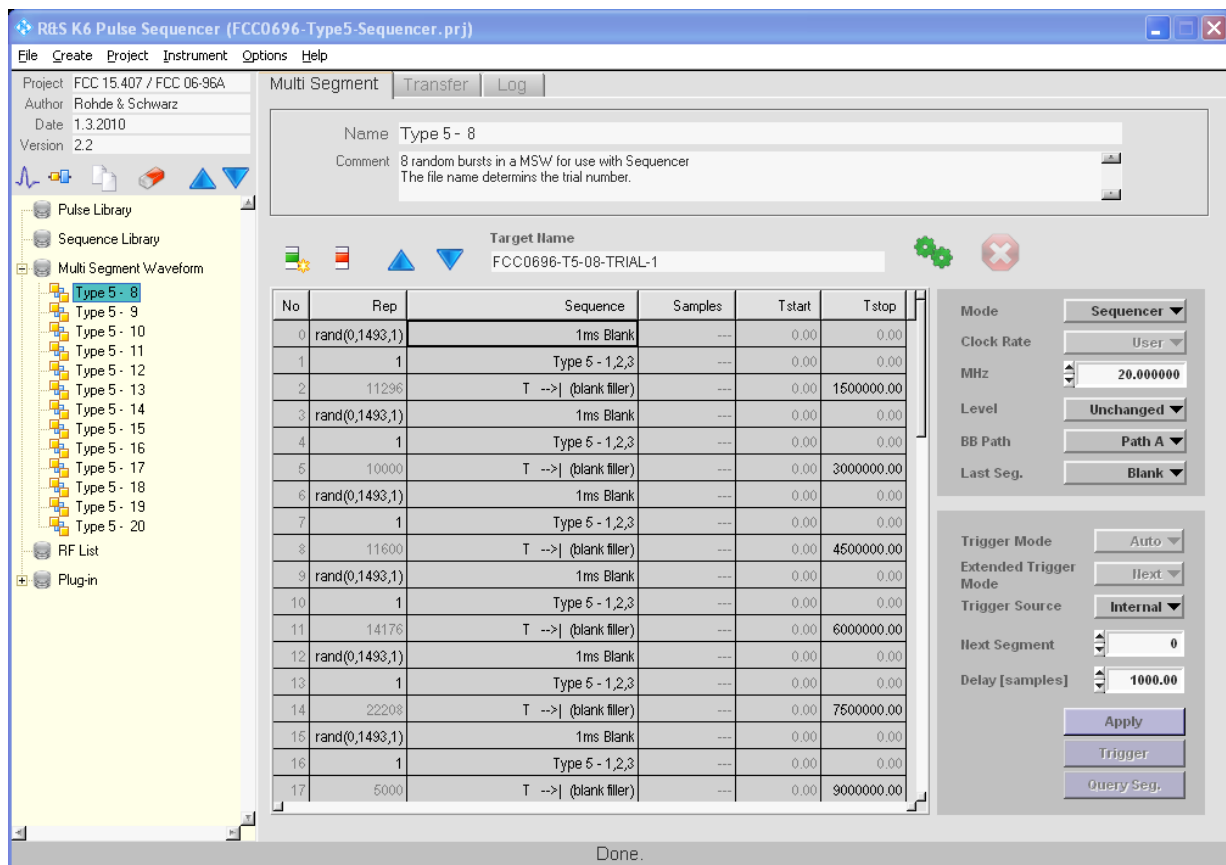
The following steps are required to load and initialize the application:

1. Ensure that Microsoft EXCEL is installed on the PC
2. Start the K& Pulse Sequencer Software
3. Load the project file 'FCC0696-Type5-Sequencer.prj'

Now, all trials can be generated from the Multi-Segment waveforms provided in the project file.

The example project contains waveform descriptions between 8 and 20 bursts. These waveforms represent the trials 1 through 13. Further trials can easily be created by copying an existing Multi-Segment waveform description and changing the trial number in the target name.

1. Select the Multi-Segment Waveform that you wish to use for the trial
2. Ensure that the correct trial suffix is used in the target name
3.  Start the build process using the 'Batch Build' button



The screenshot shows the R&S K6 Pulse Sequencer software interface. The main window displays a configuration for a Multi-Segment waveform. The 'Name' field is set to 'Type 5 - 8' and the 'Comment' field contains '8 random bursts in a MSW for use with Sequencer. The file name determines the trial number.' The 'Target Name' field is set to 'FCC0696-T5-08-TRIAL-1'. A table lists the segments of the waveform, and a control panel on the right allows for various settings like Mode, Clock Rate, MHz, Level, BB Path, Last Seg., Trigger Mode, Extended Trigger Mode, Trigger Source, Next Segment, and Delay [samples].

No	Rep	Sequence	Samples	Tstart	Tstop
0		rand(0,1493,1)	1ms Blank	0.00	0.00
1	1	Type 5 - 1,2,3		0.00	0.00
2	11296	T --> (blank filler)		0.00	1500000.00
3		rand(0,1493,1)	1ms Blank	0.00	0.00
4	1	Type 5 - 1,2,3		0.00	0.00
5	10000	T --> (blank filler)		0.00	3000000.00
6		rand(0,1493,1)	1ms Blank	0.00	0.00
7	1	Type 5 - 1,2,3		0.00	0.00
8	11600	T --> (blank filler)		0.00	4500000.00
9		rand(0,1493,1)	1ms Blank	0.00	0.00
10	1	Type 5 - 1,2,3		0.00	0.00
11	14176	T --> (blank filler)		0.00	6000000.00
12		rand(0,1493,1)	1ms Blank	0.00	0.00
13	1	Type 5 - 1,2,3		0.00	0.00
14	22208	T --> (blank filler)		0.00	7500000.00
15		rand(0,1493,1)	1ms Blank	0.00	0.00
16	1	Type 5 - 1,2,3		0.00	0.00
17	5000	T --> (blank filler)		0.00	9000000.00

Type 6

The Type 6 waveform makes use of a static pulse pattern but requires hops across a wider frequency range. The ARB implementation is not practical in such case because of the frequency range extremely high ARB clock rates will be required. This leads to very large file sizes.

Instead, a simple pulse sequence is created and synchronized with the RF List mode. This mode uses a fixed list of frequencies that are applied one after the other during waveform playback.

The Pulse Sequencer project file contains the static pulse sequence as well as frequency hopping lists.

The following steps are required to load and initialize the application:

1. Ensure that Microsoft EXCEL is installed on the PC
2. Start the K& Pulse Sequencer Software
3. Load the project file 'FCC0696-Type6.prj'


The screenshot shows the R&S K6 Pulse Sequencer software interface. The main window is titled "R&S K6 Pulse Sequencer (FCC0696-Type6.prj)". The interface includes a menu bar (File, Create, Project, Instrument, Options, Help), a toolbar, and a main workspace divided into several panels.

The left panel shows a tree view of the project structure, including "Pulse Library", "Sequence Library", and "RF List". The "Sequence Library" contains "Type 6 - 100", "Type 6 - 100 simulated", and "Multi Segment Waveform". The "RF List" contains a "Random Hop List" and a series of "NTIA List" entries from 1 to 23.

The main workspace is divided into two main sections. The top section is the "Sequence Editor" with fields for "Name" (Type 6 - 100), "Comment" (Type6, hopping. This waveform contains 100 bursts. At the very beginning of each burst the RF advances to its next entry.), and "Copyright" (Rohde & Schwarz). Below these fields is a "Waveform File" section with a file name "waveforms\FCC0696-Type6.wv".

The bottom section is a table with columns: Item, Mode, Tstart [us], Tstop [us], Samples, Pulse Object, Rep, Jitter 1, Jitter 2, Jitter 3, Jitter 4, M 1, M 2, M 3, M 4. The table contains 17 rows of data, all with "Type 6" as the Pulse Object and "9" as the Rep value. The Jitter columns are all "OFF". The M 1, M 2, M 3, and M 4 columns contain "OFF", "ALL", "OFF", and "1ST" respectively for each row.

At the bottom of the window, the text "Instrument Selected." is visible.

4. Select the 'Type 6 – 100' entry from the Sequence Library
5.  Build the waveform using the '**Build Waveform**' button
6. Send the waveform to the instrument using the Transfer panel

The waveform is static and the generation is only required once for all trials. Instead, this waveform makes use of various frequency lists that are used for the different trials.

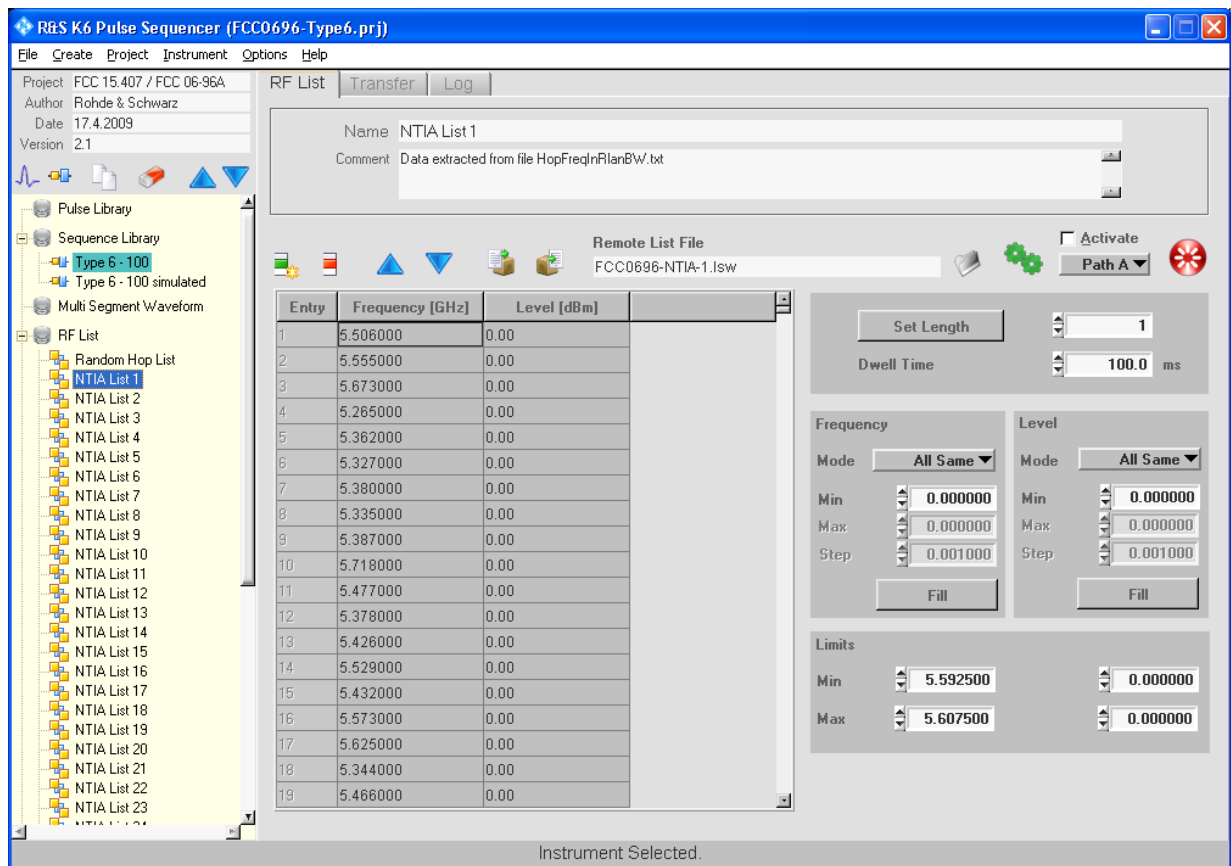
The NTIA (National Telecommunications And Information Administration) provides example RF hop lists under the following link.

<http://ntiacsd.ntia.doc.gov/dfs/>

under the file 'HopFreqInRlanBW.txt'.

The contents of these 40 lists is available as the NTIA List 1 through 40 in the FCC0696-Type6 project file. RF Hop Lists are created directly on the vector signal generator from the data that is set to it. The process of creating the list is fully automated.

1. Connect to the instrument using the Instrument Manager
2. Select one of the hopping lists from the project tree
3. Click the 'Start Transfer' button to send the list to the instrument



Please Note:

If the 'Activate' check box is disabled the Pulse Sequencer only sends the frequency list to the instrument. Before a new list is used its content needs to be 'learned' by the instrument. It is therefore advisable to send all lists to the instrument without activation and learning. During the manual testing process each list is loaded and learned before the test is executed.

Report Creation

For the filing of test results it is important that the parameters are documented that were used during the waveform generation. For this purpose the DFS projects make use of a Microsoft EXCEL reporting plugin. This plugin receives pulse parameters during the waveform generation and fills in the spread sheets.

For the Type 2,3 and 4 waveform the FCC recommends a test report of the format shown in the figure below. The report contains 30 rows that relate to the 30 trials.

Table 9: Sample Data Sheet for Radar Types 2, 3, or 4
(Use a Separate Data Sheet for Each Radar Type)

Radar Type	Trial #	Number Pulses per Burst	Pulse Width (μs)	PRI (μs)	Detection
					Yes / No
	1				
	2				
	3				
	4				
	5				
	6				

(Source: FCC 06-96A1, June 30, 2006, Table 9)

The Pulse Sequencer Software contains preconfigured Microsoft EXCEL spread sheets of the same format in the applications sub directory 'Reports'. During the signal creation these reports are populated with the pulse settings used for the waveforms.

RADAR TYPE 4				Rohde & Schwarz K6 Pulse Sequencer
Trial #	Number of Pulses per Burst	Pulse Width (μsec)	PRI (μs)	Detection (yes/no)
1	14	17.3	315	
2	14	14.9	245	
3	13	19.4	461	
4	15	14.2	277	
5	13	15.8	414	
6	15	12.2	497	
7	14	15.7	411	
8	13	11.8	494	
9	14	16.4	251	
10	16	19.1	410	
11	16	16.2	311	
12	14	19.7	296	
13	14	16.4	488	
14	12	17.5	386	
15	14	16	276	
16	12	13.6	400	
17	14	15.5	376	
18	14	15.9	249	
19	12	19	372	
20	13	16.1	226	
21	13	19.2	367	
22	13	11.1	360	
23	14	11.8	433	
24	13	17.6	397	
25	12	18.8	330	
26	14	11.2	295	
27	13	18.8	348	
28	16	18.9	436	
29	13	18.9	456	
30	16	13.6	445	

Conducting the Trials

This chapter describes how the DFS tests are executed manually. It is assumed that the waveforms, Multi Segment Waveforms, or RF hopping lists are already transferred to the instrument.

Type 1 - 4

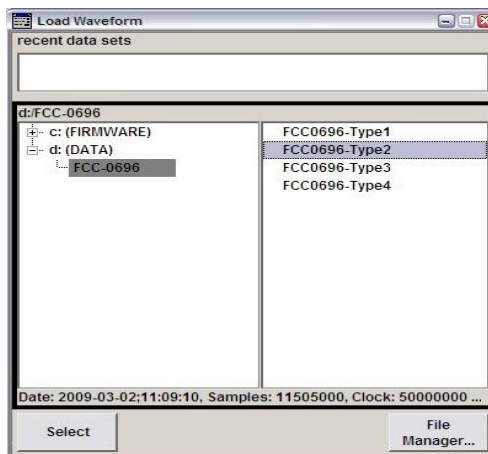
The FCC Type 1 - 4 Multi Segment Waveforms contain the required 30 random waveforms. The waveform segments do not only contain the RF signal but also provide two Marker signals that can be used for triggering or synchronization purposes. Each waveform segment contains a small initial blank period that accounts for the instruments internal processing delays of an external trigger signal. The blank period ensures that no pulse is truncated at the beginning.



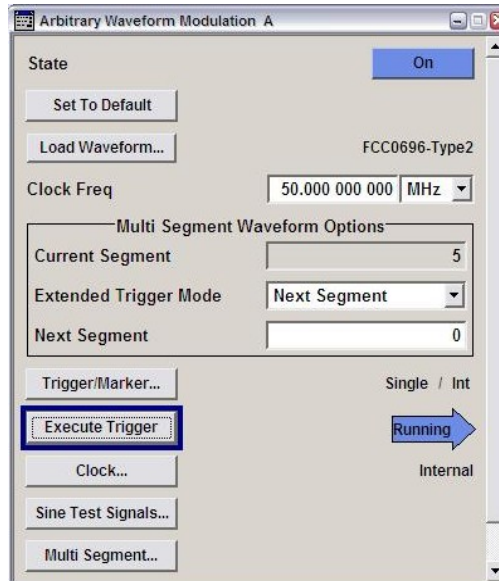
The Marker 2 signal is activated during each RF pulse and could be used for signal monitoring on an oscilloscope. There is no time delay between the Marker output and the RF signal. The Marker 1 signal is activated at the end of the last pulse until the end of the entire segment is reached. The rising edge of this signal marks the start of the measurement period for the DFS waveform detection.

The following steps are required for the manual testing with the Type 1 - 4 waveforms.

1. Turn off the RF state and configure frequency and level
2. Load the desired Multi Segment Waveform into the instruments ARB



2. Configure the ARB mode to
 - Single / Internal Trigger
 - Next Segment
3. Turn the ARB state on



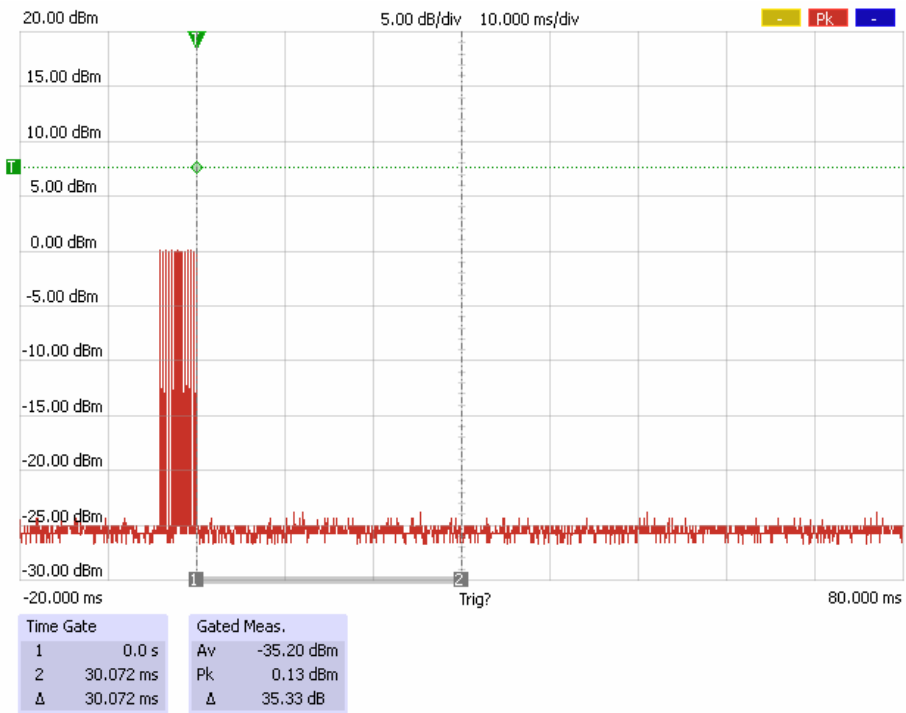
3. Now, activate the RF output
4. Go back to the ARB panel

The instrument is now configured for the manual testing with the 30 waveforms (trials). Each time the 'Execute Trigger' button is pressed the instrument plays back the selected segment a single time.

	Current	Trial / waveform segment played
	0	
(Execute Trigger)	0	1
(Execute Trigger)	1	2
(Execute Trigger)	2	3

The instrument initializes with a current segment number of zero. When the 'Execute Trigger' button is pressed for the very first time the first segment is played once and the value remains at zero. This is because the 'Current Segment' indicator show what segment has been generated!

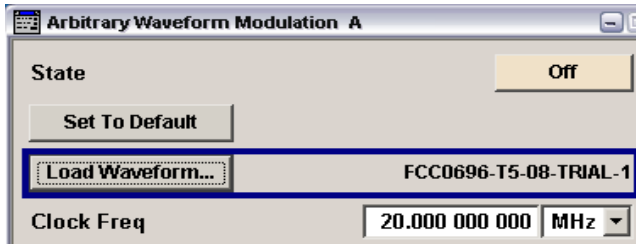
The screen shot below shows a Type 4 waveform. The Marker 1 signal from the Vector Signal Generator is as external trigger for the NRP-Z81 sensor (via the NRP-Z3 interface). The pre-trigger is configured to a value -20 ms which allows to see the RF burst and 80 ms after the burst.



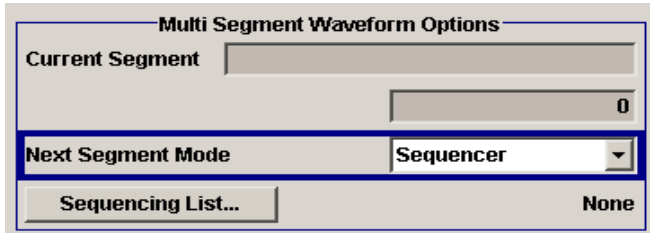
Type 5

The Type 5 waveform plays for a total duration of 12 seconds. During this time a number of eight to 20 chirped bursts are generated.

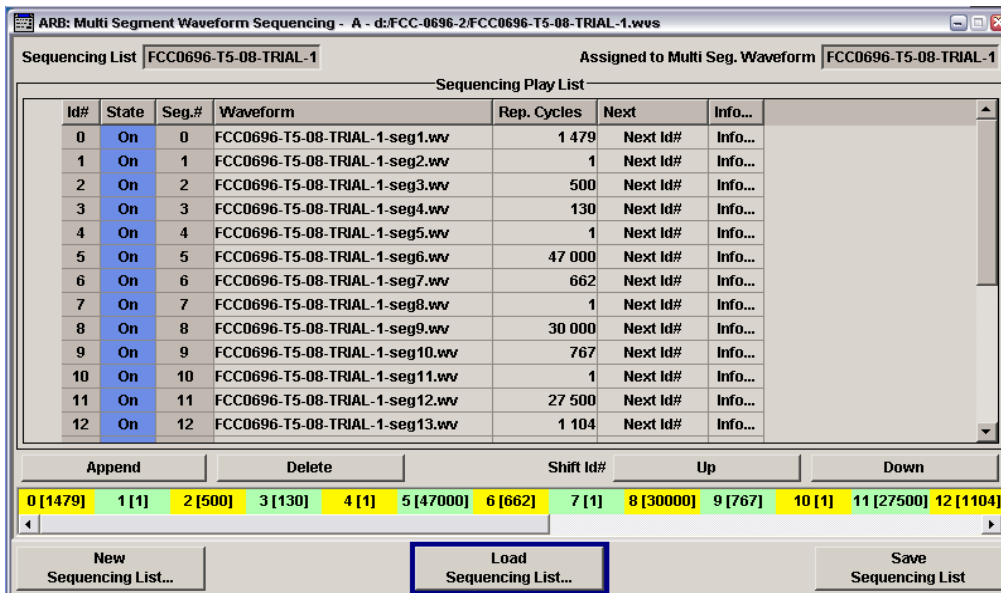
1. Load the Multi-Segment Waveform into the ARB



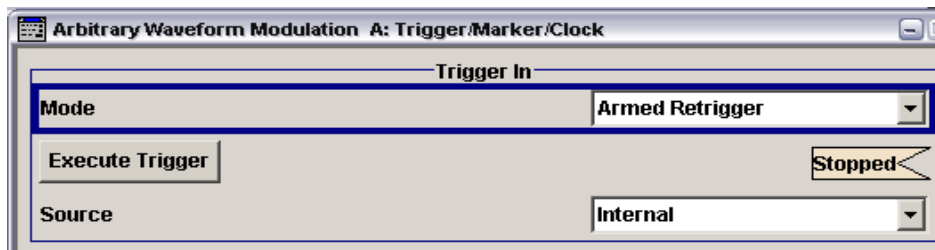
2. Set the 'Next Segment Mode' to 'Sequencer'



3. Click 'Sequencing List...' and then load the list that matches the Multi-Segment waveform



- Click 'Trigger/Marker...' and set the trigger mode to 'Armed Retrigger' and 'Internal'



- Turn the ARB state on
- The waveform playback can now be started by pressing the 'Execute Trigger' button



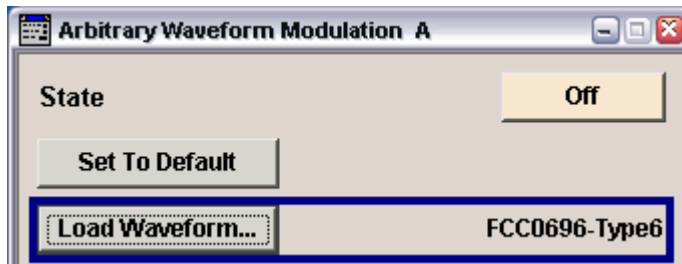
For further trials it is not required to repeat all of the above steps. Usually it is sufficient to reload the Multi-Segment waveform along with the sequencer list.

- Turn the RF signal and ARB OFF
- Load a new Multi Segment Waveform
- Load the correct sequencing list
- Turn the ARB state and the RF signal ON
- Press 'Execute Trigger'

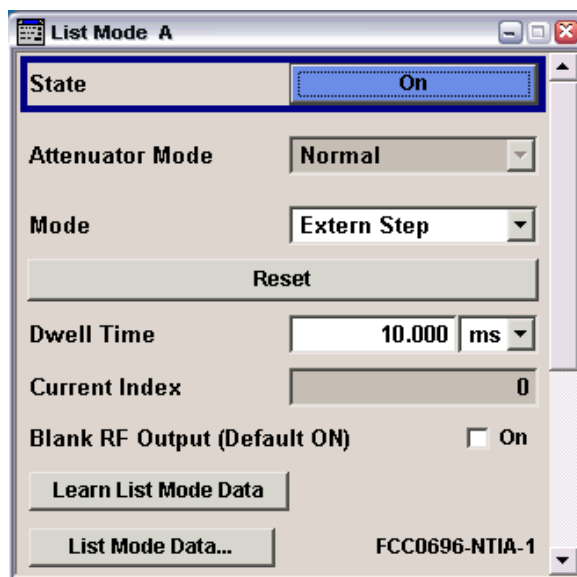
Type 6

The Type 6 waveform is a static pattern of 100 bursts. Each burst consists of a series of nine pulses and is generated at a different frequency. The Pulse Sequencer uses a combination of a fixed waveform and an RF list.

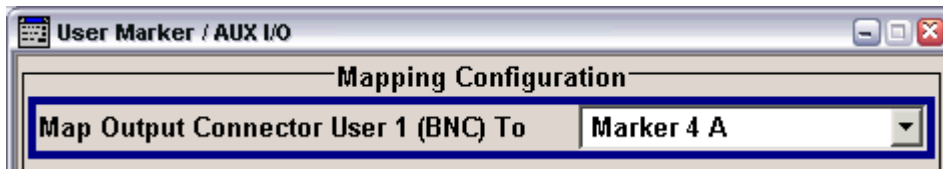
1. Load the FCC0696-Type6 waveform file into the ARB (path A)



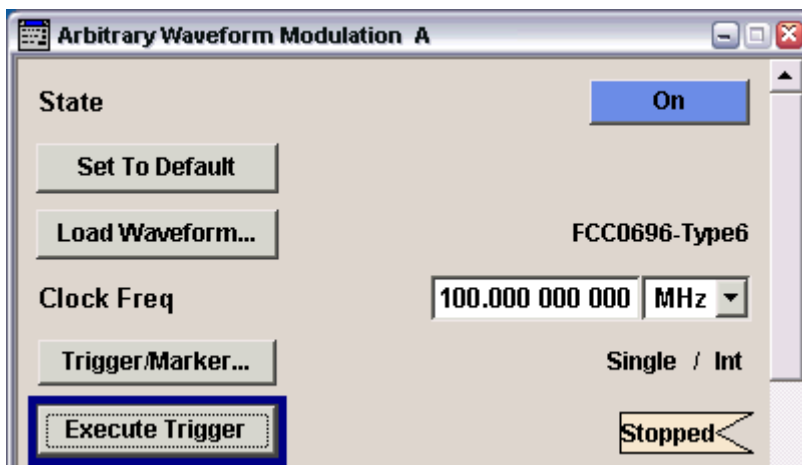
2. Setup the trigger mode to 'Single' and the trigger source to 'Internal'
3. Open the 'Automatic Level Control' dialog from the instruments RF section and enable the 'Protect RF Output' option
4. Open the 'List Mode' dialog from the instruments RF section
5. Disable the 'Blank RF Output' check box
6. Activate the RF signal output (this is important for the following learning process)
7. Select the RF list for the first trial using the 'List Mode Data' button
8. Click the 'Learn List Mode Data'
9. Set the list mode to 'Extern Step'
10. Turn the List Mode state On



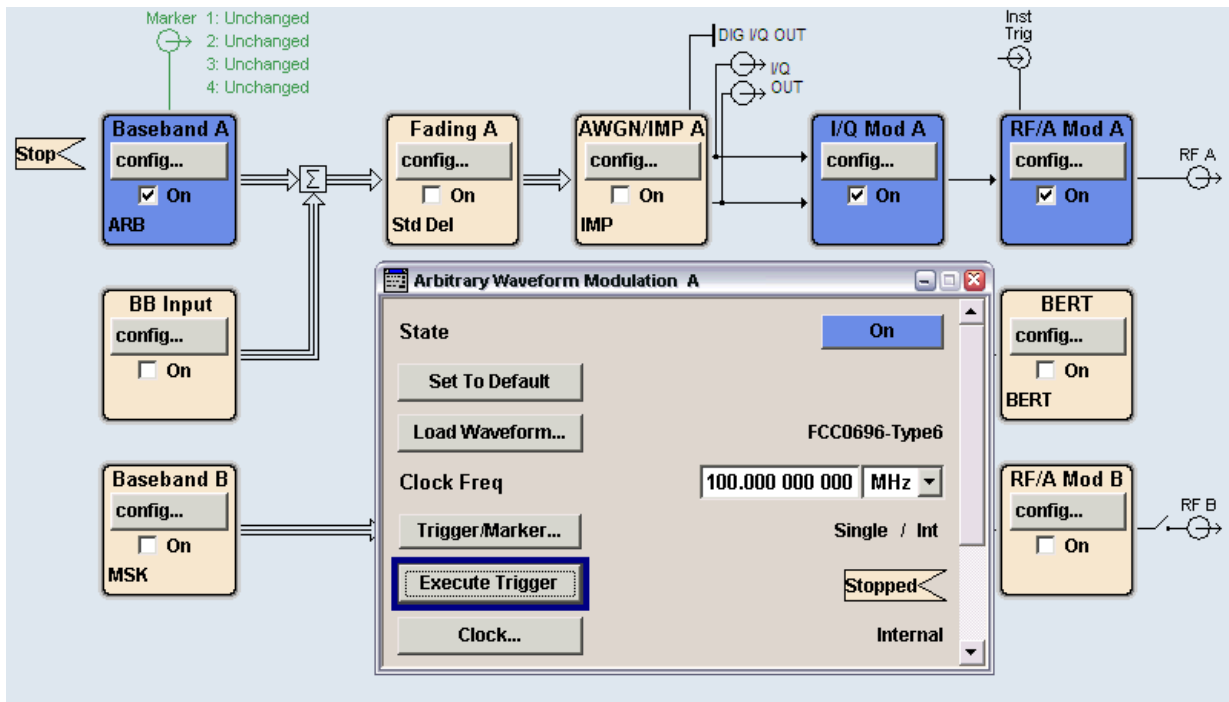
11. In the ARB panel click the 'Trigger/Marker' button and then the 'User Marker / AUX I/O Settings' button.
12. Route the Marker 4A signal to the User 1 BNC connector



13. Activate the ARB generator by setting its state to On
14. The instrument is now configured for the generation of the hopping sequence. Ensure that the User 1 signal (BNC) is connected to the 'Instr. Trigger' BNC.
15. The sequence can be started by pressing the 'Execute Trigger' button



The screen shot below shows the overall setup of the instrument.



Reloading a new RF list for the next trial requires the following steps:

1. Leave RF state switched on
2. Turn List Mode state off
3. Load new RF list file
4. Learn the RF list
5. Turn the List Mode state on
6. Execute the ARB trigger again

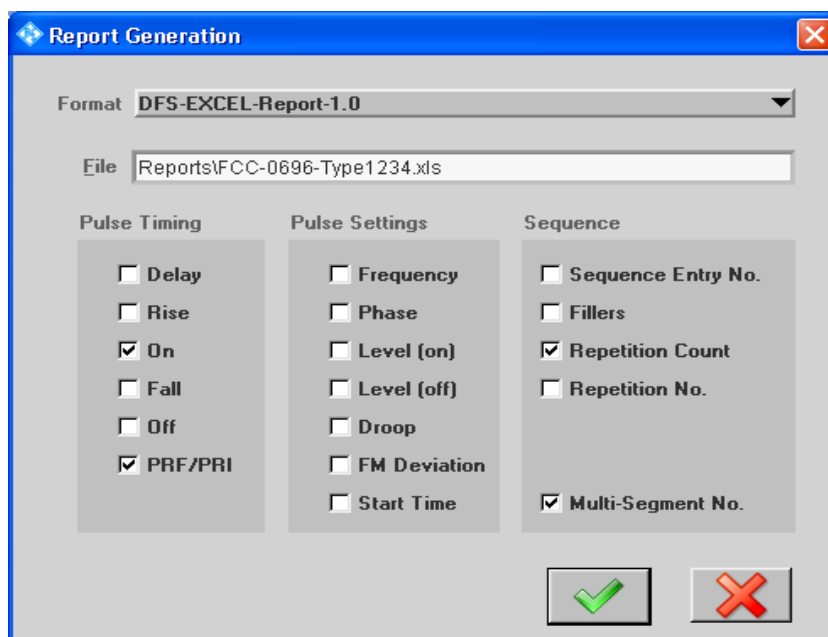
The list learning must be done with the RF signal enabled and the baseband properly setup. This is required because the instrument performs internal measurement during the learning sequence. The learned values are only valid for the set frequency, level and baseband mode. Changing one of these parameters makes the learned values invalid.

Report Generation Background

The Pulse Sequencer software can create two types of report information. The simplest type is plain ASCII text output where data is appended to a file. All data is organized in columns and a header explains the meaning of each column.

Segment	Pulses	On	PRF/PRI
1	23	2.400	200.000
2	27	2.900	210.000
3	29	2.600	210.000
4	24	1.900	217.000

The amount of information that is written to the report is defined in the sequences that are used in the Multi-Segment waveform files. In order to display these sequences it is required to disable the 'Hide Tree Items' entry in the main menu. Now one of the Type 1 - 4 sequences can be selected and the sequence editor panel becomes visible. The top right area of this editor contains the 'Report...' button that opens the 'Report Generation' dialog.



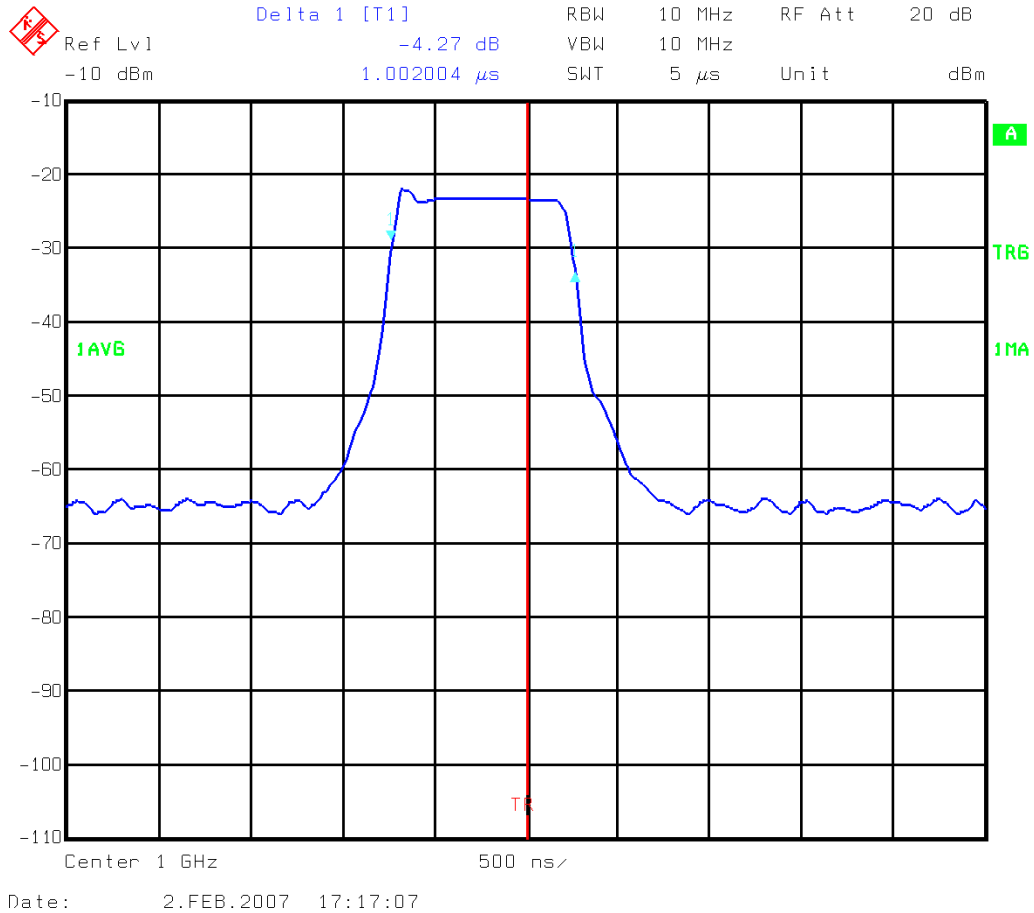
In addition the 'Comment' field in the sequence editor contains a tag in curly brackets that is evaluated by the report generation plug-in. For the FCC Type 2 test waveform this tag is as follows.

{REPORT PLUGIN: FCC-T2}

The tag is used to let the plug-in choose the correct EXCEL spread sheet page to fill in its report data.

FCC 0696 Type 1 – Single pulse with trigger

- Use the waveform from above
- Set SPA to average and measure last pulse only
- Pulse on time is 1 us



Equipment:

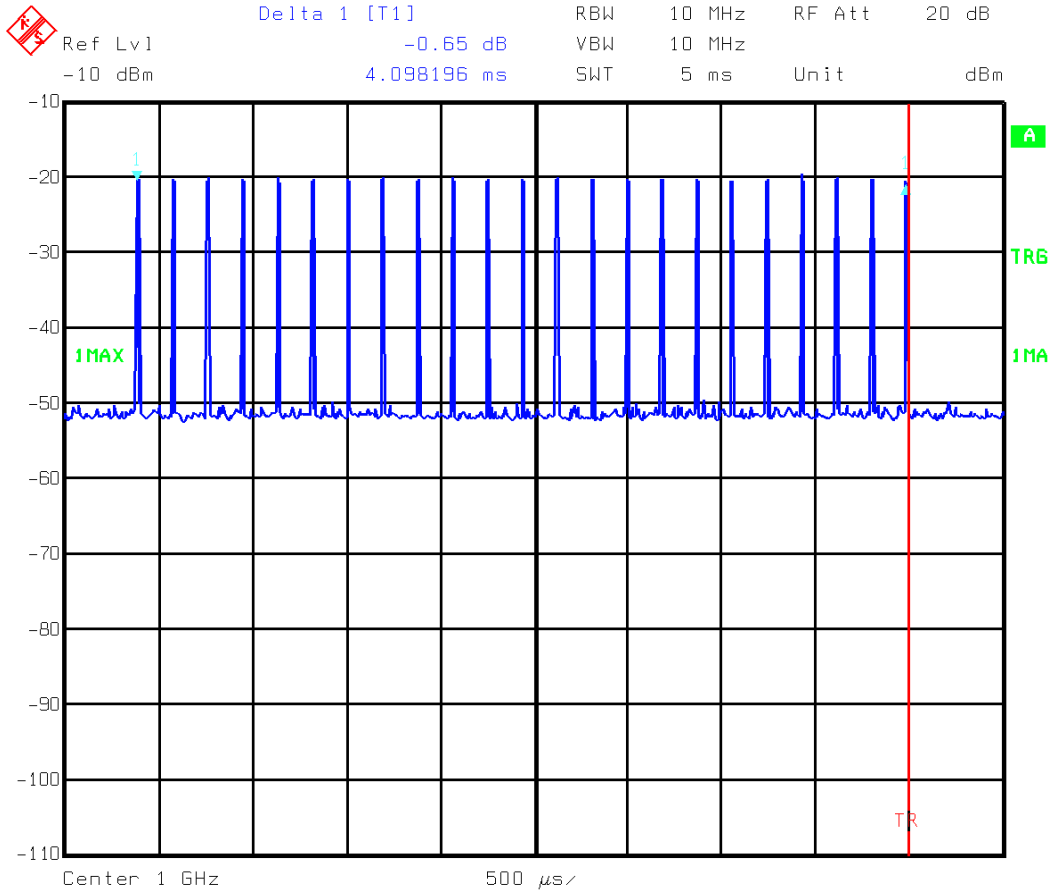
SPA Type: FSEB30
 Generator: SMU200A

FCC 0696 Type 2 – one entire burst

- Unlock Project Tree
- Create Sequence 'Radar Type 2 - 23'
- Get log file 'c:\fcc-type2.txt'
- Transfer to Instrument
- Set SPA to max hold
- 23 pulses, trigger on last pulse, total time $22 \times 186 \text{ us} = 4.092 \text{ ms}$ (186 us PRF from log file)

Type 2 features random parameters and thus, it is required to keep log file information to verify the correctness of the generated signal.

Segment	Pulses	On	PRF/PRI				
1	23	1.800	186.000				
			Delta 1 [T1]	RBW	10 MHz	RF Att	20 dB
			-0.65 dB	VBW	10 MHz		
			4.098196 ms	SWT	5 ms	Unit	dBm



Date: 2.FEB.2007 17:32:10

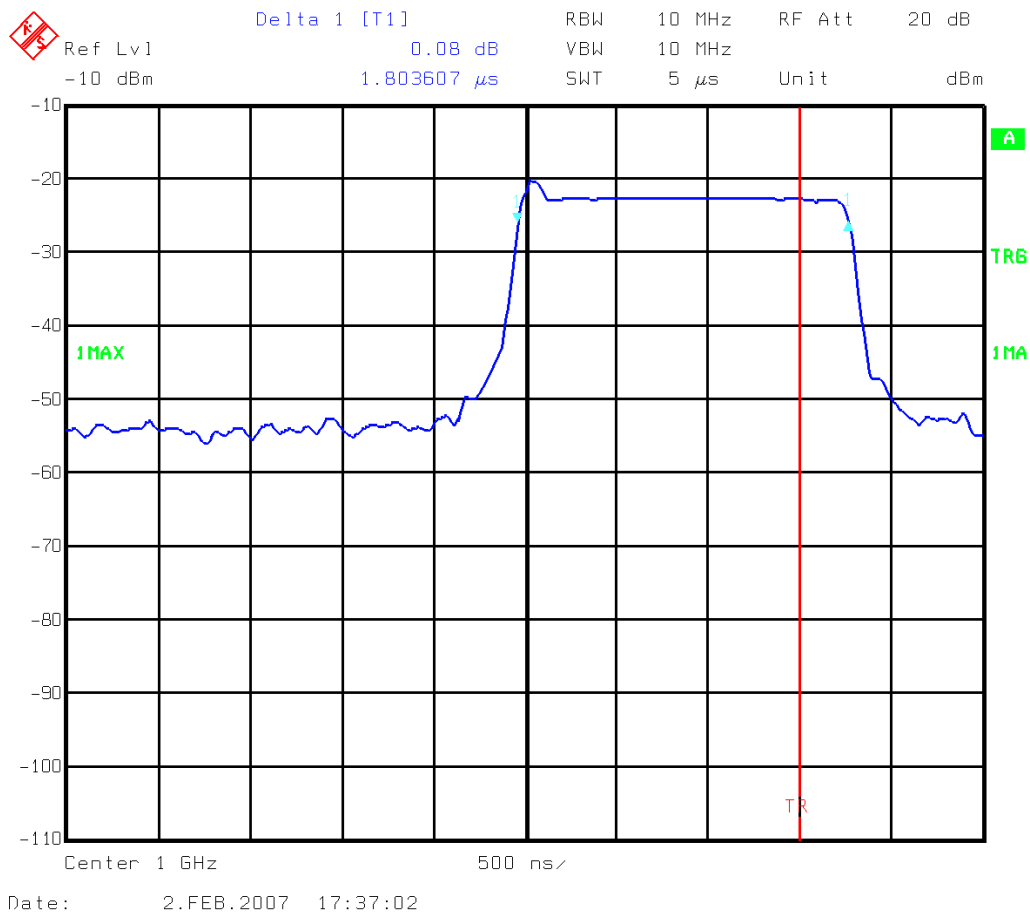
The total time (delta marker) between the first and last pulse is $22 \times 186 \text{ us} = 4.09 \text{ ms}$.

FCC 0696 Type 2 – Single pulse with trigger

- Measure last pulse
- Pulse on time is 1.8 us (from log file)

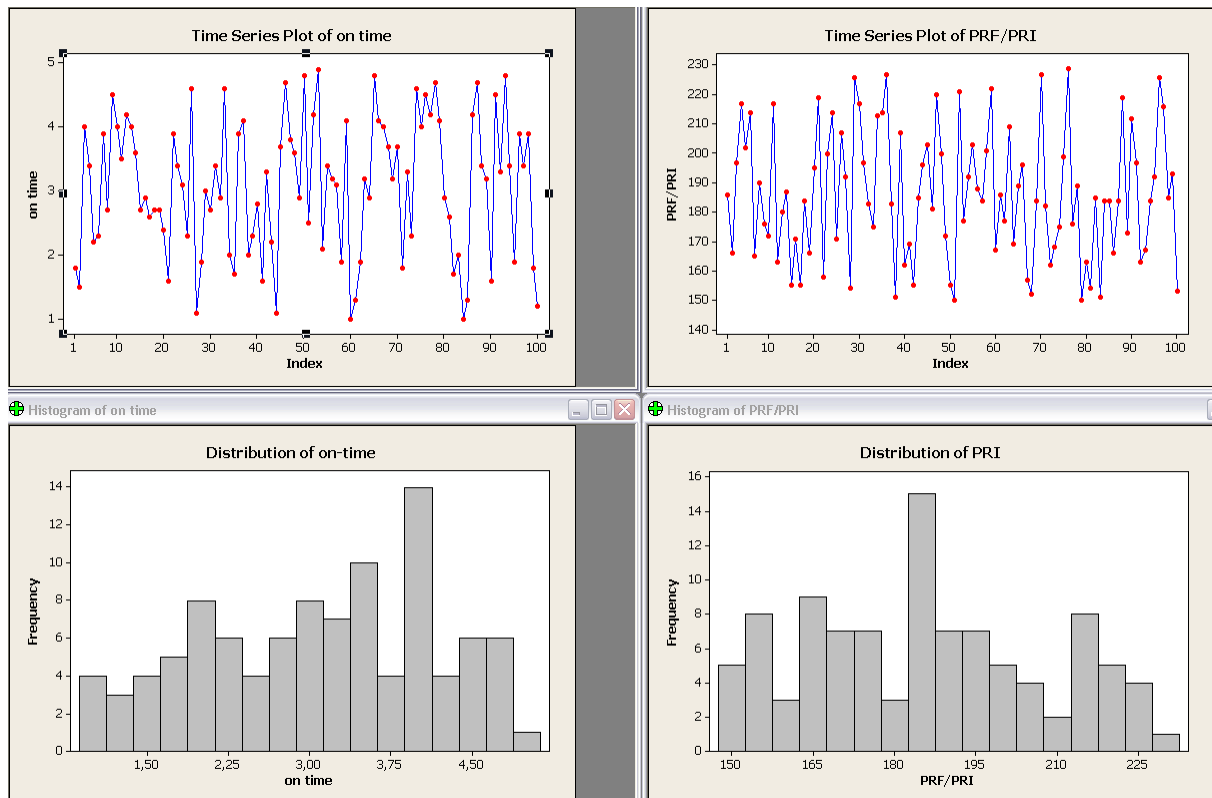
Type 2 features random parameters and thus, it is required to keep log file information to verify the correctness of the generated signal.

Segment	Pulses	On	PRF/PRI
1	23	1.800	186.000



FCC 0696 Type 2 – Random variations for PRI and pulse width

The screen shots below show the time series plot and distribution caused by jitter and used for pulse width and PRI in a type 2 waveform. Data is taken from 100 waveforms.

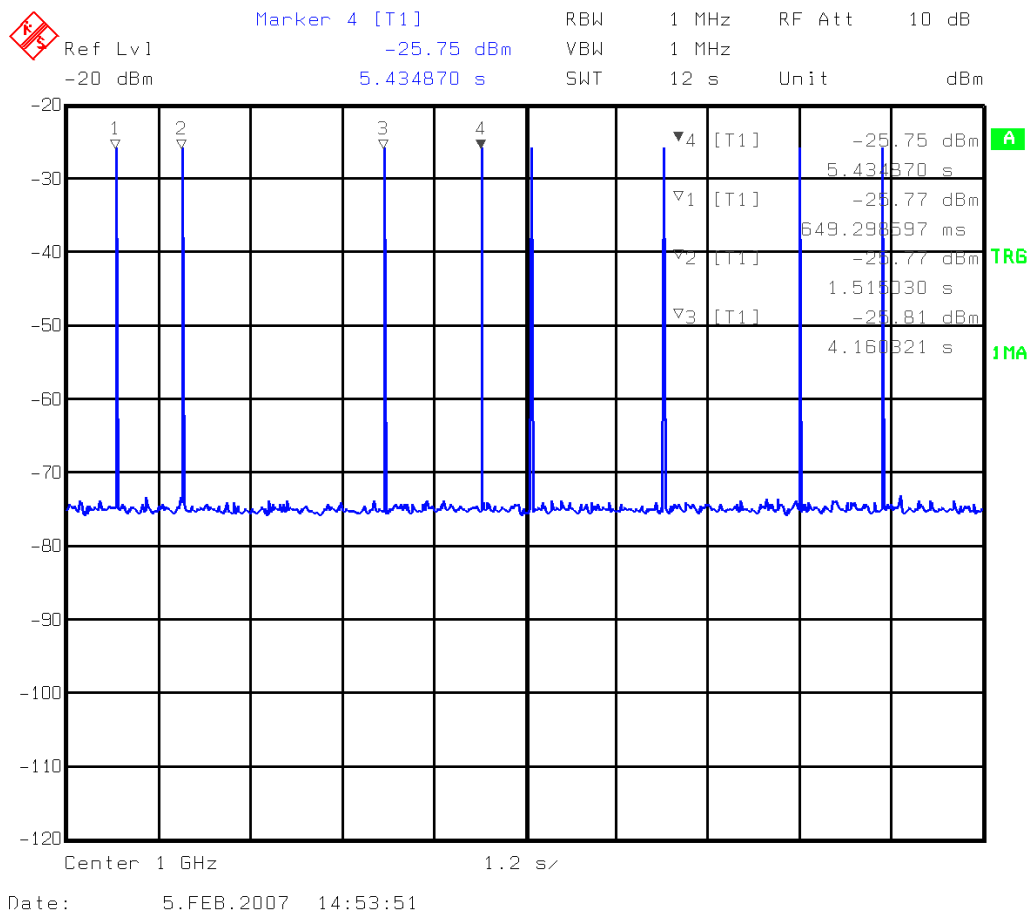


FCC 0696 Type 5 – Burst starting time

Type 5 waveforms require a multi segment waveform that contains the actual signal part and a trigger waveform that defines the starting points. This test verifies the trigger events generated by the trigger waveform and the correct playback of the multi segment waveform.

Pulse	Delay	Tstart
1	654000.000	654000.000 (M1)
2	19000.000	1519000.000 (M2)
3	1171000.000	4171000.000 (M3)
4	944000.000	5444000.000 (M4)
5	91000.000	6091000.000
6	304000.000	7804000.000
7	593000.000	9593000.000
8	167000.000	10667000.000
1	0.000	12000000.000

Each pulse seen on the spectrum analyzer screen shot is in fact one burst from the multi segment waveform.



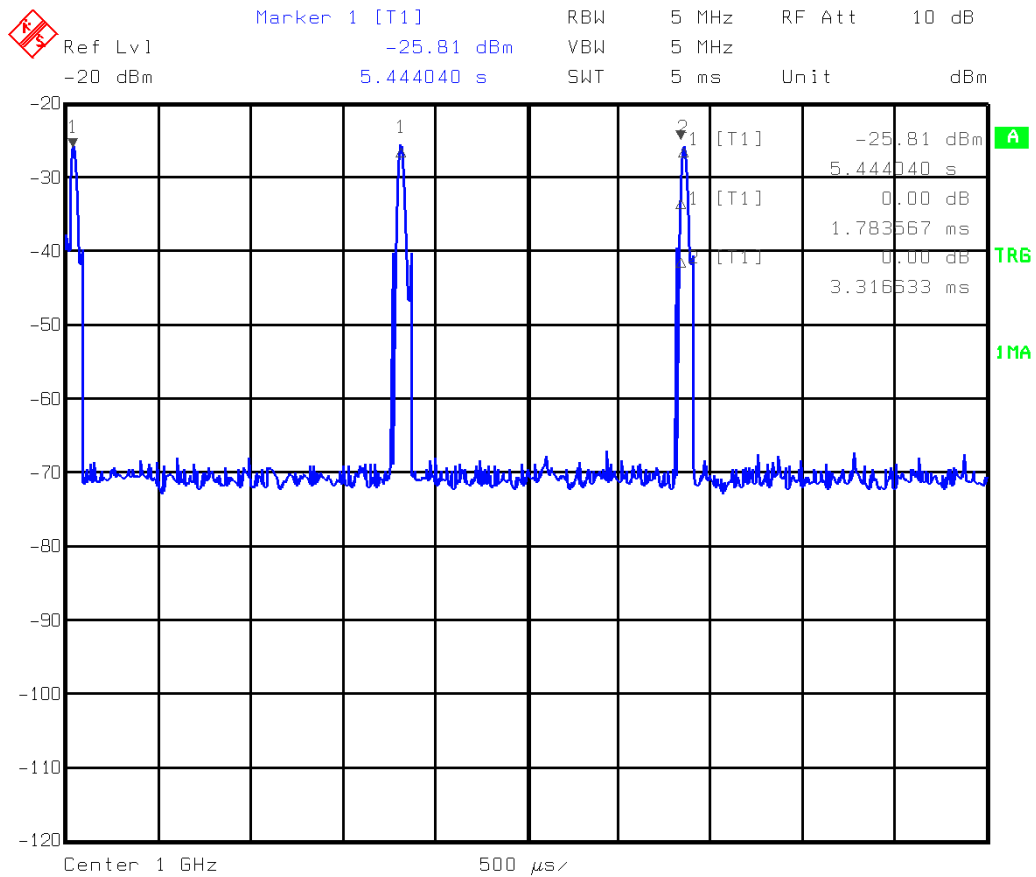
FCC 0696 Type 5 – Pulse spacing

This test verifies the spacing between pulses within the type 5 burst.

Segment	Pulses	On	PRF/PRI	Dev	Start Time
1	1	69.700	1203.000	10.000	654000.000
2	1	64.800	1426.000	14.000	1519000.000
3	2	83.900	1941.000	11.000	4171000.000
3	2	83.900	1722.000	11.000	
4	3	97.900	1776.000	16.000	5444000.000
4	3	97.900	1534.000	16.000	
4	3	97.900	1677.000	16.000	
5	2	73.800	1090.000	18.000	
5	2	73.800	1568.000	18.000	
6	2	52.300	1057.000	12.000	
6	2	52.300	1041.000	12.000	
7	1	96.900	1285.000	17.000	
8	3	75.400	1630.000	14.000	
8	3	75.400	1884.000	14.000	
8	3	75.400	1630.000	14.000	

Pulse Spacing 1-2 = 1.78 us

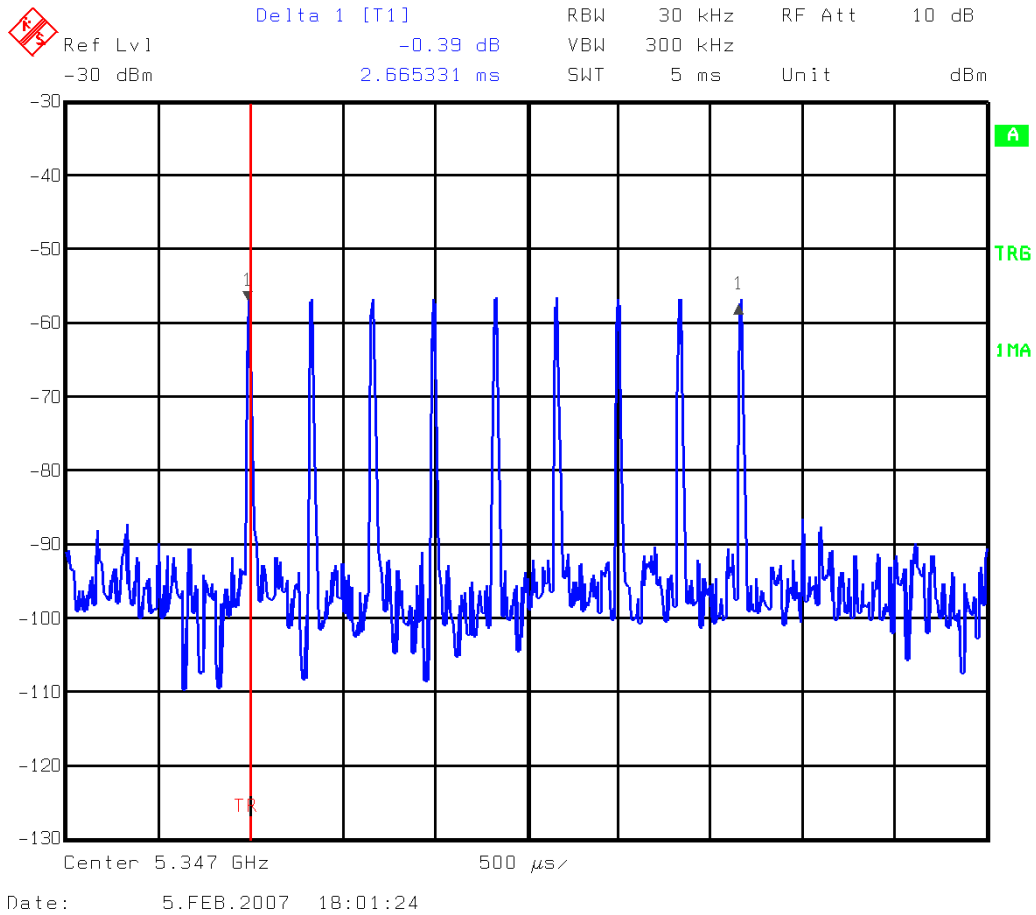
Pulse Spacing 2-3 = 1.78 + 1.53 = 3.31 us



Date: 5.FEB.2007 15:04:41

FCC 0696 Type 6 – One single burst

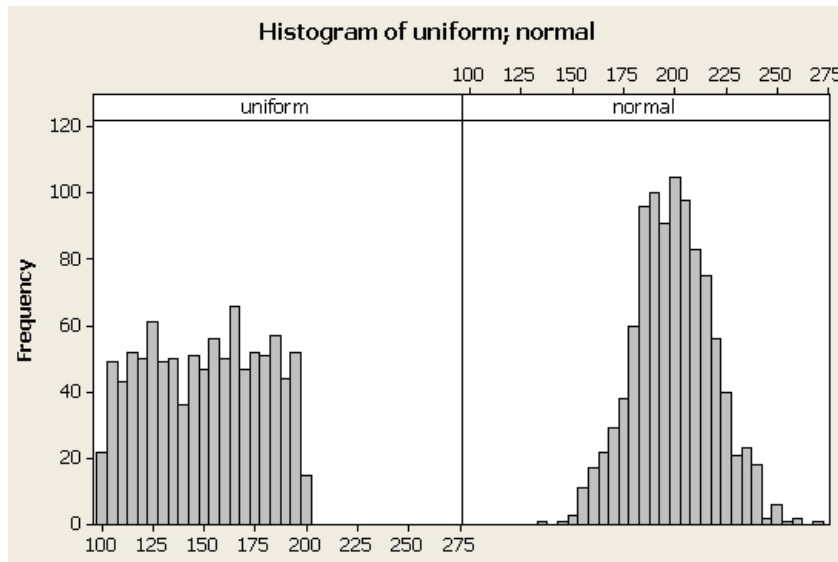
The screen shot shows one burst containing 9 pulses as generated in the type 6 hopping waveform. The spectrum analyzer is tuned to one entry of the RF list and video triggered.



Marker 1 measures the time between the very first and very last pulse as $8 \times 333 \text{ us} = 2.664 \text{ us}$. The first and the last pulse appear at the same amplitude.

Jitter Statistics

This test compares 1000 jittered values with uniform distribution between 100 and 200 and normal distribution centred around 200.



The probability plot of the (normally distributed) data of 1000 points with the mean value set to 200 and standard deviation set to 20 shows that all data fits a normal distribution.

