

Kupní smlouva

(dále jen „**Smlouva**“) uzavřená v souladu s ustanovením § 2079 a násl. zákona č. 89/2012 Sb., občanský zákoník (dále jen „**OZ**“)

1. **SMLUVNÍ STRANY**

1.1 **Fyzikální ústav AV ČR, v. v. i.,**

se sídlem: Na Slovance 1999/2, 182 21 Praha 8,
jednající: RNDr. Michael Prouza, Ph.D., ředitel,
zapsaný v rejstříku veřejných výzkumných institucí Ministerstva školství, mládeže a tělovýchovy České republiky.

Bankovní spojení: [REDACTED]
Číslo účtu: [REDACTED]
IČO: 68378271
DIČ: CZ68378271

(dále jen „**Kupující**“)

a

1.2 **T & M Direct, s.r.o.,**

se sídlem: Jaselská 308/1, 160 00 Praha 6,
jednající: Ing. Václav Haasz, jednatel,
zapsaná v rejstříku vedeném Městským soudem v Praze, oddíl C, vložka 37436.

Bankovní spojení: [REDACTED]
Číslo účtu: [REDACTED]
IČO: 63667100
DIČ: CZ63667100

(dále jen „**Prodávající**“),

(dále společně jen „**Smluvní strany**“ nebo každý z nich samostatně jen „**Smluvní strana**“).

2. ZÁKLADNÍ USTANOVENÍ

- 2.1 Kupující je veřejná výzkumná instituce, jejíž hlavní činností je vědecký výzkum v oblasti fyziky, zejména fyziky elementárních částic, kondenzovaných systémů, plazmatu a optiky.
- 2.2 Kupující pořizuje předmět plnění (**generátor libovolně tvarovaných pulzů**) pro účely časově rozlišené spektroskopie ve spojení s UHV kryogenními mikroskopy s rastrovací sondou.
- 2.3 Prodávající je vybraným dodavatelem zadávacího řízení vyhlášeného Kupujícím dle zákona č. 134/2016 Sb., o zadávání veřejných zakázek, v platném znění, pod názvem „**Generátor libovolně tvarovaných pulzů**“ (dále jen „**Zadávací řízení**“) na dodání předmětu plnění dle Smlouvy.
- 2.4 Výchozími podklady pro dodání předmětu plnění dle Smlouvy jsou
- 2.4.1 **Technické specifikace předmětu plnění jako Příloha č. 1**
- 2.4.2 Nabídka Prodávajícího podaná v rámci Zadávacího řízení v rozsahu té části, která předmět plnění technicky popisuje (dále jen „**Nabídka**“) jako **Příloha č. 2**.
- V případě kolize Příloh Smlouvy má přednost technický požadavek vyšší úrovně a jakosti.
- 2.5 Prodávající prohlašuje, že disponuje veškerými odbornými předpoklady potřebnými pro dodání předmětu plnění, k činnosti dle Smlouvy je oprávněn a na jeho straně neexistují žádné překážky, které by mu bránily předmět plnění dle Smlouvy dodat.
- 2.6 Prodávající je ve smyslu ustanovení § 5 odst. 1 OZ schopen při plnění této Smlouvy jednat se znalostí a pečlivostí, která je s jeho povoláním nebo stavem spojena, s tím, že případné jeho jednání bez této odborné péče půjde k jeho tíži. Prodávající nesmí svou kvalitu odborníka ani své hospodářské postavení zneužít k vytváření nebo k využití závislosti slabší strany a k dosažení zřejmé a nedůvodné nerovnováhy ve vzájemných právech a povinnostech Smluvních stran.
- 2.7 Prodávající bere na vědomí, že Kupující není ve vztahu k předmětu této Smlouvy podnikatelem, a ani se předmět této Smlouvy netýká podnikatelské činnosti Kupujícího.
- 2.8 Prodávající bere na vědomí, že dodání předmětu plnění ve stanovené době a kvalitě, jak vyplývá z Příloh č. 1 a 2 Smlouvy (včetně předání a vyúčtování), je pro Kupujícího zásadní. V případě, že Prodávající nesplní smluvní požadavky, může Kupujícímu vzniknout škoda.
- 2.9 Prodávající prohlašuje, že přejímá na sebe nebezpečí změny okolností ve smyslu ustanovení § 1765 odst. 2 OZ.
- 2.10 Smluvní strany prohlašují, že zachovají mlčenlivost o skutečnostech, které se dozvědí v souvislosti s touto Smlouvou a při jejím plnění a jejichž vyzrazení by jim mohlo způsobit újmu. Tímto nejsou dotčeny povinnosti Kupujícího vyplývající z právních předpisů.

3. PŘEDMĚT SMLOUVY

- 3.1 Předmětem této Smlouvy je závazek Prodávajícího předat Kupujícímu a převést na Kupujícího vlastnické právo ke

generátoru libovolně tvarovaných pulzů

specifikovaným v přílohách č. 1 a 2 této Smlouvy (dále jen „Zboží“) a Kupující se zavazuje Zboží převzít a zaplatit Prodávajícímu za Zboží sjednanou cenu.

3.2 Součástí plnění je:

3.2.1 doprava Zboží dle Příloh č. 1 a 2 této Smlouvy do místa plnění, jeho vybalení a kontrola,

3.2.2 provedení zkoušky Zboží za účelem ověření jeho funkčnosti – tj.

a. propojení generátoru do obvodu s experimentem,

b. demonstrace funkcí systému, generování nejkratších možných pulzů a kontinuálních vln o maximální frekvenci,

c. charakterizace přenosové charakteristiky obvodu pomocí dodané sondy.

3.2.3 dodání instrukcí a návodů k obsluze a údržbě Zboží v českém nebo anglickém jazyce Kupujícímu, a to v elektronické nebo tištěné podobě,

3.2.4 zaškolení obsluhy – minimálně 3 pracovníků Kupujícího po souhrnnou dobu alespoň 4 hodin,

3.2.5 záruční servis a

3.2.6 zajištění technické podpory.

3.3 Prodávající odpovídá za to, že Zboží bude v souladu s touto Smlouvou včetně Příloh, platnými technickými a kvalitativními normami, a že jej Kupující bude moci užívat k danému účelu. V případě kolize norem platí vždy norma nebo ta její část, v níž jsou stanovena přísnější kritéria.

3.4 Dodané Zboží a všechny jeho součásti musí být nové, nepoužité.

4. DOBA PLNĚNÍ

4.1 Prodávající se zavazuje Zboží řádně předat po předchozí instalaci nejpozději do 21. 12. 2018.

4.2 Doba plnění se prodlužuje o dobu, po kterou Prodávající nemohl plnit z důvodů překážek na straně Kupujícího.

4.3 Prodávající bere na vědomí, že Kupující platí kupní cenu z veřejné podpory s možností jejího čerpání a vyúčtování do 31. 12. 2018; z tohoto důvodu nemá zájem na plnění této Smlouvy, které nelze vyúčtovat do 31. 12. 2018.

5. KUPNÍ CENA, FAKTURACE, PLACENÍ

5.1 Celková kupní cena vychází z Nabídky a činí **130.347,10 EUR** (slovy: stotřicettisíc třistačtyřicet sedm Euro deset centů) bez daně z přidané hodnoty (dále jen „Kupní Cena“). Daň z přidané hodnoty vypořádají Smluvní strany dle platných českých právních předpisů.

- 5.2 Kupní Cena zahrnuje veškeré plnění Prodávajícího směřující ke splnění požadavků Kupujícího na řádné dodání Zboží dle této Smlouvy, včetně veškerých poplatků, cla, pojištění a nákladů na dopravu.
- 5.3 Kupní Cenu je Prodávající oprávněn fakturovat po řádném předání a převzetí Zboží dle odst. 9.4 Smlouvy.
- 5.4 Daňové doklady – faktury vystavené Prodávajícím na základě této Smlouvy musí obsahovat všechny náležitosti stanovené zákonem č. 235/2004 Sb., o dani z přidané hodnoty, v platném znění a číslo této Smlouvy.
- 5.5 Kupující preferuje elektronickou fakturaci na elektronickou adresu efaktury@fzu.cz. Vystavené daňové doklady nesmí být v rozporu s mezinárodními dohodami o zamezení dvojího zdanění, budou-li se na konkrétní případ vztahovat.
- 5.6 Lhůta splatnosti daňových dokladů je třicet (30) dnů od data jejich doručení Kupujícímu (dále jen „**Lhůta splatnosti**“). Zaplacením účtované částky se rozumí den jejího odeslání na účet Prodávajícího.
- 5.7 Pokud daňový doklad (faktura) nebude vystaven v souladu s platebními podmínkami stanovenými Smlouvou nebo nebude splňovat požadované zákonné náležitosti, je Kupující oprávněn daňový doklad Prodávajícímu vrátit jako neúplný k doplnění, resp. nesprávně vystavený k novému vystavení, a to ve lhůtě pěti (5) pracovních dnů od data jeho doručení Kupujícímu. Kupující přitom není v prodlení s úhradou Kupní Ceny nebo její části. Nová Lhůta splatnosti začne plynout dnem doručení opraveného nebo nově vyhotoveného daňového dokladu Kupujícímu.
- 5.8 Kupující je oprávněn pozastavit či jednostranně započítat proti pohledávkám Prodávajícího kteroukoli z plateb z důvodu:
- 5.8.1 škody způsobené Prodávajícím,
- 5.8.2 smluvní pokuty a jiné majetkové sankce.
- 5.9 Prodávající není oprávněn započítat žádnou svou pohledávku proti pohledávce Kupujícího z této Smlouvy.

6. VLASTNICKÉ PRÁVO

- 6.1 Vlastnické právo ke Zboží a zároveň i nebezpečí škody přechází na Kupujícího jeho řádným předáním dle odst. 9.4 Smlouvy.

7. MÍSTO DODÁNÍ A PŘEDÁNÍ ZBOŽÍ

- 7.1 Místem dodání a předání Zboží je místnost č. 204 v budově „C“ Fyzikálního ústavu AV ČR, v. v. i. na adrese Cukrovarnická 112/10, 162 00 Praha 6, Česká republika.

8. SOUČINNOST SMLUVNÍCH STRAN

- 8.1 Prodávající se zavazuje upozornit Kupujícího na případné překážky na své straně, které mohou negativně ovlivnit řádné dodání Zboží.
- 8.2 Prodávající je povinen upozornit Kupujícího na nevhodně provedenou připravenost místa dodání a instalace.
- 8.3 Odchylně od § 2126 OZ Smluvní strany sjednávají, že Prodávající není oprávněn využít institutu svépomocného prodeje.

9. DODÁNÍ, INSTALACE, PŘEDÁNÍ

- 9.1 Prodávající na své náklady přepraví Zboží na místo dodání a předání. Je-li dodávka neporušená, vystaví Kupující Prodávajícímu dodací list.
- 9.2 Prodávající provede a zdokumentuje instalaci Zboží a provede zkoušku Zboží spočívající v ověření jeho funkčnosti.
- 9.3 Součástí předávacího řízení je předání technické dokumentace vztahující se ke Zboží, návod k užívání a prohlášení o shodě dodaného Zboží a všech jeho součástí se schválenými standardy.
- 9.4 Předávací řízení je ukončeno předáním Zboží Kupujícímu potvrzeným předávacím protokolem obsahujícím specifikaci provedených testů (dále jen „**Předávací protokol**“). Předávací protokol obsahuje tyto povinné náležitosti:
 - 9.4.1 údaje o Prodávajícím, Kupujícím a subdodavatelích,
 - 9.4.2 popis Zboží včetně soupisu komponent a sériových / výrobních čísel,
 - 9.4.3 popis provedených zkoušek dle odst. 3.2.2 včetně dosažených parametrů,
 - 9.4.4 potvrzení o zaškolení obsluhy dle odst. 3.2.4,
 - 9.4.5 seznam technické dokumentace včetně manuálu, certifikát o kalibraci,
 - 9.4.6 případná výhrada Kupujícího týkající se drobných vad a nedodělků a způsobu a doby jejich odstranění,
 - 9.4.7 datum podpisu.
- 9.5 Předání Zboží nezbavuje Prodávajícího odpovědnosti za škody vzniklé v důsledku vad.
- 9.6 Kupující není povinen převzít Zboží, které by vykazovalo vady, byť by samy o sobě ani ve spojení s jinými nebránily užívání Zboží. V tomto případě vydá Prodávajícímu zápis o nepřevzetí Zboží s uvedením důvodu.
- 9.7 Nevyužije-li Kupující svého práva nepřevzít Zboží vykazující vady a nedodělky, uvedou Prodávající a Kupující v Předávacím protokolu soupis zjištěných vad a nedodělků, včetně způsobu a termínu jejich odstranění. Nedojde-li k dohodě mezi Smluvními stranami o termínu odstranění vad, platí, že tyto vady mají být odstraněny ve lhůtě 48 hodin ode dne předání a převzetí Zboží.

10. ZAJIŠTĚNÍ TECHNICKÉ PODPORY

- 10.1 Prodávající je povinen poskytovat Kupujícímu bezplatné konzultace a technickou podporu vztahující se k předmětu plnění po dobu trvání záruční doby. Prodávající se zavazuje poskytnout Kupujícímu konzultace a technickou podporu vztahující se k předmětu plnění i v pozáruční době.

11. ZÁSTUPCI, OZNAMOVÁNÍ:

- 11.1 Prodávající zmocnil tyto zástupce odpovědné za dodávku Zboží a ke komunikaci s Kupujícím:

[REDACTED]

- 11.2 Kupující zmocnil tyto zástupce odpovědné za komunikaci s Prodávajícím:

[REDACTED]

- 11.3 Kontaktní osoby lze změnit jednostranným písemným prohlášením Smluvní strany doručeným druhé Smluvní straně.
- 11.4 Veškerá oznámení učiněná mezi Smluvními stranami podle této Smlouvy musí být vyhotovena písemně a doručena druhé Smluvní straně osobně (s písemným potvrzením o převzetí) nebo doporučeným dopisem (na adresu Kupujícího či Prodávajícího), či jinou formou registrovaného poštovního nebo elektronického styku s elektronickým podpisem na adresu epodatelna@fzu.cz v případě Kupujícího a info@tmdirect.cz v případě Prodávajícího.
- 11.5 Ve věcech odborných nebo technických (oznámení potřeby záručního servisu apod.) je přípustná elektronická komunikace prostřednictvím zástupců ve věcech technických na e-mailové adresy uvedené v odst. 11.1 a 11.2.

12. PŘEDČASNÉ UKONČENÍ SMLOUVY

- 12.1 Tuto Smlouvu lze předčasně ukončit dohodou Smluvních stran nebo odstoupením od Smlouvy z důvodů stanovených v zákoně nebo ve Smlouvě.
- 12.2 Kupující je oprávněn od Smlouvy odstoupit bez jakýchkoliv sankcí na jeho straně, nastane-li některá z níže uvedených skutečností:
- 12.2.1 Prodávající nesplní lhůtu plnění dle odst. 4.1 Smlouvy,
 - 12.2.2 při předání Zboží nebudou splněny technické parametry či podmínky dle požadované technické specifikace podle Příloh č. 1 a 2 a dle platných technických norem,
 - 12.2.3 vyjdou najevo skutečnosti svědčící o tom, že Prodávající nebude schopen Zboží dodat,
 - 12.2.4 Prodávající nebude splňovat kvalifikační předpoklady stanovené v rámci Zadávacího

řízení.

- 12.3 Prodávající je oprávněn od Smlouvy odstoupit v případě, že Kupující je v prodlení se zaplacením daňového dokladu - faktury delším než 2 měsíce s výjimkou případů, kdy Kupující nezaplatil fakturu z důvodu vad dodaného Zboží nebo porušení Smlouvy Prodávajícím.
- 12.4 Účinky odstoupení od Smlouvy nastávají dnem doručení písemného oznámení jedné Smluvní strany o odstoupení od Smlouvy druhé Smluvní straně. Strana, které bylo před odstoupením od Smlouvy poskytnuto plnění druhou stranou, toto plnění vrátí.

13. POJIŠTĚNÍ, ODPOVĚDNOST ZA ŠKODU

- 13.1 Prodávající se zavazuje pojistit Zboží proti veškerým rizikům, a to ve výši ceny Zboží a po dobu vymezenou zahájením přepravy až do předání (odevzdání) Kupujícímu. V případě porušení této povinnosti odpovídá Prodávající za vzniklou škodu.
- 13.2 Prodávající odpovídá za škodu, kterou sám způsobí, rovněž odpovídá Kupujícímu za škodu, kterou způsobí třetí osoby, které zavázal provést plnění nebo jeho část dle této Smlouvy.

14. ZÁRUKA, MIMOZÁRUČNÍ SERVIS

- 14.1 Prodávající poskytuje Kupujícímu záruku za jakost dodaného Zboží po dobu 60 měsíců. Záruka za jakost počíná běžet dnem následujícím po podpisu předávacího protokolu dle odst. 9.4 Smlouvy. Záruka se nevztahuje na spotřební materiál.
- 14.2 Prodávající se zavazuje zajistit bezplatný servis prostřednictvím autorizovaných techniků a bezplatné pravidelné servisní prohlídky v místě předání Zboží v rozsahu stanoveném výrobcem po celou dobu záruční doby dle této Smlouvy, včetně oprav, dodávky náhradních dílů, dopravy a práce autorizovaného servisního technika.
- 14.3 Zjistí-li Kupující závadu, vyzve Prodávajícího k jejímu odstranění na adrese: info@tmdirect.cz.
- 14.4 Prodávající je povinen odstranit uplatněné vady ve lhůtě 14 dnů ode dne přijetí reklamačního oznámení. V případě vady nikoli běžné je Prodávající povinen provést opravu v době obvyklé charakteru vady a dle toho stanovit termín předání opravené věci.
- 14.5 Náklady související s opravou včetně přepravného a cestovného vždy hradí Prodávající.
- 14.6 Opravené Zboží předá Prodávající Kupujícímu na základě předávacího protokolu o opravě vady (dále jen „**Protokol o opravě vady**“) obsahujícího potvrzení obou Smluvních stran, že Zboží bylo zbaveno vad.
- 14.7 Na opravenou část Zboží se vztahuje záruční doba dle odst. 14.1 a počíná běžet dnem odstranění vady Zboží doloženým Protokolem o opravě vady.
- 14.8 Vykazuje-li Zboží vady, pro které jej nelze prokazatelně užívat v plném rozsahu více jak 40 dnů (doba závad) během šesti nebo méně po sobě jdoucích měsíců záruční doby, je Prodávající povinen odstranit vadu dodáním nového Zboží bez vady dle § 2106 odst. (1) písm. a) OZ ve lhůtě 30 dnů ode dne odeslání výzvy k dodání, nedohodnou-li se Smluvní strany jinak.

- 14.9 Prodávající se zavazuje zajistit mimozáruční servis v místě předání Zboží včetně oprav, zajištění dodávky náhradních dílů a dopravy a práce servisního technika za cenu nepřevyšující cenu obvyklou a ve lhůtě dle odst. 14.3 a 14.4.

15. SMLUVNÍ POKUTY

- 15.1 Kupující je oprávněn uplatnit vůči Prodávajícímu smluvní pokutu ve výši 0,1 % z Kupní Ceny za každý započatý den prodlení s plněním povinností dle odst. 4.1 a 14.8 Smlouvy.
- 15.2 Kupující má nárok na úhradu 2.000,- Kč za každý den, po který nemohl Zboží pro vadu podléhající záruční opravě používat, počínaje 15. dnem po uplatnění záruční vady. V případě, že byla v souladu s ustanovením odst. 14.4 stanovena na opravu vady nikoli běžné zvláštní lhůta, má Kupující nárok na úhradu 2.000,- Kč za každý den následující po uplynutí této zvláštní lhůty.
- 15.3 V případě prodlení Prodávajícího s provedením mimozáruční opravy je Kupující oprávněn uplatnit vůči Prodávajícímu smluvní pokutu ve výši 1.000,- Kč za každý započatý den prodlení.
- 15.4 V případě uplatnění důvodů pro odstoupení od Smlouvy dle odst. 12.2.1 a 12.2.2 je Kupující oprávněn uplatnit vůči Prodávajícímu smluvní pokutu ve výši 30 % Kupní Ceny.
- 15.5 Pro případ prodlení s úhradou kterékoli splatné pohledávky (peněžitého dluhu) dle Smlouvy je prodávající Kupující či Prodávající (dlužník) povinen zaplatit druhé Smluvní straně (věřiteli) úrok z prodlení v zákonné výši za každý započatý den prodlení.
- 15.6 Smluvní pokuta je splatná do 30 dnů ode dne odeslání výzvy k zaplacení.
- 15.7 Zaplacením smluvní pokuty nejsou dotčeny nároky smluvních stran na náhradu škody, použití ustanovení § 2050 OZ je vyloučeno.

16. SPORY

- 16.1 Veškeré spory vzniklé z této Smlouvy či z právních vztahů s ní souvisejících budou Smluvní strany řešit jednáním. V případě, že nebude možné spor urovnat jednáním, bude takový spor rozhodovat na návrh jedné ze Smluvních stran soud v České republice, jehož místní příslušnost je určena sídlem Kupujícího.

17. ZÁVĚREČNÁ A JINÁ UJEDNÁNÍ

- 17.1 Veškeré změny či doplnění Smlouvy lze učinit pouze na základě písemné dohody Smluvních stran, neumožňuje-li jednostrannou změnu Smlouva či právní předpis.
- 17.2 Tato Smlouva je sepsána ve třech (3) vyhotoveních, z nichž každé vyhotovení má povahu originálu, přičemž Kupující obdrží dvě (2) a Prodávající jedno (1) vyhotovení.
- 17.3 Smluvní strany výslovně souhlasí s tím, aby Smlouva jako celek včetně všech příloh a údajů o Smluvních stranách, předmětu Smlouvy, číselném označení Smlouvy, Kupní Ceně a datu jejího uzavření byla uveřejněna v souladu se zákonem č. 340/2015 Sb., o zvláštních podmínkách

účinnosti některých smluv, uveřejňování těchto smluv a registru smluv, v platném znění (dále jen „ZRS“). Smluvní strany prohlašují, že veškeré informace uvedené ve Smlouvě a jejích přílohách nepovažují za obchodní tajemství ve smyslu § 504 OZ a udělují svolení k jejich užití a zveřejnění bez stanovení jakýchkoliv dalších podmínek.

17.4 Smluvní strany se dohodly, že uveřejnění Smlouvy prostřednictvím registru smluv v souladu se ZRS zajistí Kupující.

17.5 Nedílnou součástí Smlouvy jsou tyto přílohy:

Příloha č. 1: Technická specifikace

Příloha č. 2: Nabídka Prodávajícího v rozsahu části, která technicky popisuje Zboží

17.6 Smluvní strany prohlašují, že Smlouvu před jejím podepsáním přečetly, jejímu obsahu rozumí a s jejím obsahem souhlasí. Na důkaz svého souhlasu připojují obě Smluvní strany své podpisy.

Za: Fyzikální ústav AV ČR, v. v. i.

Za: T & M Direct, s.r.o.

16. 11. 2018

14. 11. 2018

Příloha č. 1 – Technické specifikace

Tab. 1: Jednotlivé komponenty Zboží musí zahrnovat následující součásti a splňovat následující technické podmínky:

The system has to be capable of two basic functionalities: generation of arbitrary waveforms with a minimum 300MHz bandwidth and generation of continuous waves (sine) up to at least 65GHz. The system must include proper cabling and discrete RF items allowing integration with the experiment and a power meter. The detailed specifications ensue:

Popis a minimální specifikace Zboží e stanovené zadavatelem	Popis a specifikace Zboží nabízeného dodavatelem	Splňuje ANO/NE
Arbitrary waveform generator capability detailed specification	Keysight 81160A, option 002	
>=2.5 GSa/s capability, at least 2 channels	2.5 GSa/s, 2 channels	Ano
minimum 1 mHz – 300 MHz pulse bandwidth	1 μ Hz - 330 MHz	Ano
<1mHz resolution	1 μ Hz	Ano
pulse width <=1.5 ns	1.5 ns	Ano
pulse rise&fall <=1ns	1 ns	Ano
time resolution <=300ps	300 ps	Ano
Transition time (10% to 90%) <=1.5ns	1 ns	Ano
14-bit resolution	14 bits	Ano
at least 128k samples waveform memory per channel	256 kSa in total, 128 kSa per channel	Ano
Load impedance range at least 0.1 Ω - 1 M Ω	0.1 Ω to 1 M Ω	Ano
Single-ended or differential outputs	Single-ended or differential outputs	Ano
Triggers and modulation references in/out	Trigger in and out	Ano
External/Internal modulation (gating) of outputs (all types of modulation) at least to 10MHz		Ano
Pulse, sine, square, ramp, noise and arbitrary waveforms		Ano
Frequency modulation, amplitude modulation, pulse modulation, pulse width modulation		Ano
Burst mode (externally triggered)		Ano
Amplitude (differential): 50 Ω into 50 Ω : >=50 mV to >=5 V Peak-to-Peak 50 Ω into open: >=100 mV to >=10 V Peak-to-Peak	50 Ω into 50 Ω : 50 mVPP to 5 VPP 50 Ω into open: 100 mVPP to 10 VPP	Ano
Voltage window: 50 Ω into 50 Ω min. \pm 5 V 50 Ω into open min. \pm 10 V	50 Ω into 50 Ω min. \pm 5 V 50 Ω into open min. \pm 10 V	Ano
Continuous wave generator capability detailed specification	Keysight E8257D, options 567, 007, 1EU, UNW	
Frequency range min. <300 kHz and max. >65 GHz	250 kHz to 67 GHz, tunable 100 kHz to 70 GHz	Ano
Maximum output power in the range 1 to 20 GHz at least +20dBm	+21 dBm	Ano
Frequency resolution <0.02 Hz	0.01 Hz	Ano
Amplitude resolution <=1 dB	1 dB	Ano
Temperature stability <0.05 dB/°C	0.02 dB/°C	Ano
Digital and analog sweep of frequency or amplitude (and at the same time also)	Digital + analog sweep modes	Ano

Both support user correction of the output signal amplitude vs. frequency in a form of preloaded table(s)		
Digital sweep settling times Frequency < 9 ms, Amplitude < 5 ms	Sweep Settling time in Frequency 9 ms, Amplitude 5 ms	Ano
Analog sweep operating modes - frequency sweep - power sweep - manual sweep - remote control possible between start and stop frequencies	- frequency sweep - power sweep - manual sweep - remote control	Ano
Sweep rates 250 kHz to 0.5 GHz - ≥ 25 MHz/ms 0.5 to 1 GHz - ≥ 50 MHz/ms above 1 GHz - ≥ 100 MHz/ms	250 kHz to 0.5 GHz: 25 MHz/ms 0.5 to 1 GHz: 50 MHz/ms above 1 GHz: 100 MHz/ms	Ano
Frequency accuracy at least $\pm 0.05\%$ of span Sweep time resolution 1 ms	$\pm 0.05\%$ of span Sweep time resolution 1 ms	Ano
Triggering Auto, external, single	Auto, external, single, or GPIB	Ano
Pulse modulation On/off ratio ≥ 80 dB Rise/fall times < 10 ns Minimum pulse width < 30 ns	On/off ratio: 80 dB Rise/fall times: 6 ns (>400 MHz) Minimum pulse width: 20 ns (>400 MHz)	Ano
Pulse repetition frequency 10Hz - 10MHz	10Hz - 10MHz (ALC off)	Ano
Common requirements		
Mains power 100/120 VAC 50/60/400 Hz; or 220/240 VAC 50/60 Hz		Ano
Protection against short-circuits		Ano
Remote programming		Ano
communication interface LAN(TCP-IP/UDP) or serial (USB also applicable)	81160A: GPIB, USB, LAN E82570: GPIB, RS-232, LAN	Ano
Python, Labview compatible		Ano
Web interface		Ano
Interface cabling and additional components Note: the cables and bias-Tees must be supplied in two versions, each tuned to the frequency range of each of the capabilities specified above for maximum performance		
2x Impedance-matched RF cable, length >1.8m for frequencies up to 12GHz		Ano
2x Impedance-matched RF cable, length >0.8m for frequencies up to 67GHz		Ano
2x bias-Tee up to 67GHz + 2x converter from bias-Tee to BNC 2x bias-Tee up to 12GHz + 2x converter from bias-Tee to BNC (Note: the BNC converters are for DC input/output to/from the bias-Tees)		Ano
2x 50 Ohm Load (for line termination)		Ano
2x 6dB attenuator		Ano
Power meter	Keysight U2053XA	

Average Power Sensor (Frequency range > 30GHz, Minimum measurable power >= -70 dBm, Sampling rate >= 1MSa, Internal zero calibration)	33 GHz, -70 dBm, 20 MSa, internal zero calibration	Ano
USB/serial interface	USB	Ano
Robust documented communication protocol supported by Labview/Python libraries	Using SCPI codes	Ano

Intended scheme of connection of the generator to the experiment (required additional RF items are marked by *, items that can be swapped in/out of the circuit are marked by †):

*Generator (with arbitrary wave or continuous wave capability)

connector adaptor (if necessary)

*†attenuator 6dB

*RF cable IN

*†attenuator 6dB

*bias-Tee

SMA female IN (input feedthrough of the experimental device)

Experimental device

SMA female OUT (output feedthrough of the experimental device)

*bias-Tee

*RF cable OUT

connector adaptor (if necessary)

*50 Ohm terminator OR *power meter OR spectral analyzer

Note: the attenuator connectors must be compatible with the other component interfaces, or to be equipped with suitable adaptors in order to be optionally used at the specified locations in the circuit.

Příloha č. 2 - Nabídka Prodávajícího v rozsahu části, která technicky popisuje Zboží

Doplňkové informace

Katalogové listy přístrojů tvořících nabízenou sestavu „Generátor libovolně tvarovaných pulzů“

Keysight 81160A

Keysight E8257D

Keysight U2053XA



Keysight 81150A and 81160A Pulse Function Arbitrary Noise Generators

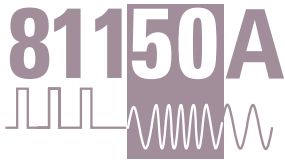


Introduction

High precision pulse generators enhanced with versatile signal generation, modulation and distortion capabilities for:

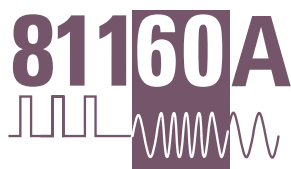
- Accurate signals to test your device and not your signal source
- Versatile waveform and noise generation to be ready for today's and tomorrow's stress test challenges
- Optional pattern generator to test in addition to analog, digital and mixed signal devices
- Integrated into one instrument to minimize cabling, space and test time

The 81150A Pulse Function Arbitrary Noise Generator at a Glance



- 1 μ Hz – 120 MHz pulse generation with variable rise/fall time
- 1 μ Hz – 240 MHz sine waveform output
- 14-bit, 2 GSa/s arbitrary waveforms
- 512 k samples deep arbitrary waveform memory per channel
- Pulse, sine, square, ramp, noise and arbitrary waveforms
- Noise, with selectable crest factor, and signal repetition time of 26 days
- FM, AM, PM, PWM, FSK modulation capabilities
- 1- or 2- channel, coupled and uncoupled
- Differential outputs
- Two selectable output amplifiers:
 - High bandwidth amplifier
 - Amplitude: 50 mV_{pp} to 5 V_{pp}; 50 Ω into 50 Ω
100 mV_{pp} to 10 V_{pp}; 50 Ω into open
 - Voltage window: \pm 5 V; 50 Ω into 50 Ω
 \pm 10 V; 50 Ω into open
 \pm 9 V; 5 Ω into 50 Ω
 - High voltage amplifier
 - Amplitude: 100 mV_{pp} to 10 V_{pp}; 50 Ω into 50 Ω ,
200 mV_{pp} to 20 V_{pp}; 5 Ω into 50 Ω , or 50 Ω into open
 - Voltage window: \pm 10 V; 50 Ω into 50 Ω
 \pm 20 V; 5 Ω into 50 Ω or 50 Ω into open
- Glitch-free change of timing parameters (delay, frequency, transition time, width, duty cycle)
- Programming language compatible with Keysight 81101A, 81104A, 81105A, 81110A, 81130A and 81160A
- ISO 17025 and Z540.3 calibration
- LXI class C (rev. 1.1) compliant
- Optional pattern generator:
 - Ideal and arbitrary bit shaped pattern up to 120 Mbit/s
 - Two, three or four level signals
 - PRBS up to 231
 - 16 Mbit pattern memory
 - Pass through pattern for combined and physical and protocol test up to 10 Mbit/s

The 81160A Pulse Function Arbitrary Noise Generator at a Glance



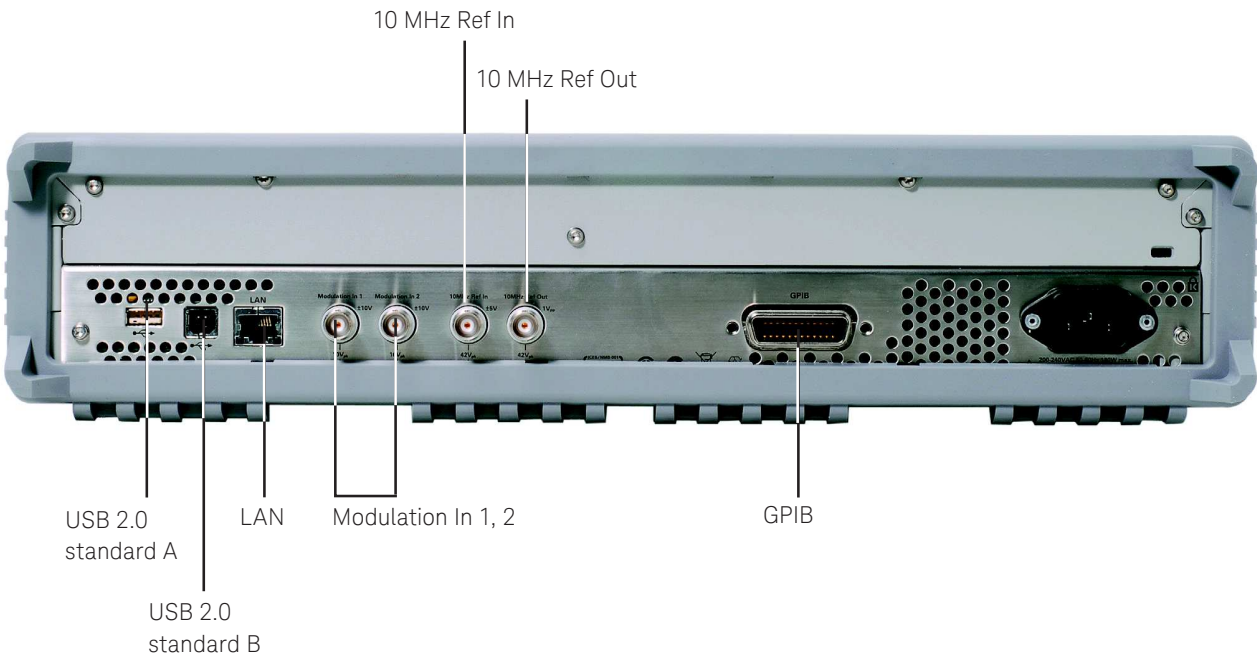
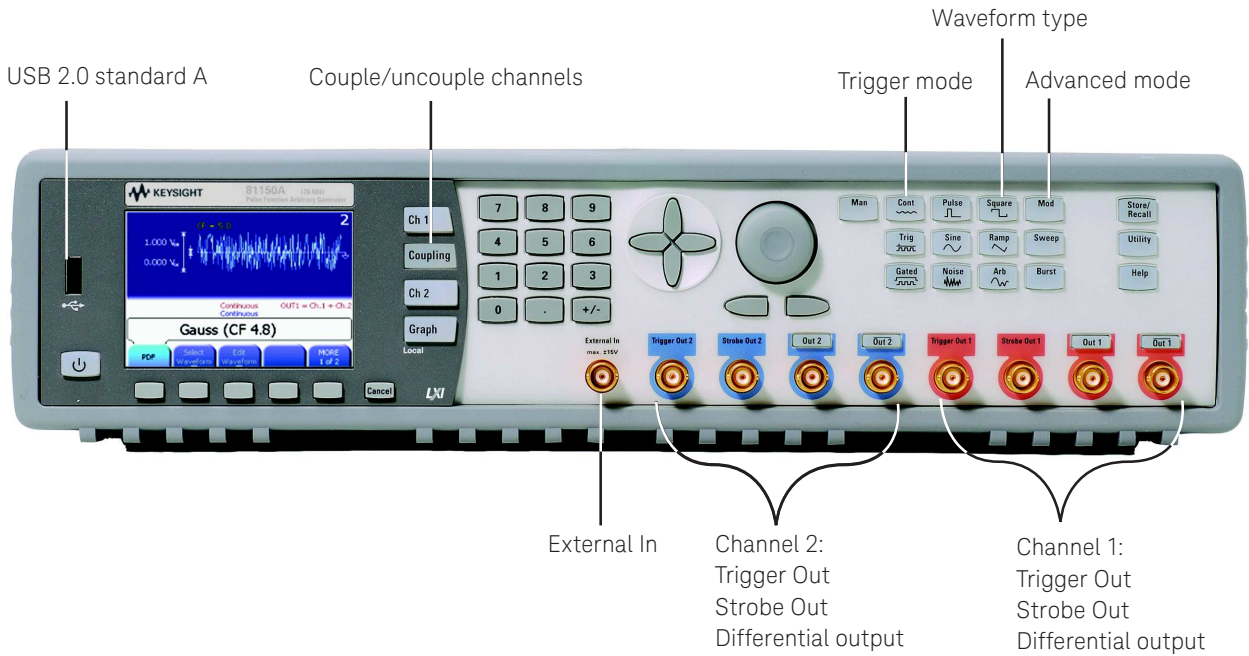
- 1 μ Hz – 330 MHz pulse generation with variable rise/fall time
- 1 μ Hz – 500 MHz sine waveform output
- 14-bit, 2.5 GSa/s arbitrary waveforms
- Up to 256k samples deep arbitrary waveform memory per channel
- Pulse, sine, square, ramp, noise and arbitrary waveforms
- Noise, with selectable crest factor, and signal repetition time of 20 days
- FM, AM, PM, PWM, FSK modulation capabilities or 2 channel, coupled and uncoupled
- Differential outputs

- Amplitude:
 - 50 Ω into 50 Ω 50 mV_{PP} to 5 V_{PP}
 - 50 Ω into open 100 mV_{PP} to 10 V_{PP}

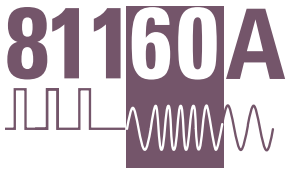
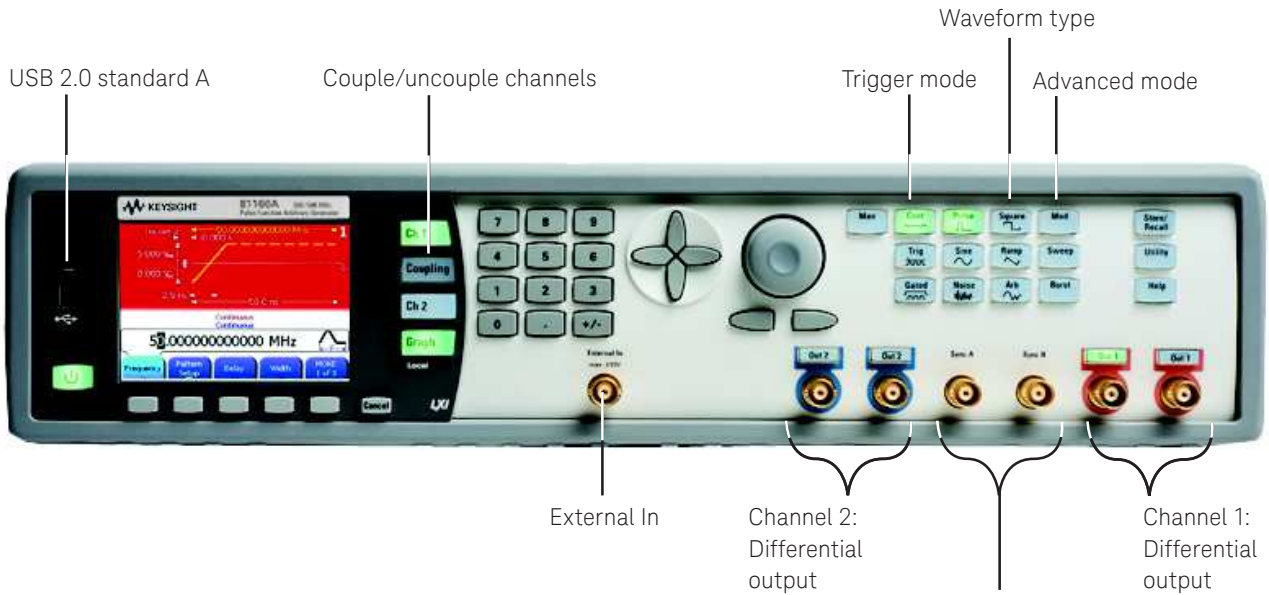
- Voltage window:
 - 50 Ω into 50 Ω \pm 5 V
 - 50 Ω into open \pm 10 V

- Glitch-free change of timing parameters (delay, frequency, transition time, width, duty cycle)
- Programming language compatible with Keysight 81101A, 81104A, 81105A, 81110A, 81130A and 81150A
- ISO 17025 and Z540.3 calibration
- LXI class C (rev 1.1) compliant
- Optional pattern generator:
 - Ideal and arbitrary bit shaped pattern up to 330 Mbit/s (Option 330) or 660 Mbit/s (Option 660)
 - Two, three or four level signals
 - PRBS up to 231
 - 4 Mbit pattern memory for the 1-channel instrument and 2 Mbit per channel for the 2-channel instrument
 - Pass through pattern for combined and physical and protocol test up to 10 Mbit/s

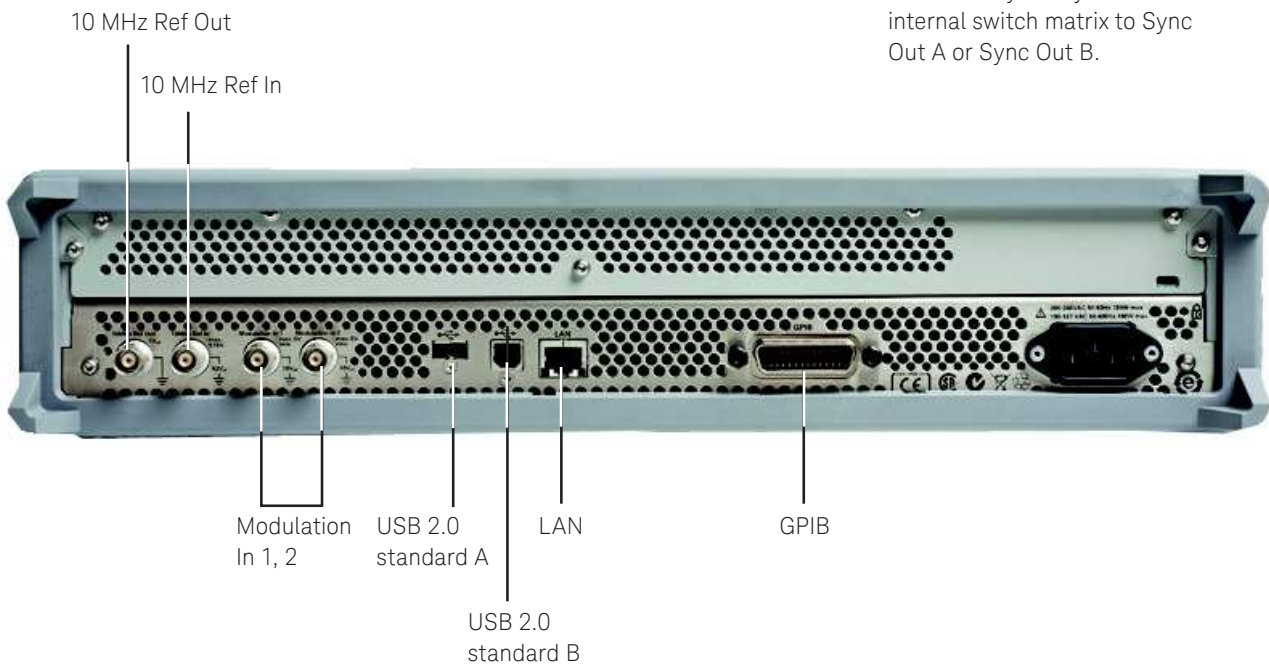
81150A



81160A

Sync out A and B:
 The logical trigger signal 1 or logical trigger signal 2 or logical strobe signal 1 or logical strobe signal 2 can be routed by a fully flexible internal switch matrix to Sync Out A or Sync Out B.



Today's Challenges Require a New Generation of Test Instruments

Keysight's offering

You are under pressure to get products to market faster and faster, with shrinking design schedules and increasing quality goals. The pressure is never ending. Because differentiation means survival in the marketplace, you often have to test unique functionality. Being confident in your results takes highly adaptable and efficient testing.

Such challenges require a new generation of test instruments, which are:

- Accurate, to test your device and not your source
- Versatile, to be ready for today's and tomorrow's test challenges
- Plug and play solutions, with minimal cabling, low space overhead and have many functions built-in

Whichever way you look at it, this starts with accurate, versatile and uncompromising signal sources.

Just test – with the signal you need.
Quad versatility – optimum signal fidelity

The Keysight Technologies, Inc. 81150A and 81160A Pulse Function Arbitrary Noise Generators set the standard for the next generation of lab: for fast, accurate insight into your design or device under test. Both of them offer:

- Pulse generators with precise signals for performance verification and characterization function arbitrary generator
 - For versatile signal generation to optimize testing
 - For modulation to shape the signal the DUT needs
- A noise generator to distort signals to build up worst case scenarios
- An optional pattern generator to test in addition to analog, digital and mixed signal devices with ideal and real-world conditions

The Keysight 81150A and the new Keysight 81160A Pulse Function Arbitrary Noise Generators are indispensable contributors to accelerate ideal and real-world testing.

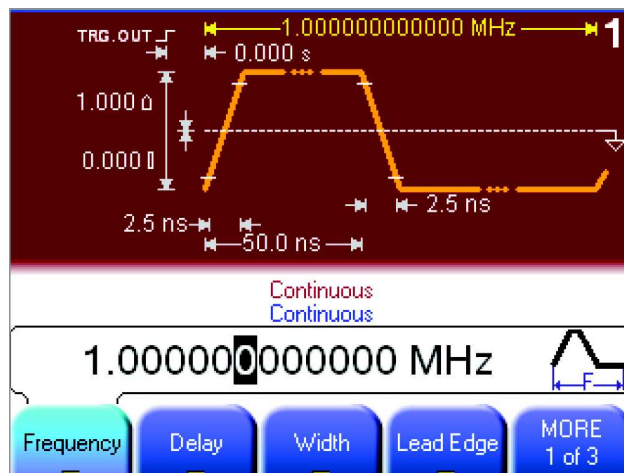


Pulse Generator – Test Your Device and Not Your Source

Superior precision pulses with unbeatable timing stability guarantee reproducible tests. The signal quality and trigger functionality provide everything you need for trigger or system clock applications.

You can change the timing parameters (delay, frequency, transition time, width, duty cycle) without dropouts or glitches. This patented, industry-leading feature means continuous operation without having to reboot or reset your device under test, for example when you are characterizing a device by sweeping the clock frequency. Apart from full control of the timing parameters, you can also adjust levels and edges as needed.

Channel 1 pulse setup

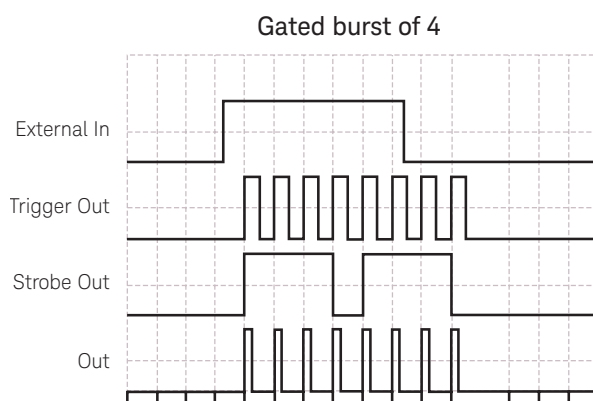


Set up complex measurements

Both, the Keysight 81150A and the Keysight 81160A Pulse Function Arbitrary Noise Generator, are available in a 1- or 2-channel version. On the two-channel version, the channels can be uncoupled, to work independently, or coupled, for example, with a defined delay between them.

Each channel provides Trigger Out, Strobe Out and differential outputs: the basis for many complex test setups.

Measurement using strobe and trigger



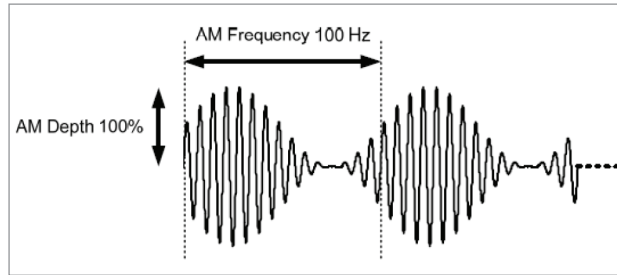
Function Arbitrary Generator

Stress Your Device to its Limit

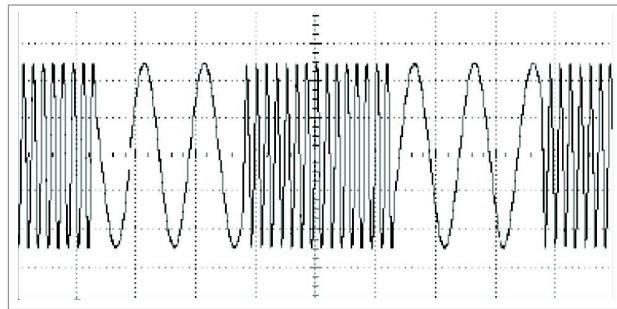
If you need further signal conditioning, the Keysight 81150A and the Keysight 81160A Pulse Function Arbitrary Noise Generators provide versatile waveforms and modulation capabilities to adapt your signal to your device's requirements. AM, FM, FSK, PM and PWM are available at modulation frequencies up to 10 MHz and to 50 MHz.

The Keysight 81150A and the Keysight 81160A Pulse Function Arbitrary Noise Generators can use internal or external modulation sources. Internal modulation can be generated from the 2nd channel or the internal modulation source of the modulated channel.

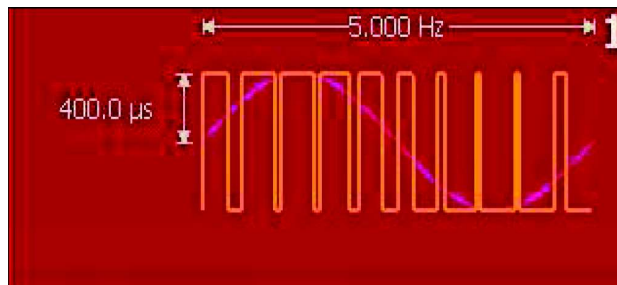
Amplitude modulation



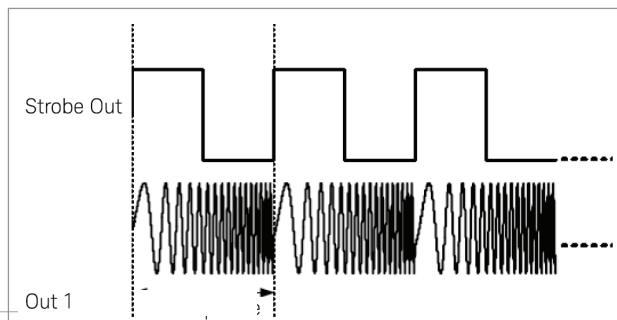
Frequency shift keying modulation



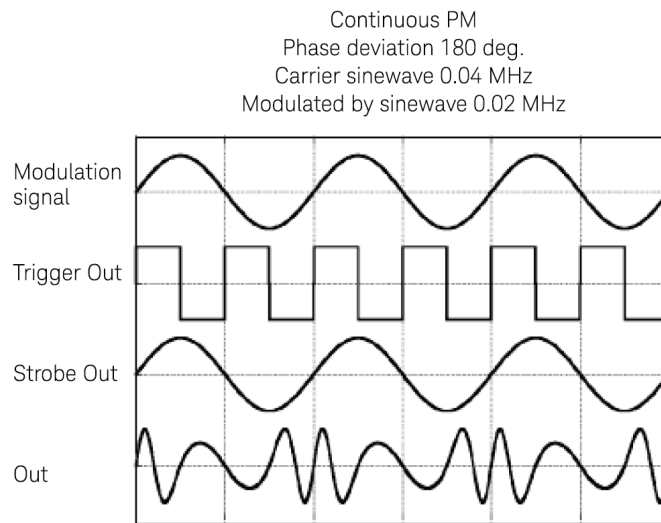
Pulse width modulation



Frequency sweep



Setting up a measurement using trigger, strobe, modulation and carrier



Noise generator – repeatable and stochastic noise

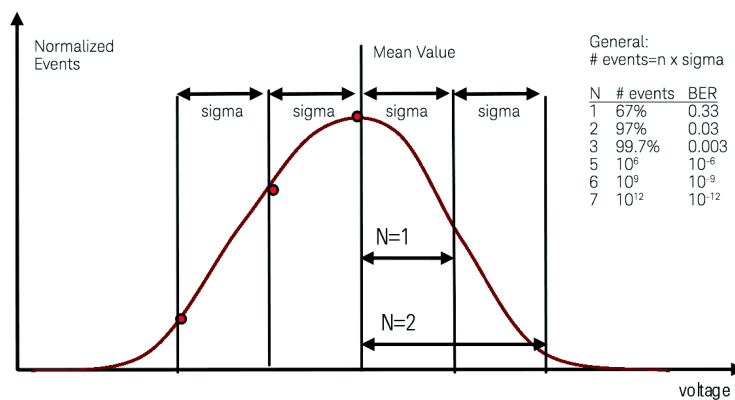
Jitter and noise cause misalignment of edges and levels, resulting in data errors. Noise is by its nature unpredictable because it can have many different causes, from signal interference caused by sudden voltage changes, to distortions introduced during transmission.

It is important to be able to simulate noise-based malfunctions, for example, to identify the additive noise produced by receiving systems—it is cheaper to lower the noise figure than to increase the transmitter power! The Keysight 81150A and the Keysight 81160A Pulse Function Arbitrary Noise Generators let you control the quality of the noise, to test different cases, and according to various specifications.

White Gaussian noise is a good approximation to many real-world situations, and creates mathematically traceable models, with statistical independent values. The Keysight 81150A and the Keysight 81160A Pulse Function Arbitrary Noise Generators provide deterministic white Gaussian noise, with a signal repetition of 20 days or 26 days respectively. You can decide on any arbitrary distribution, and trigger the noise to start when you need it.

Gaussian curve and distribution

Gaussian distribution

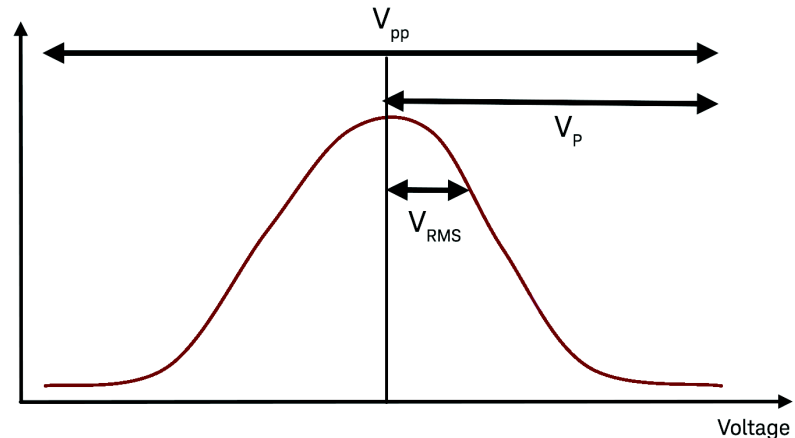


Voltage level crest factor

You can also select the crest factor out of 4 values – an indicator of signal quality – using V_P/V_{RMS} or V_{PP}/V_{RMS} scales, depending on the standard to which you are testing.

The 81150A and the 81160A use the definition: crest factor = V_P/V_{RMS}

Voltage level crest factor



The result is noise that combines two extremes:

- Random and repeatable noise, for stress tests on one side
- While still being sufficiently random

Pattern Generator – Test in Addition to Analog, Digital and Mixed Signal Devices

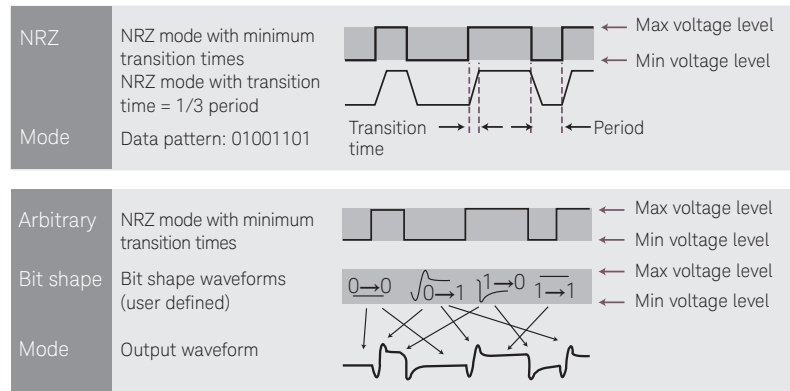
Engineers working with serial buses or designers of analog, digital and mixed signal devices require stressing their design with pattern. The optional Keysight 81150A and 81160A arbitrary bit shaped pattern generator allows sending ideal and real-world pattern. The Keysight 81150A with arbitrary bit shaped pattern (Option PAT) allows emulating overshoot, asymmetric delay and duty cycle distortion up to 120 Mbit/s, the Keysight 81160A up to 330 Mbit/s (Option 330) or even up to 660 Mbit/s (Option 660). Patterns can be easily set up and distorted at your fingertips.

Stress your device to its limits – define your own bit shape

Emulate effects like...

- Capacitive load of the channel
- Asymmetric delay
- Crossing point deviations
- Duty cycle distortions
- Arbitrary transition times
- Level noise
- Delays from/to electrical idle

...By defining the transitions so that the previous bit influences the current bit



The 81150A and the 81160A pattern generators let you define the transitions from one bit to the other so that the previous bit influences the current bit. The user can set up own defined arbitrary bit shapes.

PRBS

In addition to user-defined patterns, standard patterns like PRBS up to 231 are available.

Sequencer

The sequencer allows setting up a pre-ambule sequence so that the device under test moves into test mode.

2-, 3- and 4-level signals

Additionally to 2-level signals, it is also possible to create 3- and even 4-level signals. With the 3-level signals, it is no longer necessary to add different signals for electrical idle. 3-level signals are important e.g. for use in Ethernet environment and 4-level signals e.g. for PAM-4 applications.

Bit and block trigger mode

Besides, standard trigger modes like continuous bit and block trigger modes allow adoptions to application needs. In the bit mode you see that on every trigger, the sequence is advanced by one bit. An application example is a bit clock, which can be fed into an external clock and then into the trigger input.

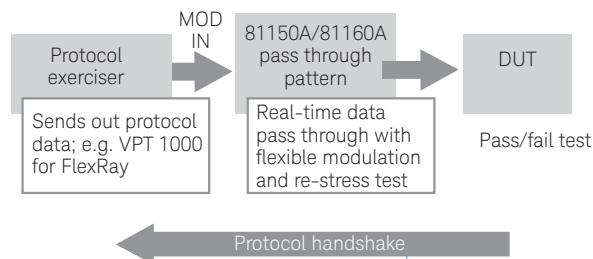
In the block mode the entire data block is generated once per trigger event. This is interesting for example in applications with protocol data.

Pass through pattern for combined physical and protocol test up to 10 Mbit/s

The 81150A and the 81160A pattern generators pass the data through to the device under test and add any kind of stress (shape and timing change).

Bridge the gap between protocol and physical layer test – in real time up to 10 Mbit/s

Increase your test efficiency by combining physical layer test with protocol test



The pass-through pattern functionality takes the protocol data via Mod In and adds any kind of stress (shape and timing changes).

Modulation

Modulation of the pattern signal enables you to emulate real-world conditions.

AM – amplitude of the pattern signal is multiplied by the modulation signal to emulate level distortions of the data signal e.g. sinusoidal interference.

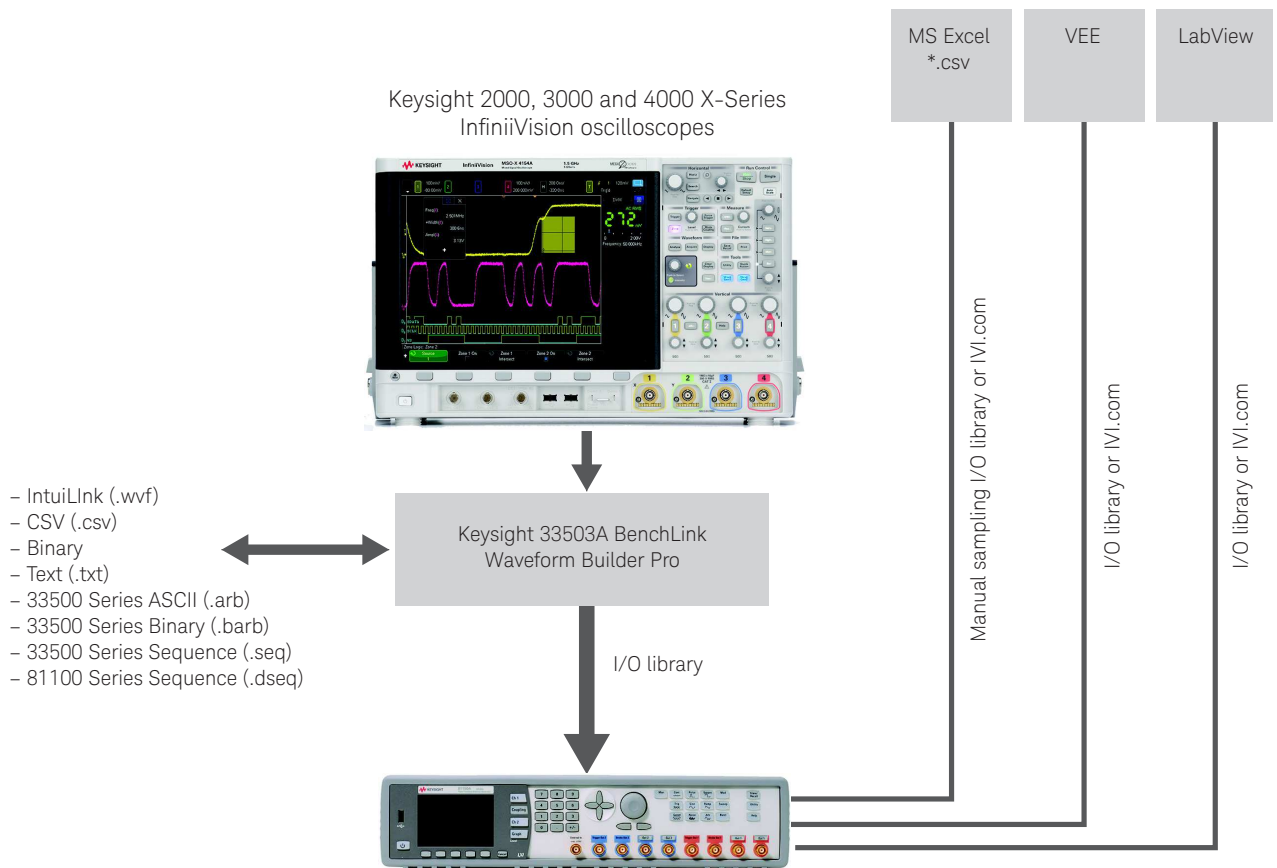
FM – frequency of the pattern signal is modulated to emulate SSC on the data signal.

PM – the phase of the data bits is modulated to emulate jitter on the data signal.

Connectivity

Filling the arbitrary memory easily

There are several possibilities for filling the arbitrary memory. There are 6 built-in, standard arbitrary waveforms, but you can also create any waveform you need, either on the instrument or on a PC, using the Keysight 33503A BenchLink Waveform Builder Pro software available for the 81150A and 81160A Pulse Function Arbitrary Noise Generators. The 33503A software is being designed for waveform creation, waveform import from Keysight scopes and waveform download to the 81150A and 81160A generators.

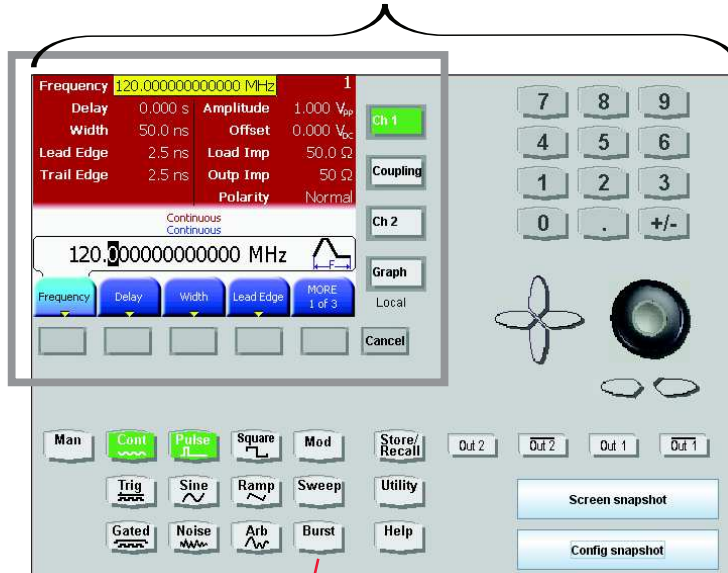


Measurement – Anywhere and Anytime

The web interface allows you to use the full functionality and feature set of the Keysight 81150A and 81160A Pulse Function Arbitrary Noise Generators from a web browser.

Channel 1: set up the signal

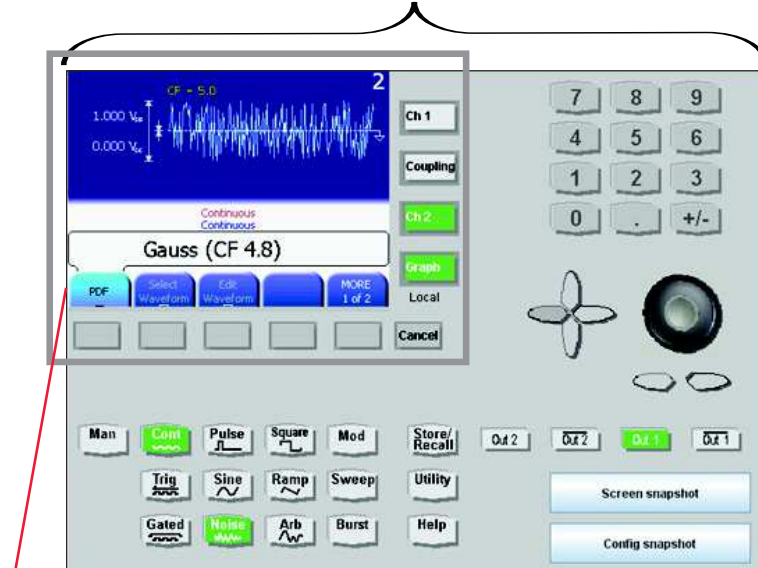
Web interface



Just decide on the waveform

Web interface

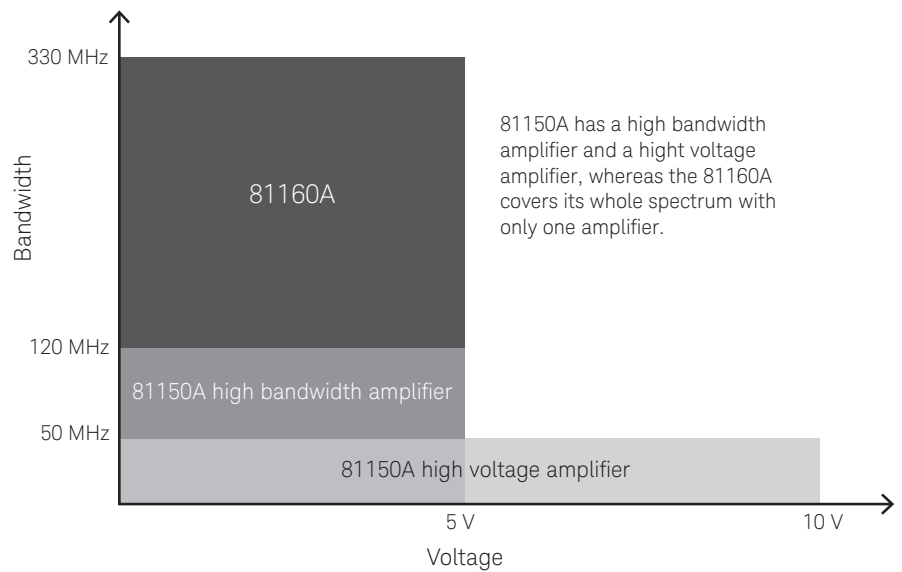
Channel 2: add noise



Choose the crest factor/probability function you need

Amplifier concept

Different applications and devices call for different bandwidth and voltage levels. Choose the performance you need.



Flexible signal synchronization

The 81150A has one trigger output and one strobe output per channel.



81160A: Sync Out A and B

The 81160A generates the trigger signal and the strobe signal per channel internally. Using a fully configurable switch matrix, two of the four internal signals can be routed to Sync Out A or Sync Out B.

Modes of Operation

There are four components to the mode of operation:

- Coupling between channels
- Trigger mode
- Waveform type
- Advanced modes

Coupling between channel 1 and 2

The two-channel version has two distinct modes of operation:

- **Coupling off:** The two channels operate independently. Frequency generation for both channels is based on the same clock reference, but can be selected independently.
- **Coupling on:** The frequency, trigger mode, waveform type and advanced mode are identical for both channels. The fix delay of channel 1 and channel 2 is the same.

Trigger modes

- **Continuous:** Continuous waveform, burst, sweep or modulation. The external In is not used in continuous mode.
- **Externally triggered:** Each active transition at the external In (rising, falling or both) generates a single waveform, burst or sweep.
- **Externally gated:** The active level (high or low) at the external In enables waveforms, bursts or sweeps. The last waveform, burst or sweep is always completed.
- **Internally triggered:** The internal clock replaces the external trigger source. This can be applied for waveform, burst, or sweep.
- **Manual:** This generates a single trigger. The source is either a button on the front panel or a remote command.

Trigger rate (internally triggered)

81150A: 1 μ Hz to 120 MHz

81160A: 1 μ Hz to 330 MHz

Trigger rate (externally triggered)

81150A: DC to 120 MHz

81160A: DC to 330 MHz

Waveform Types

- Standard waveforms: pulse, sine, square, ramp, noise, arbitrary
- Predefined arbitrary waveforms: exponential rise, exponential fall, sin(x)/x, cardiac and DC
- Pulse, sine, ramp, noise and arbitrary measured with 50 Ω source impedance into 50 Ω load impedance.

Pulse characteristics

	81150A	81160A
Frequency range		
High bandwidth amplifier	1 μHz to 120 MHz	1 μHz to 330 MHz
High voltage amplifier	1 μHz to 50 MHz	
Frequency resolution		
	1 μHz	1 μHz
Pulse width		
Range	4.1 ns to (period - 4.1 ns) typ.	1.5 ns to (period - 1.5 ns) spec.
High bandwidth amplifier	10 ns to (period - 10 ns)	
High voltage amplifier	100 ps, 6 digits	100 ps, 6 digits
Resolution	± 500 ps ± 50 ppm	± 300 ps ± 50 ppm
Accuracy		
Transition time (independent rise and fall)		
Range		
High bandwidth amplifier	2.5 ns to 1000 s (10% to 90%)	1.0 ns to 1000 s (10% to 90%)
High voltage amplifier	7.5 ns to 1000 s (10% to 90%)	
Resolution	100 ps, 6 digits	100 ps, 6 digits
Accuracy		
High bandwidth amplifier	± 500 ps ± 50 ppm	± 300 ps ± 50 ppm
High voltage amplifier	-1000 ps to +500 ps ± 50 ppm	
Overshoot		
	2% typ. ¹	4% typ. ²

1. Overshoot disappears for transition times > 5 ns (high bandwidth amplifier) and > 15 ns (high voltage amplifier).

2. Overshoot disappears for transition times > 2 ns.

Sine characteristics

	81150A			81160A		
Frequency range						
High bandwidth amplifier	1 μHz to 240 MHz			1 μHz to 500 MHz		
High voltage amplifier	1 μHz to 50 MHz					
Frequency resolution						
	1 μHz			1 μHz		
Harmonic distortion (High bandwidth amplifier 50 Ω into 50 Ω)						
		1 V_{pp}	3 V_{pp}		1 V_{pp}	3 V_{pp}
1 μHz to 2 MHz	< -62 dBc spec.	< -62 dBc spec.		1 μHz to 2 MHz	< -65 dBc spec.	< -63 dBc spec.
2 MHz to 10 MHz	< -57 dBc spec.	< -52 dBc spec.		2 MHz to 10 MHz	< -62 dBc spec.	< -53 dBc spec.
10 MHz to 35 MHz	< -45 dBc spec.	< -40 dBc spec.		10 MHz to 50 MHz	< -50 dBc spec.	< -40 dBc spec.
35 MHz to 70 MHz	< -35 dBc spec.	< -30 dBc spec.		50 MHz to 200 MHz	< -30 dBc spec.	< -27 dBc spec.
70 MHz to 240 MHz	< -22 dBc spec.	< -17 dBc spec.		200 MHz to 500 MHz	< -22 dBc spec.	< -20 dBc spec.
Harmonic distortion (High voltage amplifier 50 Ω into 50 Ω)						
		10 V_{pp}				
1 μHz to 8 MHz	< -40 dBc					
8 MHz to 50 MHz	< -25 dBc					
Non-harmonic (spurious) distortion						
1 μHz to 20 MHz	-60 dBc typ.			1 μHz to 1 MHz	-50 dBc typ.	
20 MHz to 200 MHz	-55 dBc typ.			1 MHz to 10 MHz	-55 dBc typ.	
200 MHz to 240 MHz	-50 dBc typ.			10 MHz to 280 MHz	-50 dBc typ.	
				280 MHz to 330 MHz	-45 dBc typ.	
				330 MHz to 500 MHz	-43 dBc typ.	
SSB phase noise (10 kHz offset)						
1 MHz	-119 dBc/Hz typ.			1 MHz	-115 dBc/Hz typ.	
10 MHz	-115 dBc/Hz typ.			10 MHz	-115 dBc/Hz typ.	
100 MHz	-			100 MHz	-110 dBc/Hz typ.	
240 MHz	-93 dBc/Hz typ.			240 MHz	-	
500 MHz	-			500 MHz	-100 dBc/Hz typ.	

Square characteristics

	81150A	81160A
Frequency range		
High bandwidth amplifier	1 μ Hz to 120 MHz	1 μ Hz to 330 MHz
High voltage amplifier	1 μ Hz to 50 MHz	
Frequency resolution	1 μ Hz	1 μ Hz
Duty cycle		
High bandwidth amplifier	(Freq/240 MHz) to 1 – (Freq/240 MHz) e.g. 60 MHz; 25% to 75%	(Freq/ 660 MHz) to 1 – (Freq/ 660 MHz) e.g. 115 MHz; 25% to 75% e.g. 3.3 MHz; 0.5% to 99.5%
High voltage amplifier	(Freq/100 MHz) to 1 – (Freq/100 MHz) e.g. 1 MHz 1% to 99%	
Resolution	0.1%	0.1%
Transition time (10% to 90%)		
High bandwidth amplifier	2.5 ns typ. fixed	1.1 ns typ. fixed
High voltage amplifier	6 ns typ. fixed	
Overshoot	2% typ.	4% typ.

Ramp characteristics

	81150A	81160A
Frequency range	1 μ Hz to 5 MHz	1 μ Hz to 20 MHz
Frequency resolution	1 μ Hz	1 μ Hz
Linearity	< 0.1% (f < 10 kHz)	< 0.1% (f < 10 kHz)
Symmetry	0.0% to 100%	0.0% to 100%

Noise characteristics

	81150A	81160A
Bandwidth		
High bandwidth amplifier	120 MHz typ.	160 MHz typ.
High voltage amplifier	40 MHz typ.	
Amplitude distribution	Selectable Gaussian, user defined	Selectable Gaussian, user defined
Crest factor (peak/RMS) selectable	3.1, 4.8, 6.0, 7.0 typ. (Gaussian distribution)	3.1, 4.8, 6.0, 7.0 typ. (Gaussian distribution)
Noise type	Deterministic, triggerable	Deterministic, triggerable
Repetition time	~ 26 days	~ 20 days

Arbitrary characteristics

	81150A	81160A
DAC sample rate	2 GSa/s ¹ , fixed	2.5 GSa/s, fixed
Waveform length	2 to 512 k points	1-channel instrument: 2 to 256 k points 2-channel instrument: 2 to 128 k points
Wavelength vs. memory access rate	2 to 512 k points at memory access rate 1,000 MSa/s ¹	1-channel instrument, automatic selection: 128 k to 256 k points at memory access rate 625 MSa/s ² 64 k to 128 k points at memory access rate 1,250 MSa/s ³ 2 to 64 k points at memory access rate 2,500 MSa/s 2-channel instrument, automatic selection: 64 k to 128 k points at memory access rate 625 MSa/s ² 32 to 64 k points at memory access rate 1,250 MSa/s ³ 2 to 32 k points at memory access rate 2,500 MSa/s
DAC resolution	14 bits	14 bits
Frequency range	1 µHz to 120 MHz	1 µHz to 330 MHz
Frequency resolution	1 µHz	1 µHz
Transition time (10% to 90%)		
High bandwidth amplifier	1.7 ns typ.	1.0 ns typ.
High voltage amplifier	5 ns typ.	
Filter bandwidth		
High bandwidth amplifier	240 MHz typ.	500 MHz typ.
High voltage amplifier	80 MHz typ.	
PP jitter	1 ns typ.	400 ps typ. at memory sample rate 2,500 MSa/s

1. One step linear interpolation between two memory samples. DAC clock rate is 2,000 MSa/s.
2. Three steps linear interpolation between two memory samples. DAC clock rate is 2,500 MSa/s.
3. One step linear interpolation between two memory samples. DAC clock rate is 2,500 MSa/s

Advanced Modes

Three advanced modes exist:

- Modulation: selects the modulation type: AM, FM, PM, FSK, PWM
- Sweep: for frequency sweeps
- Bursts: repeats selected waveform n times

Modulation

A modulation input (for AM, FM, PM, FSK, PWM) for each channel is provided on the back-panel. In the two-channel instrument one channel can also modulate the other channel.

Modulation In 1/modulation In 2

	81150A	81160A
Input range (full scale)	Selectable ± 2.5 V or ± 5 V	± 2.5 V
Frequency range	DC to 10 MHz	DC to 10 MHz
Input impedance	Selectable 10 k Ω , 50 Ω nom.	Selectable 10 k Ω , 50 Ω nom.
Connector	BNC, back panel	BNC, back panel

AM

	81150A	81160A
Carrier waveforms	Sine, square, ramp, arbitrary	Sine, square, ramp, arbitrary
Internal modulation	Sine, square, ramp (up, 50%, down), noise, arbitrary	Sine, square, ramp (up, 50%, down), noise, arbitrary
Modulation frequency		
Internal	1 MHz to 10 MHz	1 MHz to 50 MHz
External	DC to 10 MHz	DC to 10 MHz
Depth	0% to 120%	0% to 120%
Double-sideband suppressed carrier	Selectable on/off	Selectable on/off
Source	Internal, external, channel	Internal, external, channel

FM

	81150A	81160A
Carrier waveforms	Sine, square, ramp, arbitrary	Sine, square, ramp, arbitrary
Internal modulation	Sine, square, ramp (up, 50%, down), noise, arbitrary	Sine, square, ramp (up, 50%, down), noise, arbitrary
Modulation frequency		
Internal	1 MHz to 10 MHz	1 MHz to 50 MHz
External	DC to 10 MHz	DC to 10 MHz
Deviation range	1 μ Hz to 240 MHz ¹	1 μ Hz to 500 MHz ¹
Source	Internal, external, channel	Internal, external, channel

PM

	81150A	81160A
Carrier waveforms	Sine, square, ramp, arbitrary	Sine, square, ramp, arbitrary
Internal modulation	Sine, square, ramp (up, 50%, down), noise, arbitrary	Sine, square, ramp (up, 50%, down), noise, arbitrary
Modulation frequency		
Internal	1 MHz to 10 MHz	1 MHz to 50 MHz
External	DC to 10 MHz	DC to 10 MHz
Deviation range	0 to 360°	0 to 360°
Source	Internal, external, channel	Internal, external, channel

1. Max frequency depends on selected waveform.

FSK

	81150A	81160A
Carrier waveforms	Sine, square, ramp, arbitrary	Sine, square, ramp, arbitrary
Internal modulation	50% square	50% square
FSK rate		
Internal	1 mHz to 50 MHz	1 mHz to 50 MHz
External	1 mHz to 10 MHz	1 mHz to 10 MHz
Frequency range	1 mHz to 240 MHz ^{1,2}	1 mHz to 500 MHz ¹
Source	Internal, external, channel	Internal, external, channel

1. Max frequency depends on selected waveform.

2. For export control: Effective switching time is 40 ns.

PWM

	81150A	81160A
Carrier waveform	Pulse	Pulse
Internal modulation	Sine, square, ramp (up, 50%, down), noise, arbitrary	Sine, square, ramp (up, 50%, down), noise, arbitrary
Modulation frequency		
Internal	1 mHz to 10 MHz	1 mHz to 50 MHz
External	DC to 10 MHz	DC to 10 MHz
Deviation range	0% to 100% of pulse width	0% to 100% of pulse width
Source	Internal, external, channel	Internal, external, channel

Sweep

An independent frequency sweep is provided for each channel.

	81150A	81160A
Waveforms	Pulse, sine, square, ramp, triangle, arbitrary	Pulse, sine, square, ramp, triangle, arbitrary
Type	Linear or logarithmic	Linear or logarithmic
Direction	Up or down	Up or down
Sweep time	100 μ s to 500 s	50 μ s to 500 s
Start frequency/stop frequency	1 μ s to 240 MHz ³	1 μ Hz to 500 MHz ¹
Amplitude flatness (relative to 1 kHz, 2 V _{pp})	–	1 μ Hz to 500 MHz \pm 0.5 dB typ.
Trigger source	External, internal, manual	External, internal, manual
Marker	Frequency marker	Frequency marker

3. Max frequency depends on selected waveform.

Burst

An independent burst capability is provided for each channel.

	81150A	81160A
Waveforms	Pulse, sine, square, ramp, triangle, arbitrary	Pulse, sine, square, ramp, triangle, arbitrary
Frequency	1 μ Hz to 120 MHz	1 μ Hz to 330 MHz
Modes	Externally triggered, internally triggered, externally gated	Externally triggered, internally triggered, externally gated
# of waveforms in a burst	2 to $2^{31} - 1$ (~ 2 billion)	2 to $2^{31} - 1$ (~ 2 billion)
Trigger period	16.7 ns to 9999 s	6.1 ns to 9999s
Start phase ⁴	-360 to +360°	-360 to +360°
Gate source	External	External
Trigger source	External, internal, manual	External, internal, manual

4. Available for all waveforms except pulse, square and ramp.

Outputs

Main outputs

A selectable single-ended or differential output is provided for each channel on the front-panel.

Max. frequency

	81150A	81160A
High bandwidth amplifier	120 MHz pulse/240 MHz sine	330 MHz pulse/500 MHz sine
High voltage amplifier	50 MHz	

Out 1/Out 2

	81150A	81160A
Output type	Single-ended or differential	Single-ended or differential
Amplitude (50 Ω into 50 Ω)		
High bandwidth amplifier		
1 μ Hz to 120 MHz	50 mV _{pp} to 5 V _{pp} ¹ typ.	
120 MHz to 240 MHz	50 mV _{pp} to 3V _{pp} ¹ typ.	
1 μ Hz to 330 MHz		50 mV _{pp} to 5 V _{pp} ¹ typ.
330 MHz to 500 MHz		50 mV _{pp} to 3 V _{pp} ¹ typ.
High voltage amplifier		
1 μ Hz to 50 MHz	100 mV _{pp} to 10 V _{pp} ¹ typ.	
Amplitude (50 Ω into open, 5 Ω into 50 Ω)		
High bandwidth amplifier		
1 μ Hz to 120 MHz	100 mV _{pp} to 10 V _{pp} ¹ (to 9 V _{pp} ²) typ.	
120 MHz to 240 MHz	100 mV _{pp} to 5 V _{pp} ¹ typ.	
1 μ Hz to 60 MHz		100 mV _{pp} to 10 V _{pp} ^{1,4} typ.
High voltage amplifier		
1 μ Hz to 50 MHz	200 mV _{pp} to 20 V _{pp} ¹ typ.	
DC amplitude accuracy	\pm (1.5% of setting + 5 mV)	\pm (1.5% of setting + 5 mV)
Voltage window (50 Ω into 50 Ω)		
High bandwidth amplifier	-5 V to +5 V typ.	-5 V to +5 V typ.
High voltage amplifier	-10 V to +10 V typ.	
Voltage window (50 Ω into open, 5 Ω into 50 Ω)		
High bandwidth amplifier	-10 V to +10 V ¹ (-9 V to +9 V ²) typ.	-10 V to +10 V typ. ⁴
High voltage amplifier	-20 V to +20 V typ.	
DC offset accuracy		
\pm 5 V voltage window	\pm (25 mV + 1%)	\pm (25 mV + 1%)
\pm 10 V voltage window	\pm (50 mV + 1%)	\pm (50 mV + 1%)
\pm 20 V voltage window	\pm (75 mV + 1%)	
Resolution	1 mV, 4 digits	1 mV, 4 digits
Output impedance	Selectable 50 Ω / 5 Ω typ.	50 Ω nom.
Variable load impedance	0.3 Ω to 1 M Ω ³	0.1 Ω to 1 M Ω
Protection	Short-circuit protected, overload disables main output	Short-circuit protected, overload disables main output
Connector	BNC, front panel	BNC, front panel

1. All amplitudes are single-ended amplitudes. Differential peak-peak amplitudes are twice the single-ended value.

2. 10 V_{pp} for 50 Ω into open; 9 V_{pp} for 5 Ω into 50 Ω .

3. Current of normal Out plus current of complement Out is limited to 440 mA per channel.

4. Only for 50 Ω into open.

Clock Reference

External reference output

	81150A	81160A
Frequency	10 MHz typ.	10 MHz spec.
Accuracy	± 50 ppm	± 10 ppm
Stability	± 2 ppm, 0 to 50 °C	± 2 ppm, 0 to 55 °C
Aging	± 1 ppm per year	± 1 ppm per year
Output level	1 V nom.	1 V nom.
Impedance	50 Ω nom., AC coupled	50 Ω nom., AC coupled
Connector	BNC, rear panel	BNC, rear panel

External reference input

	81150A	81160A
Lock range	10 MHz ± 500 ppm	10 MHz ± 500 ppm typ.
Input level	200 mV _{pp} to 5 V _{pp}	200 mV _{pp} to 5 V _{pp} typ.
Impedance	1 kΩ nom., AC coupled	1 kΩ nom., AC coupled
Connector	BNC, rear panel	BNC, rear panel

Internal frequency characteristics

	81150A	81160A
Accuracy	± 50 ppm	±10 ppm
Stability	± 2 ppm, 0 to 50 °C	± 2 ppm, 0 to 55 °C
Aging	± 1 ppm per year	± 1 ppm per year

External Input

A common external input is provided for both channels on the front panel. The external input is used for external trigger or external gate modes.

	81150A	81160A
Frequency range	DC to 120 MHz	DC to 330 MHz
Input range	-10 V to +10 V	-5 V to +5 V
Maximum input amplitude	10 V _{pp}	10 V _{pp}
Input sensitivity	200 mV _{pp}	Hysteresis low: 200 mV _{pp} Hysteresis high: 350 mV _{pp}
Threshold		
Range	-10 V to 10 V	-5 V to +5 V
Resolution	100 mV	100 mV
Impedance	Selectable 10 kΩ/50 Ω, DC coupled	Selectable, 1 kΩ/50 Ω, DC coupled
Slope	Selectable, rising/falling/both	Selectable, rising/falling/both
Pulse width	> 3.3 ns	> 1.3 ns
Transition time	< 100 ns	
Connector	BNC, front panel	BNC, front panel

Frequency counter

The frequency applied to external input is measured

Gate time, up to 330 MHz	–	1 s, fix
Accuracy	–	See clock reference specifications

81150A Trigger Outputs

For 81150A, a separate trigger output is provided for each channel on the front-panel.

In advanced mode internally/externally modulated (AM, FM, PM, PWM), the trigger output has the frequency of the unmodulated carrier waveform, with a 50% duty cycle.

For FSK modulation, the trigger output has the same frequency as the data output. That is, it alternates between the two frequencies.

If noise is selected, a trigger signal is generated when noise is restarted internally, externally or manually.

For all other modes of operation the trigger signal (TRIGGER OUT) marks the start of each waveform period.

81150A Trigger Out 1/Trigger Out 2

81150A	
Output level	Selectable TTL/ECL
TTL	0 V/2.5 V nom.
ECL	-0.85 V/-1.80 V nom.
Pulse width	
Internally triggered, continuous	50% duty cycle typ.
Externally triggered	4 ns typ.
Transition time (20% to 80%)	2.0 ns typ.
Maximum rate	120 MHz ¹
Impedance	50 Ω nom.
Connector	BNC, front panel

1. For output frequencies > 120 MHz, the trigger rate is ¼ of the output frequency. If a frequency sweep or a FSK frequency exceeds 120 MHz, the trigger rate is ¼ of the output frequency.

81150A Strobe Outputs

A strobe output is provided for each channel on the front-panel of pulse generator 81150A. The strobe output signal has a different function, depending on the mode of operation.

If no advanced mode is selected, the strobe output is a constant low.

In advanced mode internally/ externally triggered or gated burst, the strobe output provides a signal indicating the duration of a burst. The rising edge of the strobe signal is synchronized to the start of the first waveform period in a burst. The falling edge is synchronized to the start of the last waveform period in the burst.

In advanced mode sweep with the frequency marker off, the strobe output is a pulse with half the duration of the sweep. The strobe signal goes high at the beginning of the sweep.

In advanced mode sweep with the frequency marker on, the strobe output goes high at the beginning of the sweep and goes low at the marker frequency.

In pattern mode (block mode = On), the strobe output goes high at the beginning of the pattern and goes low at the last bit of the pattern. Refer to the User Guide for more details.

In advanced mode internally/externally modulated (AM, FM, FSK, PM, PWM), the strobe output is the analog modulation waveform.

In pattern mode (block mode = On), the logical strobe signal goes high at the beginning of the pattern and goes low at the last bit of the pattern. Refer to the User Guide for more details.

81150A Strobe Out 1/Strobe Out 2

	81150A
Digital output level	Selectable TTL/ECL
TTL	0 V/2.5 V nom.
ECL	-0.85 V/-1.80 V nom.
Analog output level (modulator)	-2.0 V to 2.0 V (full scale)
Impedance	50 Ω nom.
Connector	BNC, front panel
Min pulse width	4 ns typ.
Transition time (20% to 80%)	2.0 ns typ.

81160A Trigger and Strobe Outputs Sync Out A and Sync Out B

For the one-channel instrument as well as the two-channel instrument two high speed outputs Sync Out A and Sync Out B are provided at the front panel. The Sync output signals can be configured very flexibly by an internal switch matrix to output the logical Trigger Out functionality or Strobe Out functionality according to the following switch matrix.

1-channel instrument

81160A	
Sync Out A source	None, logical trigger signal 1, logical strobe signal 1
Sync Out B source	None, logical trigger signal 1, logical strobe signal 1

It is e.g. possible, that the logical trigger signal 1 functionality is routed simultaneously to Sync.

2-channel instrument

81160A	
Sync Out A source	None, logical trigger signal 1, logical strobe signal 1, logical trigger signal 2, logical strobe signal 2
Sync Out B source	None, logical trigger signal 1, logical strobe signal 1, logical trigger signal 2, logical strobe signal 2

It is e.g. possible, that the logical trigger signal 1 functionality is routed simultaneously to Sync.

Sync Out A/Sync Out B

81160A	
Digital output level	Selectable TTL, ECL
TTL	0 V/2.5 V nom.
ECL	-0.85 V/-1.80 V nom.
Analog output level (modulator)	-2.0 V to 2.0 V (full scale), Available, if routed to logical Strobe Out
Impedance	50 Ω nom.
Transition time	0.8 ns typ. (20%/80%)
Connector	BNC, front panel

The logical trigger output and logical strobe output functionality is described below.

Logical trigger signal

The logical trigger signal is an internally generated signal that can be routed to the BNC connector of Sync Out A or Sync Out B. For the two-channel instrument, the logical trigger signal is generated for both, channel 1 and channel 2.

In advanced mode internally/externally modulated (AM, FM, PM, PWM), the logical trigger signal has the frequency of the unmodulated carrier waveform with 50% duty cycle.

For FSK modulation the logical trigger signal generates the same frequency as the data output – it alternates between the two frequencies.

If noise is selected, a trigger signal is generated when noise is restarted internally, externally or manually.

For all other modes of operation the logical trigger signal marks the start of each waveform period.

Logical trigger signal 1/logical trigger signal 2

81160A	
Pulse width	
Internally triggered, continuous	50% duty cycle typ.
Externally triggered	1.5 ns typ.
Maximum rate	330 MHz ¹

1. For output frequencies > 330 MHz, the trigger rate is ½ of the output frequency. In pattern mode with bit rate > 330 MBit/s, the trigger rate is ½ of the output frequency. If a frequency sweep or a FSK frequency exceeds 330 MHz, the trigger rate is ½ of the output frequency.

Logical strobe signal

The logical strobe signal is an internally generated signal that can be routed to the BNC connector of Sync Out A or Sync Out B. For the two-channel instrument, the logical strobe signal is generated for both, channel 1 and channel 2.

The logical strobe signal has a different function, depending on the mode of operation. If no advanced mode is selected, the logical strobe signal is constant low.

In advanced mode internally/externally triggered or gated burst, the logical strobe signal provides a signal indicating the duration of a burst. The rising edge of the logical strobe signal is synchronized to the start of the first waveform period in a burst. The falling edge is synchronized to the start of the last waveform period in the burst.

In advanced mode sweep with the frequency marker off, the logical strobe signal is a pulse with half of the duration of the sweep. The strobe signal goes high at the beginning of the sweep.

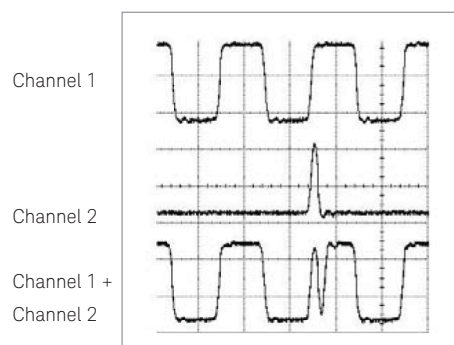
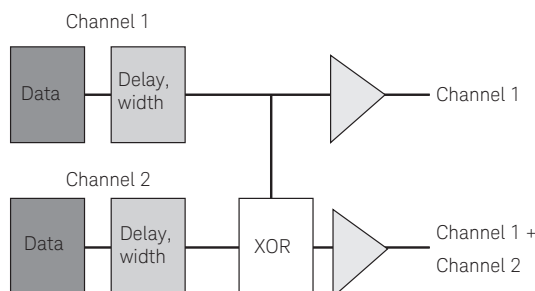
In advanced mode sweep with the frequency marker on, the logical strobe signal goes high at the beginning of the sweep and goes low at the marker frequency.

In advanced mode internally/externally modulated (AM, FM, FSK, PM, PWM), the logical strobe signal is the analog modulation waveform.

In pattern mode (block mode = On), the logical strobe signal goes high at the beginning of the pattern and goes low at the last bit of the pattern. Refer to the User Guide for more details.

Digital Channel Addition

If the instrument is equipped with two output channels, channel 2 can be added to channel 1 internally. The maximum output voltage of channel 1 remains unchanged. If channel addition is selected, channel 2 outputs the unchanged waveform of channel 2.



Timing Characteristics

External In timing characteristics

	81150A	81160A
Delay: External In to Main Out 1, 2		
Fix delay		
Advance mode: off, burst	366 ns typ.	404 ns typ.
Advanced mode: sweep	350 ns typ.	404 ns typ.
Pattern mode: on Variable delay ¹	406 ns typ.	404 ns typ.
Range	Independent for Out 1, Out 2	Independent for Out 1, Out 2
Resolution	0 s to 1000 s ²	0 s to 1000 s ²
Accuracy	1 ps, 6 digits ± 25 ps ± 50 ppm	1 ps, 6 digits ± 35 ps ± 50 ppm
Delay	External In to Trigger Out 1, 2	External In to Sync Out A, B
Fix delay		
Advanced mode: off, burst	366 ns typ.	404 ns typ.
Advanced mode: sweep	350 ns typ.	404 ns typ.
Pattern mode: on	406 ns typ.	404 ns typ.
Jitter ³		
External In to Main Out 1, 2	15 ps RMS typ.	15 ps RMS typ.
External In to Trigger Out 1, 2	15 ps RMS typ.	–
External In to Strobe Out 1, 2	15 ps RMS typ.	–
External In to Sync Out A, B	–	15 ps RMS typ.

1. Not available, if sweep or modulation is selected
2. Trigger period ≥ variable delay
3. External In amplitude > 500 mV. External In transition time < 10 ns. Valid for externally triggered pulse, square, sine, ramp, arb. Externally triggered noise or externally triggered sweep has peak-peak jitter of 8 ns for the 81150A and 3.2 ns for the 81160A, measured with 50 Ω source impedance at main output.

Continuous or internally triggered timing characteristics

	81150A	81160A
Delay	Trigger Out 1, 2 to Main Out 1, 2	Sync Out A, B to Main Out 1, 2
Fix delay	0 ns typ.	0 ns typ.
Variable delay Out 1, 2 ¹	Independent for Out 1, Out 2	Independent for Out 1, Out 2
Range in continuous mode ²	0 to 1 waveform period	0 to 1 waveform period
Range in internally triggered mode ³	0 s to 1000 s typ.	0 s to 1000 s spec.
Resolution	1 ps, 6 digits	1 ps, 6 digits
Accuracy	± 25 ps ± 50 ppm	± 35 ps ± 50 ppm
Delay	Trigger Out 1, 2 to Strobe Out 1, 2	Sync Out A to Sync Out B
Advanced mode: burst	0 ns typ.	0 ns typ.
Jitter ⁴	Jitter Main Out 1, 2 to Main Out 1, 2: 7 ps RMS typ. Trigger Out 1, 2 to Main Out 1, 2: 8 ps RMS typ. Trigger Out 1, 2 to Strobe Out 1, 2: 9 ps RMS typ. Trigger Out 1, 2 to Trigger Out 1, 2: 9 ps RMS typ.	Jitter Main Out 1, 2 to Main Out 1, 2: 7 ps RMS typ. Sync Out A, B to Main Out 1, 2: 8 ps RMS typ. Sync Out A to Sync Out B: 9 ps RMS typ.

1. Not available, if sweep or modulation is selected.
2. Advanced mode = off or advanced mode = burst.
3. Trigger period \geq variable delay.
4. Measured with 50 Ω source impedance at Main Out. Valid for continuous or internally triggered pulse, square, sine, ramp, arb. Internally triggered or continuous noise or sweep has peak-peak jitter of 8 ns typ. for the 81150A and 3.2 ns for the 81160A.

Coupled mode On timing characteristics

	81150A	81160A
Delay: Main Out 1 to Main Out 2		
Fix delay	0 ns typ.	0 ns typ.
Variable delay Out 1, 2 ⁵	Independent for Out 1, Out 2	Independent for Out 1, Out 2
Range in continuous mode ⁶	0 to 1 waveform period	0 to 1 waveform period
Range in internally triggered mode ⁷	0 s to 1000 s typ.	0 s to 1000 s spec.
Resolution	1 ps, 6 digits	1 ps, 6 digits
Accuracy	± 25 ps ± 50 ppm	± 35 ps ± 50 ppm

5. Not available, if sweep or modulation is selected.
6. Advanced mode = off or advanced mode = burst.
7. Trigger period \geq variable delay.

Pattern generator (optional)

	81150A Option PAT	81160A Option 330	81160A Option 660
Data rate	1 μ bit/s to 120 Mbit/s (with internal pattern source)	1 μ bit/s to 330 Mbit/s	1 μ bit/s to 660 Mbit/s
Pattern memory	16 Mbit with 1 bit resolution	4 Mbit for 1-channel instrument 2 Mbit per channel for 2-channel instrument	
Pattern memory resolution	1 bit		1 bit for data rate 1 μ bit/s to 330 Mbit/s 2 bits for data rate 330 Mbit/s to 660 Mbit/s
Number of levels	2, 3, or 4 (user selectable)		
Sequencing	Preamble followed by one looped data block-loop count: 1 – 10,000,000 the whole sequence can loop indefinitely or triggered		
Trigger modes	Continuous, gated, one bit per trigger event, one sequence per trigger event		
Pattern sources	Internal: PRBS -7, 9, 11, 15, 23, and 31 User-defined External: Pass through pattern mode. Pattern is applied and sampled at Modulation In. Indefinite pattern length. Up to 10 Mbit/s. Selectable automatic sampling for asynchronous operation or fix sampling for synchronous operation		
External sampling	Automatic and fix		
Pattern modulation	AM, FM, PM		
Arbitrary bit shapes	User-defined and predefined bit transitions with up to 64 arbitrary waveform points per bit transition		

Download Times

Block transfer is the fastest way to download waveforms to both the Keysight 81150A and 81160A Pulse Function Arbitrary Noise Generators.

Download times: block transfer (meas.)

	81150A			81160A		
	USB 2.0	GPIB	LAN	USB 2.0	GPIB	LAN
1 k points	31 ms typ.	35 ms typ.	35 ms typ.	23 ms typ.	44 ms typ.	27 ms typ.
8 k points	65 ms typ.	120 ms typ.	80 ms typ.	68 ms typ.	198 ms typ.	86 ms typ.
64 k points	700 ms typ.	1 s typ.	730 ms typ.	330 ms typ.	1.36 s typ.	449 ms typ.
256 k points	–	–	–	1.25 s typ.	5.4 s typ.	1.75 s typ.
512 k points	2.9 s typ.	5.2 s typ.	3.7 s typ.	–	–	–

Download times: integer comma separated values (meas.)

	81150A			81160A		
	USB 2.0	GPIB	LAN	USB 2.0	GPIB	LAN
1 k points	220 ms typ.	200 ms typ.	220 ms typ.	214 ms typ.	188 ms typ.	181 ms typ.
8 k points	1.8 s typ.	1.6 s typ.	1.4 s typ.	1.6 s typ.	1.45 s typ.	1.39 s typ.
64 k points	14.2 s typ.	12.6 s typ.	12 s typ.	13.0 s typ.	11.5 s typ.	11.0 s typ.

Download times: float comma separated values (meas.)

	81150A			81160A		
	USB 2.0	GPIB	LAN	USB 2.0	GPIB	LAN
1 k points	290 ms typ.	280 ms typ.	270 ms typ.	297 ms typ.	256 ms typ.	236 ms typ.
8 k points	2.4 s typ.	2.1 s typ.	1.9 s typ.	2.23 s typ.	1.98 s typ.	1.8 s typ.
64 k points	20 s typ.	16 s typ.	15 s typ.	18.2 s typ.	15.7 s typ.	14.3 s typ.

General Specifications

	81150A	81160A
Power supply	100 V to 240 V ~, 50 to 60 Hz 100 V to 127 V ~, 50 to 400 Hz	100 V to 240 V ~, 50 to 60 Hz 100 V to 127 V ~, 50 to 400 Hz
Power consumption	110 W nom.	90 W nom.
Operating temperature	0 to 50 °C	0 to 55 °C
Operating altitude	Up to 2000 m	Up to 2000 m
Storage temp.	-40 to 70 °C	-40 to 70 °C
Stored states	4 named user configurations and factory default	4 named user configurations and factory default
Power on state	Default or last state	Default or last state
Interface	2 x USB 2.0 standard A, 1 x USB 2.0 standard B, GPIB and LAN	2 x USB 2.0 standard A, 1 x USB 2.0 standard B, GPIB and LAN
Programming language	SCPI-1997 IEEE-488.2 LXI compliant to LXI class C (rev. 1.1)	SCPI-1997 IEEE-488.2 LXI compliant to LXI class C (rev. 1.1)
Dimensions (WxHxD)		
Bench top	439 mm x 108 mm x 456 mm	439 mm x 108 mm x 456 mm
Rack mount	428 mm x 89 mm x 439 mm	428 mm x 89 mm x 439 mm
Weight	8 kg	8 kg
Safety designed to	IEC61010-1 UL61010 CSA22.2 61010.1 certified	IEC61010-1 UL61010 CSA22.2 61010.1 certified
EMC tested to	IEC61326	IEC61326
Warm up time	30 min.	30 min.
Calibration interval	2 years recommended	2 years recommended
Cooling requirements	When operating the instrument choose a location that provides at least 80 mm of clearance at rear, and at least 30mm of clearance at each side	When operating the instrument choose a location that provides at least 80 mm of clearance at rear, and at least 30mm of clearance at each side

Definitions

Specification (spec.)	The warranted performance of a calibrated instrument that has been stored for a minimum of 2 hours within the operating temperature range of 0 °C to 55 °C and after a 45-minute warm up period. Within ± 10 °C after autocal. All specifications include measurement uncertainty and were created in compliance with ISO-17025 and Z540 methods. Data published in this document are specifications (spec.) only where specifically indicated.
Typical (typ.)	The characteristic performance, which 80% or more of manufactured instruments will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 23 °C).
Nominal (nom.)	The mean or average characteristic performance, or the value of an attribute that is determined by design such as a connector type, physical dimension, or operating speed. This data is not warranted and is measured at room temperature (approximately 23 °C).
Measured (meas.)	An attribute measured during development for purposes of communicating the expected performance. This data is not warranted and is measured at room temperature (approximately 23 °C).
Accuracy	Represents the traceable accuracy of a specified parameter. Includes measurement error and timebase error, and calibration source uncertainty.

Available Modes of Operation

Continuous

		81150A and 81160A						
		Pulse	Square	Sine	Ramp	Noise	Arb	DC
Advanced mode: off		Y	Y	Y	Y	Y	Y	Y
Advanced mode: burst		Y	Y	Y	Y	N	Y	N
Advanced mode: modulation	AM	N	Y	Y	Y	N	Y	N
	FM	N	Y	Y	Y	N	Y	N
	PM	N	Y	Y	Y	N	Y	N
	FSK	N	Y	Y	Y	N	Y	N
	PWM	Y	N	N	N	N	N	N
Advanced mode: sweep		N	Y	Y	Y	N	Y	N

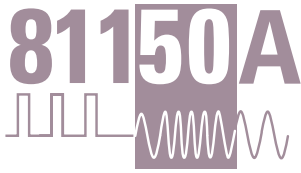
Internally triggered or externally triggered

		81150A and 81160A						
		Pulse	Square	Sine	Ramp	Noise	Arb	DC
Advanced mode: off		Y	Y	Y	Y	Y	Y	N
Advanced mode: burst		Y	Y	Y	Y	N	Y	N
Advanced mode: modulation	AM	N	N	N	N	N	N	N
	FM	N	N	N	N	N	N	N
	PM	N	N	N	N	N	N	N
	FSK	N	N	N	N	N	N	N
	PWM	N	N	N	N	N	N	N
Advanced mode: sweep		N	Y	Y	Y	N	Y	N

Gated

		81150A and 81160A						
		Pulse	Square	Sine	Ramp	Noise	Arb	DC
Advanced mode: off		Y	Y	Y	Y	Y	Y	N
Advanced mode: burst		Y	Y	Y	Y	N	Y	N
Advanced mode: modulation	AM	N	N	N	N	N	N	N
	FM	N	N	N	N	N	N	N
	PM	N	N	N	N	N	N	N
	FSK	N	N	N	N	N	N	N
	PWM	N	N	N	N	N	N	N
Advanced mode: sweep		N	Y	Y	Y	N	Y	N

Ordering Information for



Keysight 81150A

#001	1-channel pulse function arbitrary noise generator
#002	2-channel pulse function arbitrary noise generator
#1A7	ISO17025 calibration documents
#Z54	Z540.3 calibration documents
#PAT	License for 120 Mbit/s pattern generator

Accessories included

- Certificate of calibration
- Local power cord
- USB cable
- Product CD
(User Guide, Getting Started Guide, IVI-COM driver, examples for remote access)

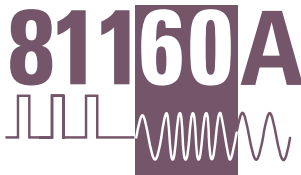
Optional accessories

#DOC	Printed documentation. Includes printed Getting Started Guide and printed User Guide
#1CP	Rack mount kit

Upgrades for 81150A, 81150AU

#PAT	License for pattern generator
#DOC	Printed documentation
#EHD	Fixture for 100 Mbit Ethernet and HDMI 1.4

Ordering Information for



Keysight 81160A

#001	1-channel pulse function arbitrary noise generator
#002	2-channel pulse function arbitrary noise generator
#1A7	ISO17025 calibration documents
#Z54	Z540.3 calibration documents
#330	License for 330 Mbit/s pattern generator
#660	License for 660 Mbit/s pattern generator

Accessories included

- Certificate of calibration
- Local power cord
- USB cable
- Product CD
(User Guide, Getting Started Guide, IVI-COM driver, examples for remote access)

Optional accessories

#DOC	Printed documentation. Includes printed Getting Started Guide and printed User Guide
#1CP	Rack mount kit

Upgrades for 81160A, 81160AU

#330	License for 330 Mbit/s pattern generator
#660	License for 660 Mbit/s pattern generator
#326	License for upgrade from 330 Mbit/s to 660 Mbit/s pattern generator
#DOC	Printed documentation

Related Literature

Literature title	Publication number
<i>Pulse Pattern and Data Generators, Brochure</i>	5980-0489E
<i>81150A and 81160A Pulse Function Arbitrary Noise Generator, Demo Guide</i>	5989-7718EN
<i>81150A Pulse Function Arbitrary Noise Generator, Flyer</i>	5989-7720EN
<i>81150A and 81160A Pulse Function Arbitrary Noise Generator, Application Booklet</i>	5989-7860EN
<i>81150A Quick Fact Sheet</i>	5990-4565EN
<i>81160A Quick Fact Sheet</i>	5990-6984EN
<i>33503A BenchLink Waveform Builder Pro Software, Data Sheet</i>	5990-7569EN

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Keysight Technologies

E8257D PSG

Microwave Analog Signal Generator

Data Sheet

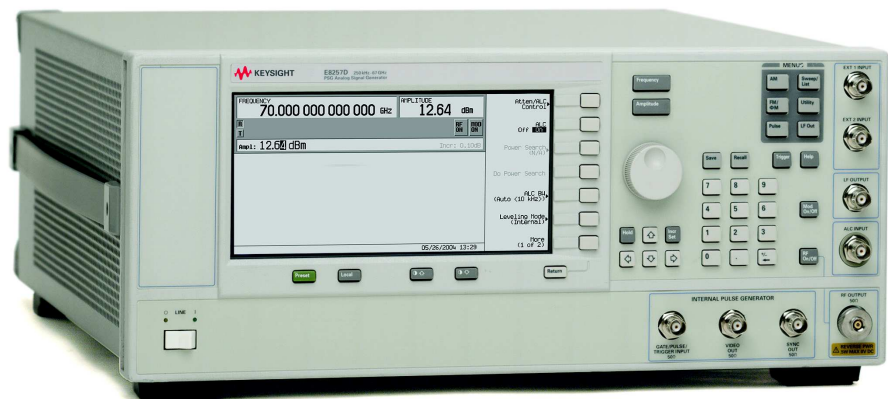


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Introduction

The Keysight E8257D is a fully-synthesized signal generator with high output power, low phase noise, and modulation capability.

Specifications apply over a 0 to 55 °C range, unless otherwise stated, and apply after a 45 minute warm-up time. Supplemental characteristics, denoted as typical, nominal, or measured, provide additional (non-warranted) information at 25 °C, which may be useful in the application of the product.

Unless otherwise noted, this data sheet applies to units with serial numbers ending with 50420000 or greater.

Definitions

Specifications (spec): Represents warranted performance for instruments with a current calibration.

Typical (typ): Represents characteristic performance which is non-warranted. Describes performance that will be met by a minimum of 80% of all products.

Nominal (nom): Represents characteristic performance which is non-warranted. Represents the value of a parameter that is most likely to occur; the expected mean or mode of all instruments at room temperature (approximately 25 °C).

Measured: Represents characteristic performance which is non-warranted. Represents the value of a parameter measured on an instrument during design verification.

Specifications

Frequency			
Range	Specified range	Tunable range	
Option 513	250 kHz to 13 GHz	100 kHz to 13 GHz	
Option 520	250 kHz to 20 GHz	100 kHz to 20 GHz	
Option 521 ¹	10 MHz to 20 GHz	10 MHz to 20 GHz	
Option 532	250 kHz to 31.8 GHz	100 kHz to 31.8 GHz	
Option 540	250 kHz to 40 GHz	100 kHz to 40 GHz	
Option 550	250 kHz to 50 GHz	100 kHz to 50 GHz	
Option 567	250 kHz to 67 GHz	100 kHz to 70 GHz	
Resolution			
CW	0.001 Hz		
All sweep modes ²	0.01 Hz		
CW switching speed ^{3, 4, 5}	Standard	Opt UNX	Opt UNY
	< 11 ms (typ)	< 11 ms (typ)	< 26 ms (typ)
	< 7 ms (nom)	< 7 ms (nom)	< 22 ms (nom)
Phase offset	Adjustable in nominal 0.1 ° increments		
Frequency bands	Frequency range	N ⁶	
1	250 kHz to 250 MHz	1/8	
2	> 250 to 500 MHz	1/16	
3	> 500 MHz to 1 GHz	1/8	
4	> 1 to 2 GHz	1/4	
5	> 2 to 3.2 GHz	1/2	
6	> 3.2 to 10 GHz	1	
7	> 10 to 20 GHz	2	
8	> 20 to 40 GHz	4	
9	> 40 GHz	8	
Accuracy	± [(time since last adjustment x aging rate) + temperature effects + line voltage effects + calibration accuracy]		
Internal timebase reference oscillator (OCXO)			
Aging rate ⁷	< ± 3 x 10 ⁻⁸ /year or < ± 2.5 x 10 ⁻¹⁰ /day after 30 days		
Initial achievable calibration accuracy	< ± 4 x 10 ⁻⁸		
Temperature effects (typ)	< ± 4.5 x 10 ⁻⁹ from 0 to 55 °C		
Line voltage effects (typ)	< ± 2 x 10 ⁻¹⁰ for ± 10% change		

- For Option 521, performance is degraded below 500 MHz. Refer to specifications for more detail.
- In ramp sweep mode (Option 007), resolution is limited with narrow spans and slow sweep speeds. Refer to ramp sweep specifications for more information.
- Time from GPIB trigger to frequency within 0.1 ppm of final frequency above 250 MHz or within 100 Hz below 250 MHz. CW switching speed to within 0.05% of final frequency is ≥ 5 ms (nom).
- Add 12 ms (typical) when switching from greater than 3.2 GHz to less than 3.2 GHz. Option HY2 switching speed is 30 ms (nom) for 250 kHz to 3.2 GHz and 40 ms (nom) for > 3.2 GHz.
- With Option 1EH low band harmonic filters off. With the 1EH filters turned on, add 4 ms.
- N is a factor used to help define certain specifications within the document.
- Not verified by Keysight N7800A TME Calibration and Adjustment Software. Daily aging rate may be verified as a supplementary chargeable service, on request.

Specifications (continued)

External reference			
Frequency	10 MHz only		
Lock range	± 1.0 ppm		
Reference output			
Frequency	10 MHz		
Amplitude	> +4 dBm into 50 Ω load (typ)		
External reference input			
Amplitude	5 dBm \pm 5 dB ¹		
Input impedance	50 Ω (nom)		
Step (digital) sweep			
Operating modes			
	Step sweep of frequency or amplitude or both (start to stop)		
	List sweep of frequency or amplitude or both (arbitrary list)		
Sweep range			
Frequency sweep	Within instrument frequency range		
Amplitude sweep	Within attenuator hold range (see "Output" section)		
Dwell time			
	1 ms to 60 s		
Number of points			
Step sweep	2 to 65535		
List sweep	2 to 1601 per table		
Triggering			
	Auto, external, single, or GPIB		
Settling time			
	Standard	Opt UNX	Opt UNY
Frequency ²	< 9 ms (typ)	< 9 ms (typ)	< 24 ms (typ)
Amplitude	< 5 ms (typ)	< 5 ms (typ)	< 5 ms (typ)

1. To optimize phase noise use 5 dBm \pm 2 dB.

2. 19 ms (typ) when stepping from greater than 3.2 GHz to less than 3.2 GHz. Option HY2 switching speed is 30 ms (nom) for 250 kHz to 3.2 GHz and 40 ms (nom) for > 3.2 GHz.

Specifications (continued)

Ramp (analog) sweep (Option 007) ¹			
Operating modes			
<ul style="list-style-type: none"> - Synthesized frequency sweep (start/stop), (center/span), (swept CW) - Power (amplitude) sweep (start/stop) - Manual sweep <ul style="list-style-type: none"> - RPG control between start and stop frequencies - Alternate sweep <ul style="list-style-type: none"> - Alternates successive sweeps between current and stored states 			
Sweep span range	Settable from minimum ² to full range		
Maximum sweep rate	Start frequency	Maximum sweep rate	Max span for 100 ms sweep
	250 kHz to < 0.5 GHz	25 MHz/ms	2.5 GHz
	0.5 to < 1 GHz	50 MHz/ms	5 GHz
	1 to < 2 GHz	100 MHz/ms	10 GHz
	2 to < 3.2 GHz	200 MHz/ms	20 GHz
	≥ 3.2 GHz	400 MHz/ms	40 GHz
Frequency accuracy	± 0.05% of span ± timebase (at 100 ms sweep time, for sweep spans less than maximum values given above). Accuracy improves proportionally as sweep time increases ³		
Sweep time (forward sweep, not including bandswitch and retrace intervals)			
Manual mode	Settable 10 ms to 200 seconds		
Resolution	1 ms		
Auto mode	Set to minimum value determined by maximum sweep rate and 8757D setting		
Triggering	Auto, external, single, or GPIB		
Markers	10 independent continuously variable frequency markers		
Display	Z-axis intensity or RF amplitude pulse		
Functions	M1 to center, M1/M2 to start/stop, marker delta		
Two-tone (master/slave) measurements ⁴	Two PSGs can synchronously track each other, with independent control of start/stop frequencies		
Network analyzer compatibility	Compatible with Keysight 8757D scalar network analyzer. Also useable with Keysight 8757A/C/E scalar network analyzers for making basic swept measurements. ⁵		

1. During ramp sweep operation, AM, FM, phase modulation, and pulse modulation are usable but performance is not guaranteed.
2. Minimum settable sweep span is proportional to carrier frequency and sweep time. Actual sweep span may be slightly different than desired setting for spans less than $[0.00004\% \text{ of carrier frequency or } 140 \text{ Hz}] \times [\text{sweep time in seconds}]$. Actual span will always be displayed correctly.
3. Typical accuracy for sweep times > 100 ms can be calculated from the equation: $[(0.005\% \text{ of span})/(\text{sweep time in seconds})] \pm \text{timebase}$. Accuracy is not specified for sweep times < 100 ms.
4. For master/slave operation use Keysight part number 8120-8806 master/slave interface cable.
5. GPIB system interface is not supported with 8757A/C/E, only with 8757D. As a result, some features of 8757A/C/E, such as frequency display, pass-through mode, and alternate sweep, do not function with PSG signal generators.

Specifications (continued)

Output					
Minimum settable output power					
Standard	-20 dBm				
With Option 1E1 step attenuator					
Options 513, 520, 521, 532, and 540	-135 dBm				
Options 550 and 567	-110 dBm				
Maximum output power (dBm) ¹			Spec (Typ)		
Frequency range ²	Standard	Option 1EU	Option 1E1	Options 1E1 + 1EU	Option HY2 ³
Options 513 and 520					
Low phase noise mode on					
10 to 250 MHz (filters on)	+11	+11 (+13)	+11	+11 (+13)	
1 to 250 MHz (filters off) ⁴	+15	+16 (+17)	+15	+16 (+17)	
Low phase noise mode off					
10 to 250 MHz (filters on)	+15	+15 (+17)	+15	+15 (+17)	
> 0.25 to 2 GHz (filters on)	+15	+16 (+17)	+15	+16 (+17)	
250 kHz to 10 MHz	+14	+14 (+17)	+14	+14 (+17)	
> 10 to < 60 MHz	+15	+16 (+19)	+15	+16 (+19)	
60 to 400 MHz	+15	+20 (+21)	+15	+20 (+21)	
> 0.4 to 3.2 GHz ⁵	+15	+21 (+23)	+15	+21 (+23)	
> 3.2 to 10 GHz	+15	+22 (+23)	+14	+21 (+22)	
> 10 to 20 GHz	+15	+21 (+23)	+14	+19 (+21)	
Option HY2 carrier frequency ⁶					
250 kHz to < 1 MHz					+14 (+17)
1 MHz to < 10 MHz					+16 (+17)
10 to 250 MHz					+11 (+13)
> 0.25 to 2 GHz					+16 (+17)
> 2 to 3.2 GHz					+21 (+23)
> 3.2 to 10 GHz					+21 (+22)
> 10 GHz to 20 GHz					+19 (+21)
Option 521 ⁷					
Low phase noise mode on					
10 to 250 MHz (filters on)	+11 (+13)	n/a	+11 (+13)	n/a	
10 to 250 MHz (filters off) ⁴	+16 (+17)	n/a	+16 (+17)	n/a	
Low phase noise mode off					
10 to 250 MHz (filters on)	+16 (+18)	n/a	+16 (+18)	n/a	
> 0.25 to 2 GHz (filters on)	+18 (+20)	n/a	+18 (+20)	n/a	
10 to 250 MHz	+19 (+21)	n/a	+19 (+21)	n/a	
> 0.25 to 1 GHz	+24 (+26)	n/a	+24 (+26)	n/a	
> 1 to 6 GHz ⁵	+28 (+30)	n/a	+28 (+30)	n/a	
> 6 to 14 GHz	+28 (+30)	n/a	+27 (+28)	n/a	
> 14 to 17.5 GHz	+26 (+28)	n/a	+25 (+27)	n/a	
> 17.5 to 20 GHz	+24 (+27)	n/a	+23 (+26)	n/a	

- Maximum power specifications are warranted from 15 to 35 °C, and are typical from 0 to 15 °C. Maximum power over the 35 to 55 °C range typically degrades less than 2 dB.
- With Option 1EH low-pass filters below 2 GHz switched off, unless otherwise specified.
- Option HY2 requires ordering Option 1E1 +1EH +1EU. Maximum power specifications are warranted from 15 to 35 °C and are typical from 0 to 15 °C. Maximum operating temperature of Option HY2 is 35 °C.
- In this mode, harmonics are large and output power refers to the total power including harmonics.
- With Option 1EH low-pass filters below 2 GHz switched off. With filters on, this specification applies above 2 GHz.
- With Option HY2 operating in SNR mode.
- Option 521 includes low-pass filters below 2 GHz as standard.

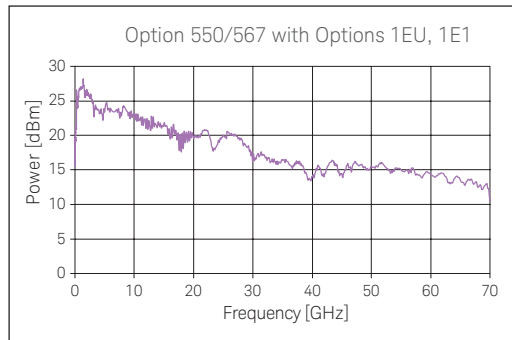
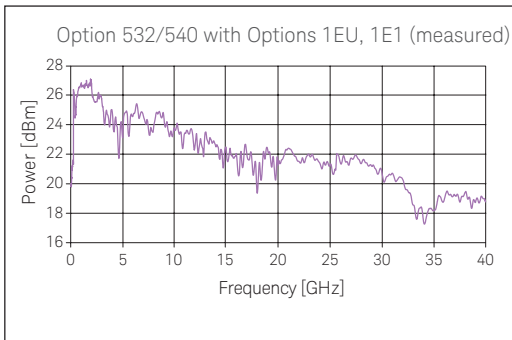
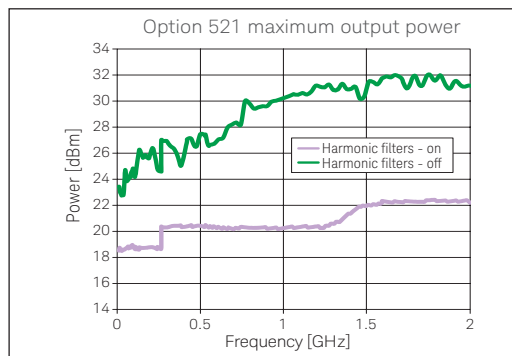
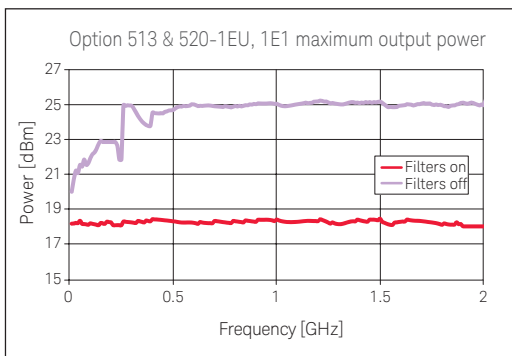
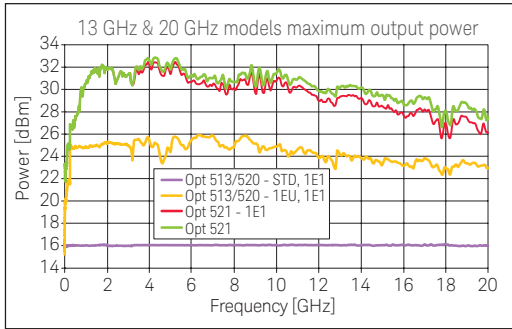
Specifications (continued)

Option 532 and 540				
Low phase noise mode on				
10 to 250 MHz (filters on)	+10	+10 (+12)	+10	+10 (+12)
1 to 250 MHz (filters off) ¹	+11	+15 (+16)	+11	+15 (+16)
Low phase noise mode off				
10 to 250 MHz (filters on)	+11	+14 (+16)	+11	+14 (+16)
> 0.25 to 2 GHz (filters on)	+11	+15 (+16)	+11	+15 (+16)
250 kHz to 10 MHz	+11	+13 (+16)	+11	+13 (+16)
> 10 to < 60 MHz	+11	+15 (+18)	+11	+15 (+18)
60 to 400 MHz	+11	+19 (+21)	+11	+19 (+21)
> 0.4 to 3.2 GHz ²	+11	+20 (+22)	+11	+20 (+22)
> 3.2 to 17 GHz	+11	+19 (+21)	+10	+17 (+20)
> 17 to 37 GHz	+11	+16 (+19)	+9	+14 (+17)
> 37 to 40 GHz	+11	+14 (+17)	+9	+12 (+16)
Option 550 and 567				
Low phase noise mode on				
10 to 250 MHz (filters on)	+5	+9 (+11)	+5	+9 (+11)
1 to 250 MHz (filters off) ¹	+5	+14 (+16)	+5	+14 (+16)
Low phase noise mode off				
10 to 250 MHz (filters on)	+5	+13 (+15)	+5	+13 (+15)
> 0.25 to 2 GHz (filters on)	+5	+14 (+15)	+5	+14 (+15)
250 kHz to 10 MHz	+5	+12 (+15)	+5	+12 (+15)
> 10 to < 60 MHz	+5	+14 (+17)	+5	+14 (+17)
60 to 400 MHz	+5	+18 (+20)	+5	+18 (+20)
> 0.4 to 3.2 GHz ²	+5	+19 (+21)	+5	+19 (+21)
> 3.2 to 15 GHz	+5	+18 (+21)	+4	+17 (+20)
> 15 to 30 GHz	+5	+14 (+16)	+3	+13 (+15)
> 30 to 65 GHz	+5	+11 (+14)	+3	+9 (+12)
> 65 to 67 GHz	+5	+10 (+14)	+3	+8 (+12)
> 67 to 70 GHz	(+5)	(+8)	(-3)	(+6)

1. In this mode, harmonics are large and output power refers to the total power including harmonics.

2. With Option 1EH low-pass filters below 2 GHz switched off. With filters on, this specification applies above 2 GHz.

Specifications (continued)



Maximum output power (measured)

Step attenuator (Option 1E1)¹

Options 513, 520, 521, 532, and 540	0 dB and 5 dB to 115 dB in 10 dB steps
With Optimize S/N on ²	0 dB to 115 dB in 5 dB steps
Options 550 and 567	0 dB to 90 dB in 10 dB steps

Attenuator hold range

Minimum	From -20 dBm to maximum specified output power with step attenuator in 0 dB position. Can be offset using Option 1E1 attenuator.
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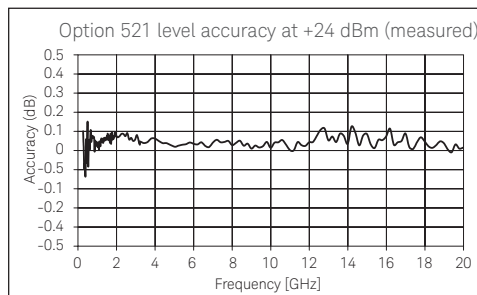
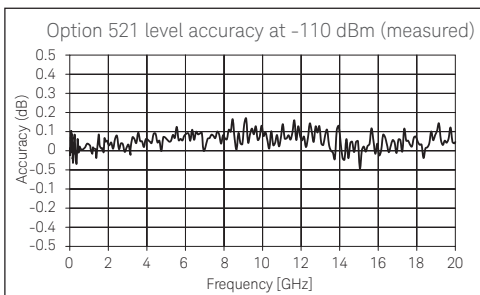
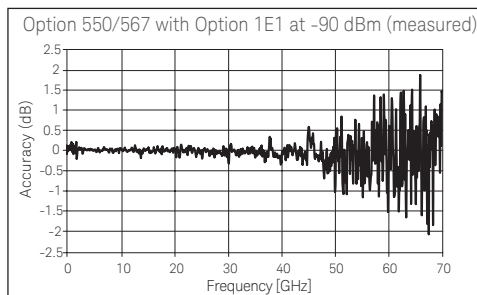
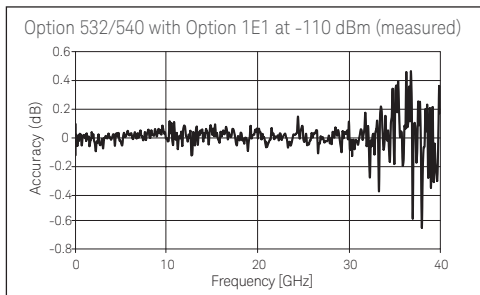
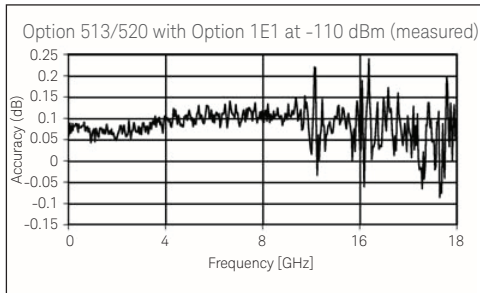
- The step attenuator provides coarse power attenuation to achieve low power levels. Fine power level adjustment is provided by the ALC (automatic level control) within the attenuator hold range.
- With attenuator in auto mode. Optimize S/N mode provides improved signal/noise performance and is included with Option 521 and Option 1EU models. Specs in the following sections (such as level accuracy, spectral purity, modulation, etc) are only tested with Optimize S/N mode turned off.

Specifications (continued)

Amplitude switching speed							
ALC on	< 6 ms (typ) ¹						
ALC off	< 10 ms (typ) (not including power search) ²						
Level accuracy ³ (dB)	> 20 dBm	20 to > 16 dBm	16 to > 10 dBm	10 to > 0 dBm	0 to -10 dBm	< -10 to -20 dBm	
Options 513, 520, 532, 540, 550, 567							
250 kHz to 2 GHz ^{4,5}	± 0.8	± 0.8 ⁶	± 0.6	± 0.6	± 0.6	± 1.2	
> 2 to 20 GHz	± 1.0	± 0.8	± 0.8	± 0.8	± 0.8	± 1.2	
> 20 to 40 GHz		± 1.0	± 1.0	± 0.9	± 0.9	± 1.3	
> 40 to 50 GHz				± 1.3	± 0.9	± 1.2	
> 50 to 67 GHz				± 1.5	± 1.0	± 1.2 (typ)	
Option 521							
10 to < 500 MHz ^{4,7}	± 1.9 (typ)	± 1.2 (typ)	± 1.2 (typ)	± 1.1 (typ)	± 1.2 (typ)	± 1.2 (typ)	
0.5 to 20 GHz	± 1.0 ⁸	± 0.8	± 0.8	± 0.8	± 0.9	± 1.1 ⁹	
Level accuracy with step attenuator (Option 1E1) ¹⁰ (dB)							
	26 to > 20 dBm	20 to > 16 dBm	16 to > 10 dBm	10 to > 0 dBm	0 to -10 dBm	< -10 to -70 dBm	< -70 to -90 dBm
Options 513, 520, 53, 540, 550, 567							
250 kHz to 2 GHz ^{4,5}	± 1.0	± 0.8 ⁶	± 0.6	± 0.6	± 0.6	± 0.7	± 0.8
> 2 to 20 GHz	± 1.0	± 0.8	± 0.8	± 0.8	± 0.8	± 0.9	± 1.0
> 20 to 40 GHz	–	± 1.0	± 1.0	± 0.9	± 0.9	± 1.0	± 2.0
> 40 to 50 GHz	–	–	–	± 1.3	± 0.9	± 1.5	± 2.5
> 50 to 67 GHz	–	–	–	± 1.5	± 1.0	± 1.5 (typ)	± 2.5 (typ)
Option 521							
10 to < 500 MHz ^{4,11}		± 1.3	± 0.8	± 0.8	± 0.7	± 1.0	± 1.0
0.5 to 20 GHz	± 1.0 ⁸	± 0.8	± 0.8	± 0.8	± 0.8	± 1.1	± 1.1

- To within 0.1 dB of final amplitude within one attenuator range. Does not apply to Option 521 below 500 MHz.
- To within 0.5 dB of final amplitude within one attenuator range. Also applies to Option 521 below 500 MHz with ALC on. Add up to 50 ms when using power search.
- Specifications apply in CW and list/step sweep modes over the 15 to 35 °C temperature range with the ALC on. Degradation outside this temperature range, for power levels > -10 dBm is typically < 0.3 dB (except < 0.5 dB from 2 to 3.2 GHz and with Option 521 below 500 MHz). In ramp sweep mode (with Option 007), specifications are typical. For instruments with Type-N connectors (Option 1ED), specifications are degraded typically 0.2 dB above 18 GHz.
- When Option UNX or UNY low phase noise mode is on, specifications below 250 MHz apply only when Option 1EH low-pass filters below 2 GHz are on. With Option 1EH low-pass filters below 2 GHz off, accuracy is typically ± 2 dB.
- For Option 550 and 567, degrade level accuracy by 0.2 dB from 1.7 to 2 GHz when step attenuator is set to 0 dB or when Option 1E1 is not present.
- Nominal above +16 dBm from 10 MHz to 60 MHz.
- With Option 521, specifications below 500 MHz are typical, and apply for a 50 Ω load with VSWR less than 1.4:1.
- Typical above +26 dBm.
- Typical below -15 dBm.
- Specifications apply in CW and list/step sweep modes over the 15 to 35 °C temperature range, with the ALC on and attenuator hold off (normal operating mode). Degradation outside this temperature range, with attenuator hold on and ALC power levels > -10 dBm, is typically < 0.3 dB (except < 0.5 dB from 2 to 3.2 GHz and with Option 521 below 500 MHz). In ramp sweep mode (with Option 007), specifications are typical. For instruments with type-N connectors (Option 1ED), specifications apply to 18 GHz only. From 18 to 20 GHz, typical level accuracy degrades by 0.2 dB. Specifications do not apply above the maximum specified power.
- With Option 521, specifications below 500 MHz apply with step attenuator set to 5 dB or higher (requiring Attenuator Hold ON above 8 dBm). With step attenuator set to 0 dB, refer to level accuracy specifications without Option 1E1.

Specifications (continued)



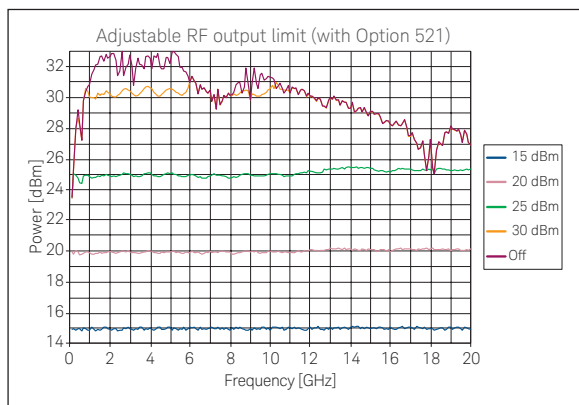
Level accuracy (measured)

Resolution	0.01 dB
Temperature stability	0.02 dB/°C (typ) ¹
User flatness correction	
Number of points	2 to 1601 points/table
Number of tables	Up to 10,000, memory limited
Path loss	Arbitrary, within attenuator range
Entry modes	Remote power meter ² , remote bus, manual (user edit/view)
Output impedance	50 Ω (nom)
SWR (internally leveled)	
Options 513, 520, 532, 540, 550, 567	
250 kHz to 2 GHz	< 1.4:1 (typ) ³
> 2 GHz to 20 GHz	< 1.6:1 (typ)
> 20 GHz to 40 GHz	< 1.8:1 (typ)
> 40 GHz to 67 GHz	< 2.0:1 (typ)

1. Options 550 and 567: 0.03dB/°C (typ) above 2 GHz. Option 521: 0.03 dB/°C (typ) below 500 MHz.
 2. Compatible with Keysight EPM/EPM-P Series power meters.
 3. For Options 550 and 567, SWR is 1.7:1 (typ) from 1.7 to 2.0 GHz when the step attenuator is set to 0 dB.

Specifications (continued)

Option 521	
10 to < 500 MHz	< 6:1 (typ) without Option 1E1, or step attenuator set to 0 dB < 1.6:1 (typ) with Option 1E1 step attenuator set \geq 5 dB
0.5 to 20 GHz	< 1.8:1 (typ)
Leveling modes	Internal leveling, external detector leveling, millimeter source module, ALC off
External detector leveling	
Range	-0.2 mV to -0.5 V (nom) (-36 dBm to +4 dBm using Keysight 33330D/E detector)
Bandwidth	Selectable 0.1 to 100 kHz (nom) (Note: not intended for pulsed operation)
Maximum reverse power	1/2 Watt, 0 V _{DC} ¹
Adjustable RF output limit	
Function	Protects external devices by limiting maximum RF output. Operates in all leveling modes (internal, external, source module)
Range	User-adjustable from +15 dBm to maximum output power
Accuracy	
+15 to +25 dBm	\pm 1 dB (typ)
> +25 dBm	\pm 1.5 dB (typ)
Resolution	1 dB
Response time	30 μ sec (measured)
Adjustment	Can be locked to prevent accidental change



RF output limit (measured)

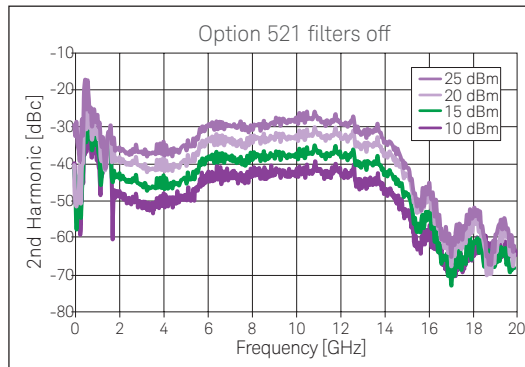
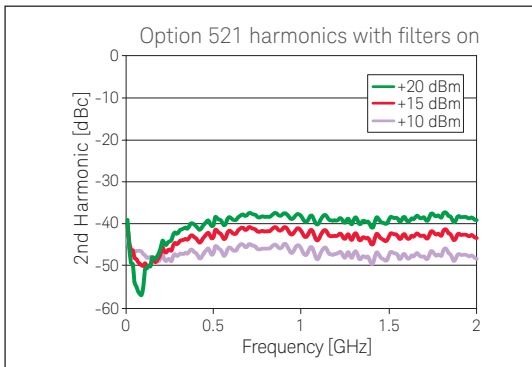
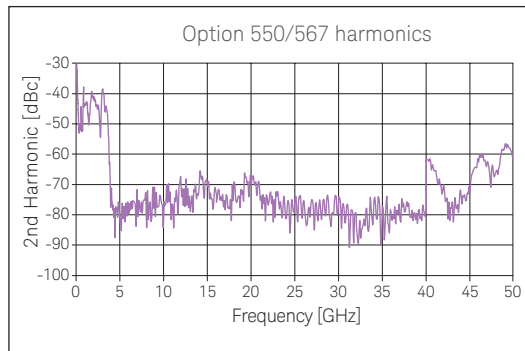
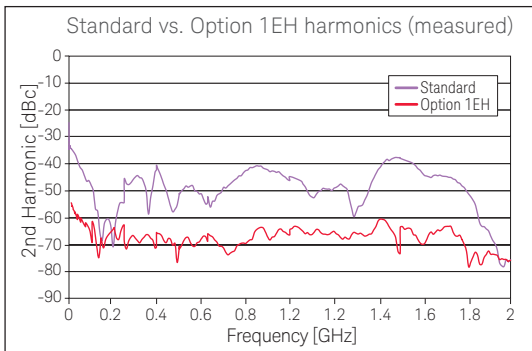
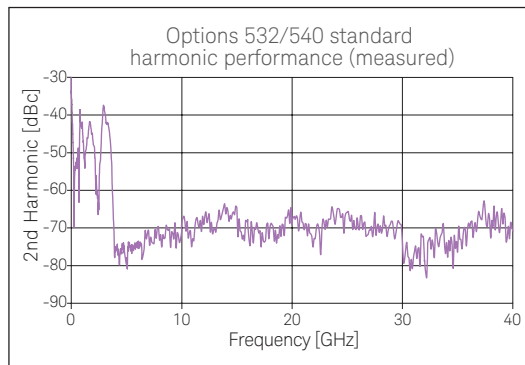
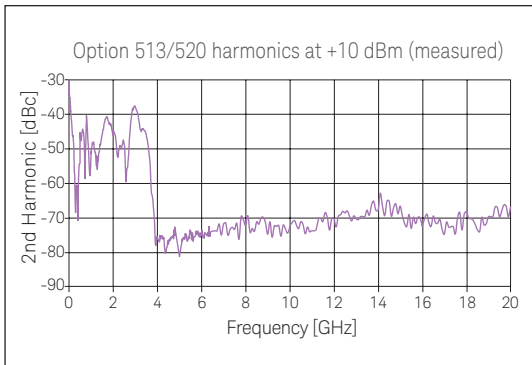
- For Option 521, maximum reverse power is 1/2 watt when Option 1E1 step attenuator is set at or above 5 dB. When Option 1E1 step attenuator = 0 dB, or for units without Option 1E1, maximum reverse power is 2 watts above 250 MHz, 1/2 watt below 250 MHz.

Specifications (continued)

Spectral purity		
Harmonics ¹ (dBc at +10 dBm or maximum specified output power, whichever is lower)		
Frequency	Options 513, 520, 532, 540, 550, 567	Option 521
< 1 MHz	-25 dBc (typ)	
1 to < 10 MHz	-25 dBc	
10 to < 60 MHz	-28 dBc	-25 dBc
10 to < 60 MHz with Option 1EH filters on	-45 dBc ²	-35 dBc ^{2,3}
10 to 250 MHz with Option HY2 in SNR mode and filters off	-8 dBc (typ)	
0.06 to 2 GHz	-30 dBc	-25 dBc
0.06 to 2 GHz with Option 1EH filters on	-55 dBc ²	-35 dBc ^{2,3}
> 0.25 to 2 GHz with Option HY2 in SNR mode and filters off	-25 dBc (typ)	
> 2 to 20 GHz	-55 dBc	-35 dBc
> 20 to 67 GHz	-50 dBc (typ)	
10 to 250 MHz, Option UNX or UNY low phase noise mode		
With Option 1EH filters off	-8 dBc (typ)	-8 dBc (typ)
With Option 1EH filters on	-55 dBc ⁴	-35 dBc

1. Specifications are typical for harmonics beyond specified frequency range (beyond 50 GHz for Option 567). Specifications are with Option 1EH Low-pass Filters below 2 GHz off and Option UNX or UNY low phase noise mode off unless noted.
2. Below 250 MHz in ramp sweep mode (Option 007), Option 1EH filters are always off. Refer to harmonic specification with filters off.
3. Option 521 includes low-pass filters below 2 GHz as standard.
4. -45 dBc below 60 MHz.

Specifications (continued)



Harmonics (measured)

Specifications (continued)

Sub-harmonics ¹ (dBc at +10 dBm or maximum specified output power, whichever is lower)				
250 kHz to 10 GHz	None			
> 10 GHz to 20 GHz	< -60 dBc			
> 20 GHz	< -50 dBc			
Non-harmonics ^{2,3} (dBc at +10 dBm or maximum specified output power, whichever is lower)				
Frequency	Offsets > 3 kHz (standard) Spec (typ)	Offsets > 300 Hz (Opt UNX or UNY) Spec (typ)	Offsets > 3 kHz (Option UNY) Spec (typ)	Line-related (≤ 300 Hz) (typ)
250 kHz to 250 MHz	-58 (-62 ⁴)	-58 (-62 ⁴)	-58	(-55)
1 to 250 MHz ⁵	-80 (-88)	-80 (-88)	-80	(-55)
> 250 MHz to 1 GHz	-80 (-88)	-80 (-88)	-80	(-55)
> 1 to 2 GHz	-74 (-82)	-74 (-82)	-80	(-55)
> 2 to 3.2 GHz	-68 (-76)	-68 (-76)	-76	(-55)
> 3.2 to 10 GHz	-62 (-70)	-62 (-70)	-70	(-50)
> 10 to 20 GHz	-56 (-64)	-56 (-64)	-64	(-45)
> 20 to 40 GHz	-50 (-58)	-50 (-58)	-58	(-39)
> 40 GHz	-44 (-52)	-44 (-52)	-52	(-37)
Residual FM (RMS, 50 Hz to 15 kHz bandwidth)				
CW mode	< N x 6 Hz (typ)			
CW mode with Option UNX or UNY	< N x 4 Hz (typ)			
Ramp sweep mode	< N x 1 kHz (typ)			
Broadband noise (CW mode at +10 dBm or maximum specified output power, whichever is lower, for offsets > 10 MHz)				
10 MHz to 20 GHz (without Option 521)	< -148 dBc/Hz (typ)			
10 MHz to 20 GHz (Option 521)	< -142 dBc/Hz (typ)			
> 20 to 40 GHz	< -141 dBc/Hz (typ)			
> 40 GHz	< -135 dBc/Hz (typ)			

1. Sub-harmonics are defined as carrier freq*(x/y), where x and y are integers, and x is not an integer multiple of y. Specifications are typical for sub-harmonics beyond specified frequency range. For Option 567, specifications are typical for carrier frequencies above 50 GHz.
2. Specifications are typical for spurs beyond specified frequency range (beyond 50 GHz for Option 567). Specifications apply for CW mode, without modulation. In ramp sweep mode (Option 007), performance is typical for offsets > 1 MHz.
3. Excluding external mechanical vibration.
4. For offsets > 10 kHz.
5. Option UNX or UNY low phase noise mode.

Specifications (continued)

Measured RMS jitter¹				
Standard carrier frequency	SONET/SDH data rates	RMS jitter bandwidth	Unit intervals (μ UI)	Time (fs)
155 MHz	155 MB/s	100 Hz to 1.5 MHz	30	190
622 MHz	622 MB/s	1 kHz to 5 MHz	27	43
2.488 GHz	2488 MB/s	5 kHz to 20 MHz	84	34
9.953 GHz	9953 MB/s	10 kHz to 80 MHz	222	22
39.812 GHz	39812 MB/s	40 kHz to 320 MHz	804	21
Option UNX carrier frequency	SONET/SDH data rates	RMS jitter bandwidth	Unit intervals (μ UI)	Time (fs)
155 MHz	155 MB/s	100 Hz to 1.5 MHz	7	47
622 MHz	622 MB/s	1 kHz to 5 MHz	27	43
2.488 GHz	2488 MB/s	5 kHz to 20 MHz	86	35
9.953 GHz	9953 MB/s	10 kHz to 80 MHz	197	20
39.812 GHz	39812 MB/s	40 kHz to 320 MHz	817	21
Option UNY carrier frequency	SONET/SDH data rates	RMS jitter bandwidth	Unit intervals (μ UI)	Time (fs)
155 MHz	155 MB/s	100 Hz to 1.5 MHz	6	36
622 MHz	622 MB/s	1 kHz to 5 MHz	21	34
2.488 GHz	2488 MB/s	5 kHz to 20 MHz	53	21
9.953 GHz	9953 MB/s	10 kHz to 80 MHz	97	10
39.812 GHz	39812 MB/s	40 kHz to 320 MHz	415	10

1. Calculated from phase noise performance in CW mode only at +10 dBm. For other frequencies, data rates, or bandwidths, please contact your sales representative.

Specifications (continued)

SSB phase noise (dBc/Hz) (CW) ^{1,2}		20 kHz offset from carrier	
Frequency		Spec	Typical
250 kHz to 250 MHz		-130	-134
> 250 to 500 MHz		-134	-138
> 500 MHz to 1 GHz		-130	-134
> 1 to 2 GHz		-124	-128
> 2 to 3.2 GHz		-120	-124
> 3.2 to 10 GHz		-110	-113
> 10 to 20 GHz		-104	-108
> 20 to 40 GHz		-98	-102
> 40 to 67 GHz		-92	-96

Option UNX: absolute SSB phase noise (dBc/Hz) (CW) ^{1,2}		Offset from carrier				
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
250 kHz to 250 MHz	-58 (-66)	-87 (-94)	-104 (-120)	-121 (-128)	-128 (-132)	-130 (-133)
> 250 to 500 MHz	-61 (-72)	-88 (-98)	-108 (-118)	-125 (-132)	-132 (-136)	-136 (-141)
> 500 MHz to 1 GHz	-57 (-65)	-84 (-93)	-101 (-111)	-121 (-130)	-130 (-134)	-130 (-135)
> 1 to 2 GHz	-51 (-58)	-79 (-86)	-96 (-106)	-115 (-124)	-124 (-129)	-124 (-129)
> 2 to 3.2 GHz	-46 (-54)	-74 (-82)	-92 (-102)	-111 (-120)	-120 (-124)	-120 (-124)
> 3.2 to 10 GHz	-37 (-44)	-65 (-72)	-81 (-92)	-101 (-109)	-110 (-114)	-110 (-115)
> 10 to 20 GHz	-31 (-38)	-59 (-66)	-75 (-87)	-95 (-106)	-104 (-107)	-104 (-109)
> 20 to 40 GHz	-25 (-32)	-53 (-60)	-69 (-79)	-89 (-99)	-98 (-101)	-98 (-103)
> 40 to 67 GHz	-20 (-26)	-47 (-56)	-64 (-73)	-84 (-90)	-92 (-95)	-92 (-97)

Option UNY: absolute SSB phase noise (dBc/Hz) (CW) ^{1,2}		Offset from carrier, optimized for less than 150 kHz (mode 1)				
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
250 kHz to 250 MHz	-64 (-70)	-92 (-98)	-115 (-125)	-123 (-135)	-138 (-144)	-141 (-144)
> 250 to 500 MHz	-67 (-77)	-93 (-101)	-111 (-116)	-125 (-132)	-138 (-144)	-142 (-147)
> 500 MHz to 1 GHz	-62 (-69)	-91 (-99)	-105 (-111)	-121 (-128)	-138 (-143)	-138 (-144)
> 1 to 2 GHz	-57 (-63)	-86 (-90)	-100 (-106)	-115 (-121)	-133 (-138)	-133 (-139)
> 2 to 3.2 GHz	-52 (-58)	-81 (-84)	-96 (-102)	-111 (-117)	-128 (-134)	-128 (-134)
> 3.2 to 10 GHz	-43 (-49)	-72 (-76)	-85 (-91)	-101 (-107)	-120 (-126)	-120 (-125)
> 10 to 20 GHz	-37 (-43)	-66 (-70)	-79 (-85)	-95 (-101)	-114 (-121)	-114 (-119)
> 20 to 40 GHz	-31 (-37)	-60 (-66)	-73 (-79)	-89 (-95)	-108 (-113)	-108 (-113)
> 40 to 67 GHz	-26 (-32)	-54 (-60)	-68 (-73)	-84 (-90)	-102 (-107)	-102 (-107)

1. Phase noise specifications are warranted from 15 to 35 °C, excluding external mechanical vibration. Option UNY specifications at 1 kHz offset apply from 25 to 35 °C.
2. Measured at +10 dBm or maximum specified power, whichever is less.

Specifications (continued)

Frequency	Option HY2: absolute SSB phase noise (dBc/Hz) (CW) operating in SNR mode ^{1, 2, 3, 4}							
	Offset from carrier							
	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)	1 MHz spec (typ)	10 MHz spec (typ)
250 kHz to 1 MHz	-64 (-70)	-92 (-98)	-115 (-125)	-123 (-135)	-138 (-144)	-141 (-144)	N/A	N/A
1 MHz	-116 (-130)	-140 (-148)	-153 (-160)	-160 (-166)	-160 (-166)	-160 (-165)	N/A	N/A
10 MHz	-96 (-112)	-126 (-136)	-140 (-152)	-155 (-162)	-155 (-163)	-155 (-163)	N/A	N/A
100 MHz	-80 (-93)	-105 (-117)	-120 (-133)	-138 (-152)	-150 (-157)	-150 (-156)	-152 (-157)	-152 (-158)
250 MHz	-68 (-85)	-100 (-109)	-115 (-126)	-133 (-144)	-144 (-153)	-148 (-153)	-150 (-155)	-150 (-156)
> 250 MHz to 500 MHz	-67 (-79)	-93 (-104)	-111 (-116)	-125 (-137)	-138 (-149)	-145 (-150)	-150 (-157)	-151 (-158)
> 500 MHz to 1 GHz	-62 (-71)	-91 (-99)	-105 (-110)	-121 (-133)	-138 (-147)	-141 (-145)	-150 (-155)	-151 (-156)
> 1 GHz to 2 GHz	-57 (-67)	-86 (-92)	-100 (-107)	-115 (-129)	-133 (-141)	-134 (-139)	-147 (-152)	-155 (-160)
> 2 GHz to 3 GHz	-52 (-64)	-81 (-89)	-96 (-102)	-111 (-125)	-128 (-137)	-130 (-135)	-143 (-150)	-153 (-159)
> 3 GHz to 3.2 GHz	-52 (-58)	-81 (-84)	-96 (-102)	-111 (-125)	-128 (-137)	-128 (-134)	-145 (-148)	-147 (-153)
> 3.2 GHz to 10 GHz	-43 (-49)	-72 (-76)	-85 (-92)	-101 (-115)	-120 (-128)	-120 (-126)	-137 (-140)	-150 (-157)
> 10 GHz to 20 GHz	-37 (-43)	-66 (-70)	-79 (-85)	-95 (-101)	-114 (-121)	-114 (-119)	-129 (-133)	-145 (-152)

1. Phase noise specifications are warranted from 15 to 35 °C, excluding external mechanical vibration. Option UNY specifications at 1 kHz offset apply from 25 to 35 °C. Maximum operating temperature of Options HY2 is 35 °C.
2. Measured at +10 dBm or maximum specified power, whichever is less.
3. At carrier ≤ 10 MHz, the offset farthest from the carrier would be limited to $0.99 \times$ carrier frequency.
4. At carriers $1 \text{ MHz} \leq F \leq 250 \text{ MHz}$, measured with filters off at +16 dBm or maximum achievable leveled power, whichever is less.

Specifications (continued)

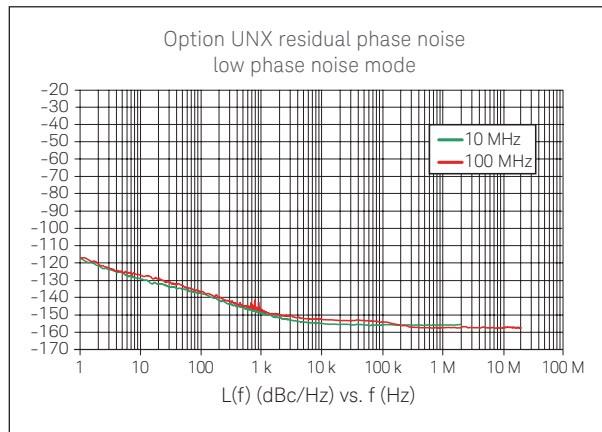
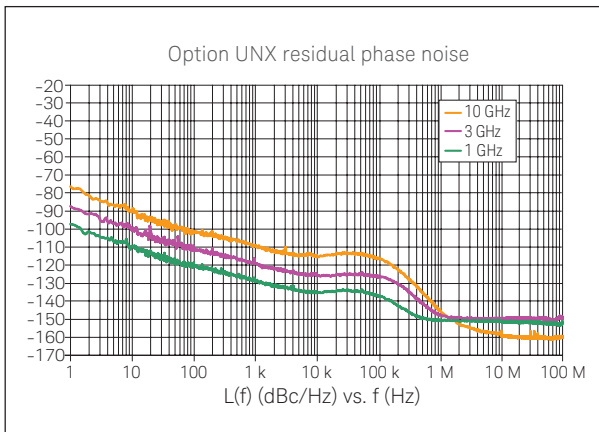
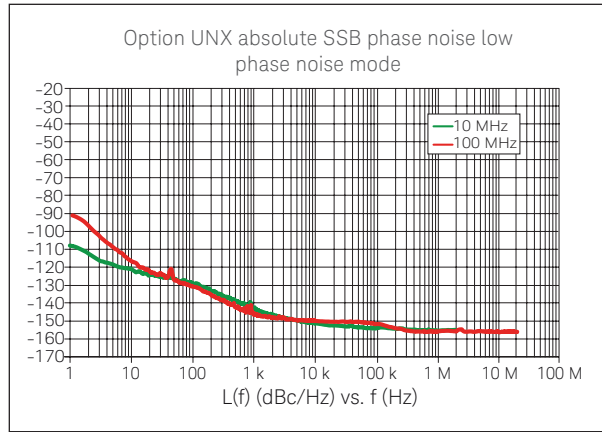
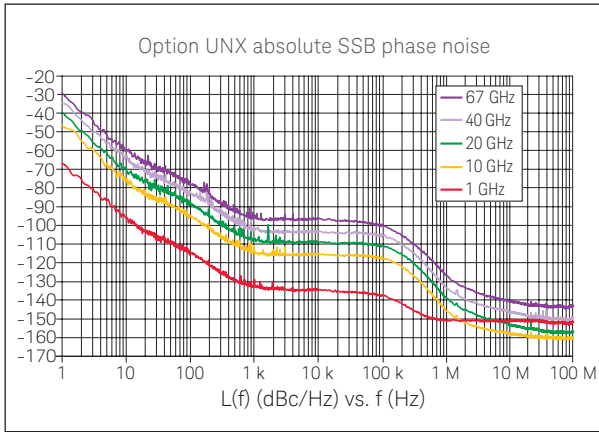
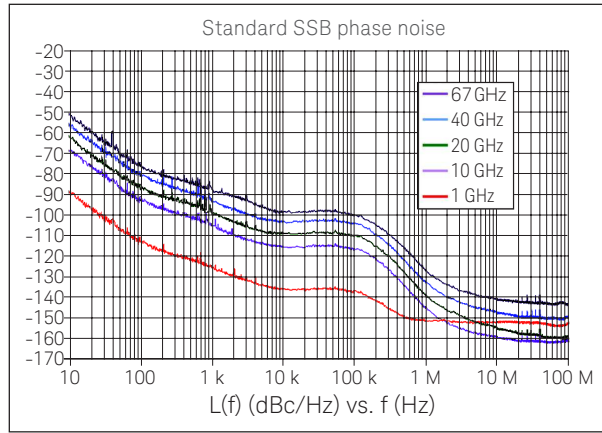
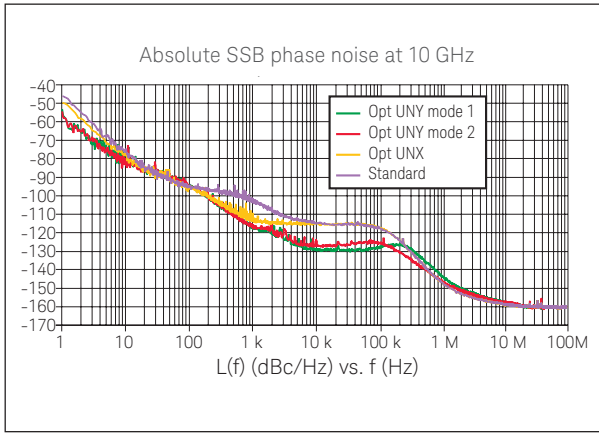
Option UNX: residual SSB phase noise (dBc/Hz) (CW) ^{1,2}			Offset from carrier			
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
250 kHz to 250 MHz	(-94)	-100 (-107)	-110 (-118)	-120 (-126)	-128 (-132)	-130 (-133)
> 250 to 500 MHz	(-101)	-105 (-112)	-115 (-122)	-124 (-131)	-132 (-136)	-136 (-141)
> 500 MHz to 1 GHz	(-94)	-100 (-107)	-110 (-118)	-120 (-126)	-130 (-134)	-130 (-134)
> 1 to 2 GHz	(-89)	-96 (-101)	-104 (-112)	-114 (-120)	-124 (-129)	-124 (-129)
> 2 to 3.2 GHz	(-85)	-92 (-97)	-100 (-108)	-110 (-116)	-120 (-124)	-120 (-124)
> 3.2 to 10 GHz	(-74)	(-87)	(-98)	(-106)	(-114)	(-115)
Option UNY: residual SSB phase noise (dBc/Hz) (CW) ^{1,2}			Offset from carrier, optimized for less than 150 kHz (mode 1)			
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
250 kHz to 250 MHz	(-94)	-100(-107)	-110 (-118)	-123 (-135)	-138 (-144)	-141 (-144)
> 250 to 500 MHz	(-101)	-105 (-112)	-115 (-122)	-124 (-130)	-138 (-144)	-140 (-147)
> 500 MHz to 1 GHz	(-94)	-100 (-108)	-110 (-118)	-120 (-126)	-135 (-142)	-135 (-145)
> 1 to 2 GHz	(-89)	-96 (-101)	-104 (-112)	-115 (-121)	-133 (-138)	-133 (-139)
> 2 to 3.2 GHz	(-85)	-92 (-97)	-100 (-108)	-111 (-117)	-128 (-134)	-128 (-134)
> 3.2 to 10 GHz	(-74)	(-87)	(-98)	(-104)	(-126)	(-125)
Option UNX: absolute SSB phase noise (dBc/Hz) (CW)						
Low phase noise mode (1 to 250 MHz) ^{1,3}			Offset from carrier			
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
1 MHz	(-109)	(-120)	(-130)	(-143)	(-150)	(-150)
10 MHz	-90 (-95)	-125 (-130)	-130 (-135)	-143 (-148)	-155 (-158)	-155 (-158)
10 MHz (Option 521)	(-95)	(-115)	(-125)	(-138)	(-145)	(-145)
100 MHz	-70 (-75)	-97 (-102)	-119 (-124)	-130 (-135)	-140 (-145)	-140 (-145)
250 MHz	(-76)	(-104)	(-121)	(-138)	(-142)	(-142)
Option UNY: absolute SSB phase noise (dBc/Hz) (CW)						
Low phase noise mode (1 to 250 MHz) ^{1,3}			Offset from carrier, optimized for less than 150 kHz (mode 1)			
Frequency	1 Hz spec (typ)	10 Hz spec (typ)	100 Hz spec (typ)	1 kHz spec (typ)	10 kHz spec (typ)	100 kHz spec (typ)
1 MHz	-116 (-129)	-140 (-151)	-153 (-161)	-160 (-166)	-160 (-167)	-160 (-165)
10 MHz	-96 (-111)	-126 (-133)	-140 (-150)	-155 (-162)	-155 (-165)	-155 (-165)
10 MHz (Option 521)	(-100)	(-120)	(-135)	(-145)	(-150)	(-150)
100 MHz	-80 (-96)	-105 (-120)	-120 (-130)	-138 (-146)	-150 (-157)	-150 (-157)
100 MHz (Option 521)	-80 (-92)	-105 (-110)	-120 (-125)	-138 (-145)	-150 (-152)	-150 (-152)
250 MHz	-68 (-77)	-100 (-108)	-114 (-122)	-133 (-139)	-144 (-153)	-144 (-154)
250 MHz (Option 521)	-68 (-77)	-100 (-105)	-114 (-118)	-133 (-139)	-144 (-152)	-144 (-152)

1. Phase noise specifications are warranted from 15 to 35 °C, excluding external mechanical vibration. Option UNY specifications at 1 kHz offset apply from 25 to 35 °C.

2. Measured at +10 dBm or maximum specified power, whichever is less.

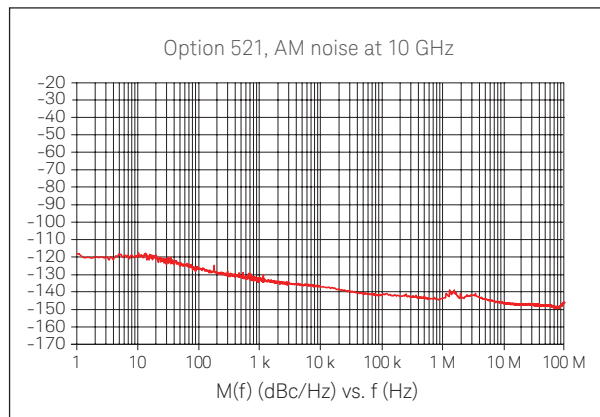
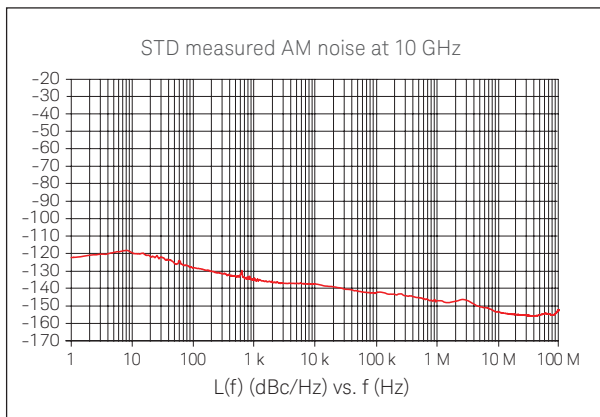
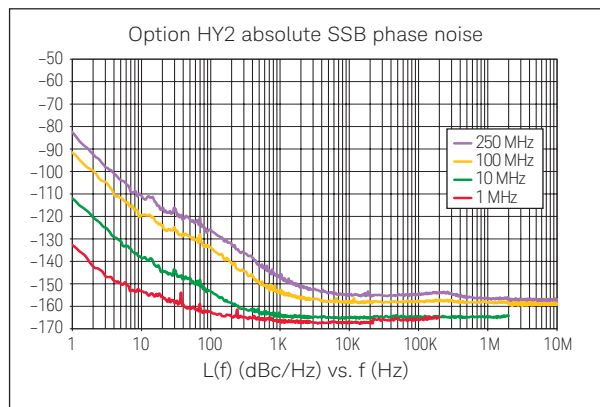
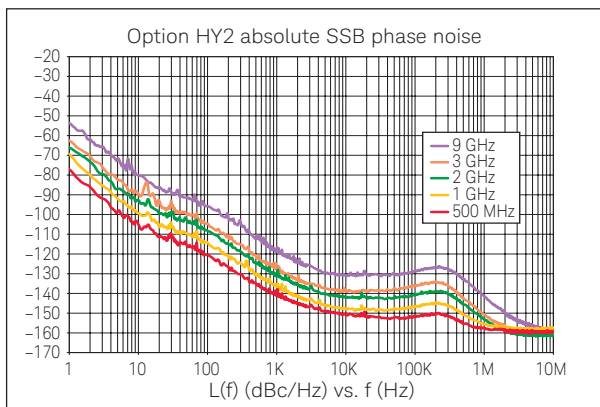
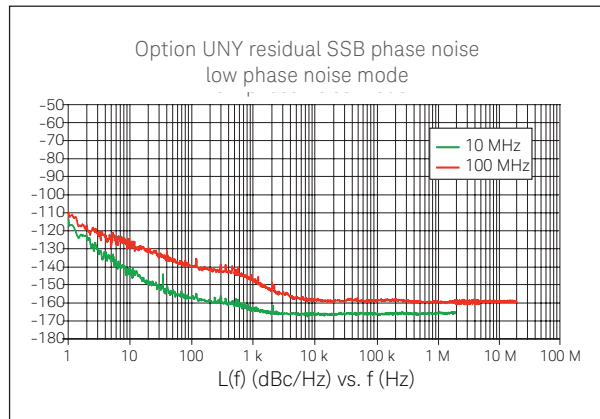
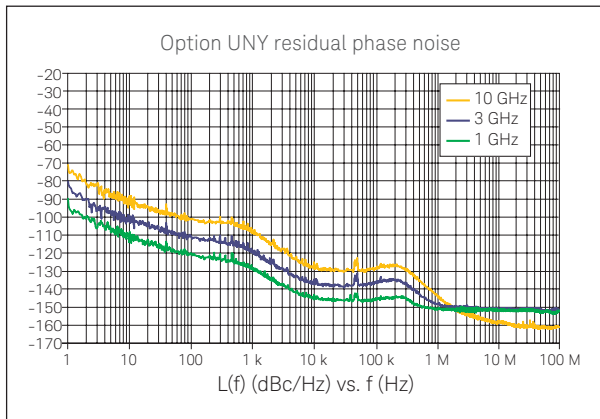
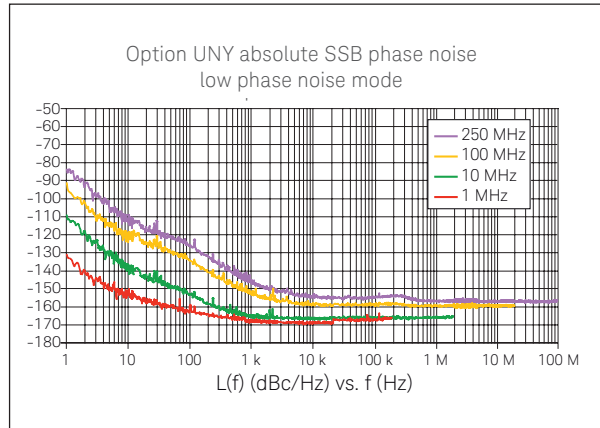
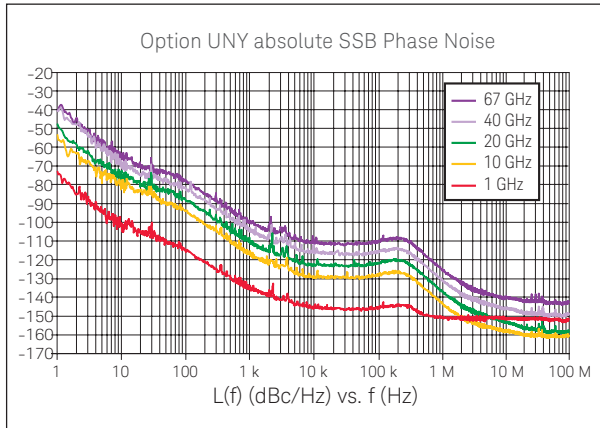
3. Measured with filters off at +16 dBm or maximum achievable leveled power, whichever is less. Without Option 1EU, frequencies of 10 MHz and below are not specified. Without Option 1EU or 521, offsets of 10 kHz and greater are not specified.

Specifications (continued)



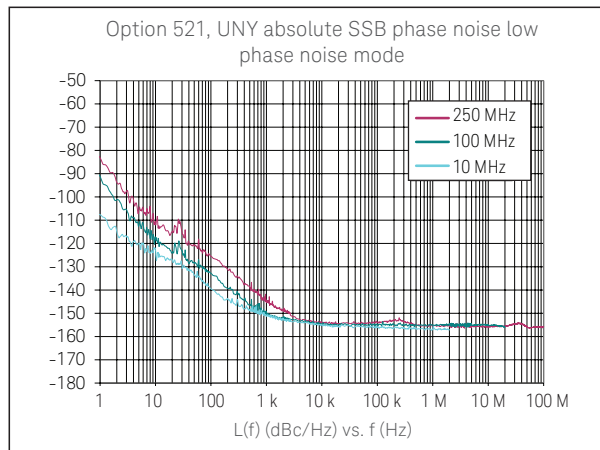
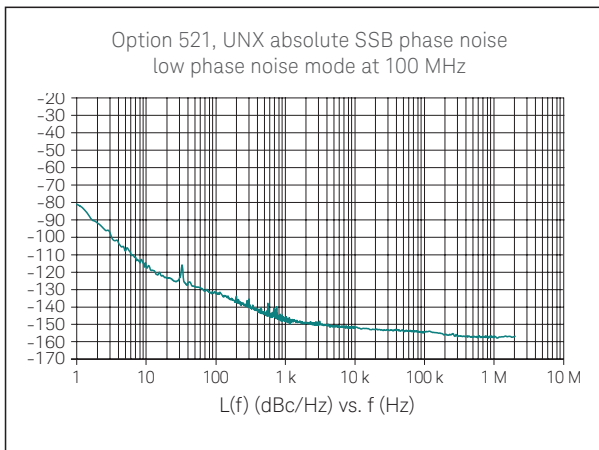
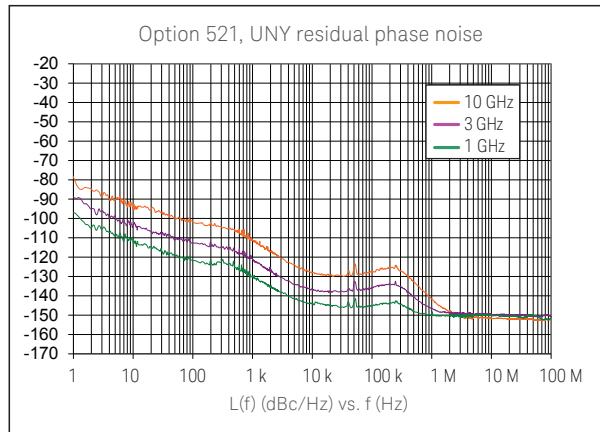
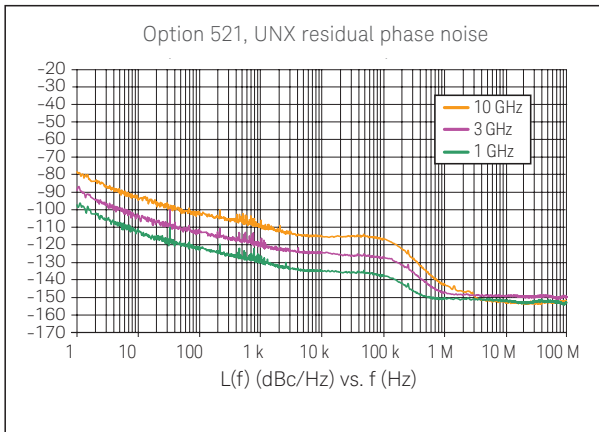
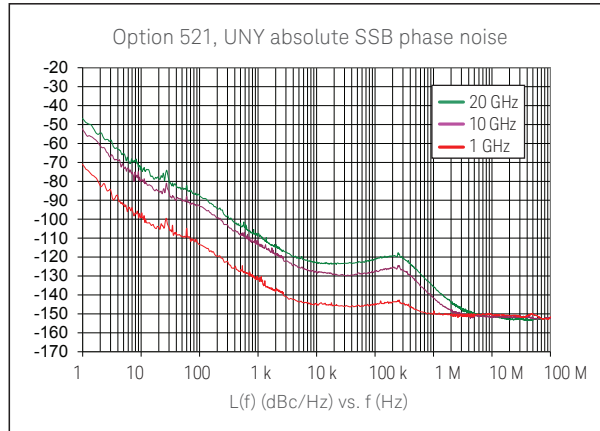
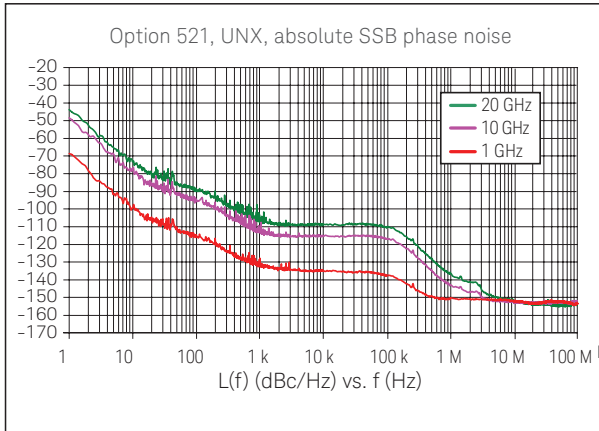
Measured phase noise (data collected with the E5500 and plotted without spurs)

Specifications (continued)



Measured phase noise (data collected with the E5500 and plotted without spurs); Option UNY phase noise optimized for offsets less than 150 kHz (mode 1)

Specifications (continued)



Measured phase noise (data collected with the E5500 and plotted without spurs)
 Option UNY phase noise optimized for offsets less than 150 kHz (mode 1)

Specifications (continued)

Frequency modulation ¹ (Option UNT)		
Maximum deviation ²		
Default RF path	Frequency	Max deviation
	250 kHz to 250 MHz	2 MHz
	> 250 to 500 MHz	1 MHz
	> 500 MHz to 1 GHz	2 MHz
	> 1 GHz to 2 GHz	4 MHz
	> 2 GHz to 3.2 GHz	8 MHz
	> 3.2 GHz to 10 GHz	16 MHz
	> 10 GHz to 20 GHz	32 MHz
	> 20 GHz to 40 GHz	64 MHz
	> 40 GHz to 67 GHz	128 MHz
Option UNX or UNY low phase noise mode	Frequency	Max deviation
	> 0.98 to 1.953 MHz	3.906 kHz
	> 1.953 to 3.906 MHz	7.8125 kHz
	> 3.906 to 7.813 MHz	15.625 kHz
	> 7.813 to 15.63 MHz	31.25 kHz
	> 15.63 to 31.25 MHz	62.5 kHz
	> 31.25 to 62.5 MHz	125 kHz
	> 62.5 to 125 MHz	250 kHz
	> 125 to 250 MHz	500 kHz
Resolution	0.1% of deviation or 1 Hz, whichever is greater	
Deviation accuracy	< ± (3.5% of FM deviation + 20 Hz) (1 kHz rate, deviations < N x 800 kHz)	
Modulation frequency response ³ (at 100 kHz deviation)		
Path [coupling]	1 dB bandwidth	3 dB bandwidth (typ)
Standard or Option UNX		
FM path 1 [DC]	DC to 100 kHz	DC to 10 MHz
FM path 2 [DC]	DC to 100 kHz	DC to 1 MHz
FM path 1 [AC]	20 Hz to 100 kHz	5 Hz to 10 MHz
FM path 2 [AC]	20 Hz to 100 kHz	5 Hz to 1 MHz
Option UNY		
FM path 1 [DC]	DC to 100 kHz	DC to 9.3 MHz
FM path 2 [DC]	DC to 100 kHz	DC to 1 MHz
FM path 1 [AC]	20 Hz to 100 kHz	5 Hz to 9.3 MHz
FM path 2 [AC]	20 Hz to 100 kHz	5 Hz to 1 MHz
DC FM 4 carrier offset	± 0.1% of set deviation + (N x 8 Hz)	

1. Above 50 GHz, FM is useable; however performance is not warranted.
2. Through any combination of path1, path2, or path1 + path2.
3. Specifications apply in CW and list/step sweep modes. During ramp sweep operation (Option 007), 3 dB bandwidth is typically 50 kHz to 10 MHz (FM1 path), and 50 kHz to 1 MHz (FM2 path).
4. At the calibrated deviation and carrier frequency, within 5 °C of ambient temperature at time of user calibration.

Specifications (continued)

Distortion	< 1% (1 kHz rate, deviations < N x 800 kHz)
Sensitivity	$\pm 1 V_{\text{peak}}$ for indicated deviation
Paths	FM1 and FM2 are summed internally for composite modulation. Either path may be switched to any one of the modulation sources: Ext1, Ext2, internal1, internal2. The FM2 path is limited to a maximum rate of 1 MHz. The FM2 path must be set to a deviation less than FM1. To avoid distortion and clipping, signals applied with any combination of FM1, FM2, or FM1+FM2 should not exceed $1 V_{\text{peak}}$.

Phase modulation ¹ (Option UNT)			
Maximum deviation ²			
Standard or Option UNX default RF path	Frequency	100 kHz BW mode	1 MHz BW mode
	250 kHz to 250 MHz	20 rad	2 rad
	> 250 to 500 MHz	10 rad	1 rad
	> 500 MHz to 1 GHz	20 rad	2 rad
	> 1 GHz to 2 GHz	40 rad	4 rad
	> 2 GHz to 3.2 GHz	80 rad	8 rad
	> 3.2 GHz to 10 GHz	160 rad	16 rad
	> 10 GHz to 20 GHz	320 rad	32 rad
	> 20 GHz to 40 GHz	640 rad	64 rad
	> 40 GHz to 67 GHz	1280 rad	128 rad
Option UNY default RF path	Frequency	1 MHz BW mode	10 MHz BW mode
	250 kHz to 250 MHz	2 rad	0.2 rad
	> 250 to 500 MHz	1 rad	0.1 rad
	> 500 MHz to 1 GHz	2 rad	0.2 rad
	> 1 GHz to 2 GHz	4 rad	0.4 rad
	> 2 GHz to 3.2 GHz	8 rad	0.8 rad
	> 3.2 GHz to 10 GHz	16 rad	1.6 rad
	> 10 GHz to 20 GHz	32 rad	3.2 rad
	> 20 GHz to 40 GHz	64 rad	6.4 rad
	> 40 GHz to 67 GHz	128 rad	12.8 rad
Option UNX low phase noise mode	Frequency	100 kHz BW mode	1 MHz BW mode
	> 0.98 to 1.953 MHz	0.03906 rad	0.003906 rad
	> 1.953 to 3.906 MHz	0.078125 rad	0.0078125 rad
	> 3.906 to 7.813 MHz	0.15625 rad	0.015625 rad
	> 7.813 to 15.63 MHz	0.3125 rad	0.03125 rad
	> 15.63 to 31.25 MHz	0.625 rad	0.0625 rad
	> 31.25 to 62.5 MHz	1.25 rad	0.125 rad
	> 62.5 to 125 MHz	2.5 rad	0.25 rad
	> 125 to 250 MHz	5 rad	0.5 rad

1. Above 50 GHz, phase modulation is useable; however performance is not warranted.
2. Through any combination of path1, path2, or path1 + path2.

Specifications (continued)

Option UNY low phase noise mode	Frequency	1 MHz BW mode	10 MHz BW mode	
	> 0.98 to 1.953 MHz	0.003906 rad	0.0003906 rad	
	> 1.953 to 3.906 MHz	0.0078125 rad	0.00078125 rad	
	> 3.906 to 7.813 MHz	0.015625 rad	0.0015625 rad	
	> 7.813 to 15.63 MHz	0.03125 rad	0.003125 rad	
	> 15.63 to 31.25 MHz	0.0625 rad	0.00625 rad	
	> 31.25 to 62.5 MHz	0.125 rad	0.0125 rad	
	> 62.5 to 125 MHz	0.25 rad	0.025 rad	
> 125 to 250 MHz	0.5 rad	0.05 rad		
Resolution	0.1% of set deviation			
Deviation accuracy	< ± 5% of deviation + 0.01 radians (1 kHz rate with 1 MHz BW mode for Option UNY or 100 kHz BW mode otherwise)			
Modulation frequency response ¹	Rates (3 dB bandwidth)	Standard	UNX	UNY
100 kHz BW mode	DC to 100 kHz	Normal	Normal	n/a
1 MHz BW mode	DC to 1 MHz (typ) ²	High	High	Normal
10 MHz BW mode	DC to 10 MHz (typ)	n/a	n/a	High
Distortion				
Standard or Option UNX	< 1% (1 kHz rate, total harmonic distortion (THD), deviation < N x 80 rad, 100 kHz BW mode)			
Option UNY	< 1% (1 kHz rate, total harmonic distortion (THD), deviation < N x 8 rad, 1 MHz BW mode)			
Sensitivity	± 1 V _{peak} for indicated deviation			
Paths	FM1 and FM2 are summed internally for composite modulation. Either path may be switched to any one of the modulation sources: Ext1, Ext2, internal1, internal2. The FM2 path is limited to a maximum rate of 1 MHz. The FM2 path must be set to a deviation less than FM1. To avoid distortion and clipping, signals applied with any combination of FM1, FM2, or FM1+ FM2 should not exceed 1 V _{peak} .			

- Specifications apply in CW and list/step sweep modes. During ramp sweep operation (Option 007), 3 dB bandwidth is typically 50 kHz to 1 MHz (high BW mode).
- Path 1 is useable to 4 MHz for external inputs less than 0.3 V_{peak}; useable to 8 MHz for external inputs less than 0.1 V_{peak}.

Specifications (continued)

Amplitude modulation ^{1,2}(Option UNT) (typical)			
Depth	Linear mode	Exponential (log) mode (downward modulation only)	
		Option UNT	Option UNT + 1SM ³
Maximum			
ALC on	> 90%	> 20 dB	> 20 dB
ALC off with power search ⁴ or ALC on with deep AM ⁵	> 95%	> 50 dB ⁶	> 60 dB ⁶
Settable	0 to 100%	0 to 40 dB	0 to 40 dB
Sensitivity	0 to 100 %/V	0 to 40 dB/V	0 to 40 dB/V
Resolution	0.1%	0.01 dB	0.01 dB
Depth accuracy (1 kHz rate)			
ALC on	± (6% of setting + 1%)	± (2% of setting + 0.2 dB)	± (2% of setting + 0.2 dB)
ALC off with power search ⁴ or ALC on with deep AM ⁵			
< 2 dB depth	–	–	± 0.5 dB
< 10 dB depth	–	–	± 1 dB
< 40 dB depth	–	–	± 2 dB
< 50 dB depth	–	–	± 3 dB
< 60 dB depth	–	–	± 5 dB
External input (selectable polarity)			
Sensitivity for indicated depth	1 V _{peak}	-1 V or +1 V	-1 V or +1 V
Maximum allowable	± 1 V	± 3.5 V ⁷	± 3.5 V ⁷
Rates (3 dB bandwidth, 30% depth)			
DC coupled	0 to 100 kHz		
AC coupled	10 Hz to 100 kHz (useable to 1 MHz) ⁸		
Distortion ⁹ (1 kHz rate, ALC On, linear mode, total harmonic distortion)			
30% AM	< 1.5%		
60% AM	< 2%		
Paths	AM1 and AM2 are summed internally for composite modulation. Either path may be switched to any one of the modulation sources: Ext1, Ext2, Internal1, Internal2		

- All AM specifications are typical. For carrier frequencies below 2 MHz or above 50 GHz, AM is useable but not specified. Unless otherwise stated, specifications apply with ALC on, deep AM off, and envelope peaks within ALC operating range (-20 dBm to maximum output power, excluding step-attenuator setting.)
- Below 250 MHz with Option UNX and UNY low phase noise mode on, AM is useable but not recommended or specified.
- Option 1SM scan modulation is available with Options 513 and 520 only, and provides exponential (log) AM with improved accuracy. In this mode, maximum output power is reduced up to 3 dB below 3.2 GHz.
- ALC off is used for narrow pulse modulation and/or high AM depths with envelope peaks below ALC operating range (40 dB). Carrier power level will be accurate after a power search is executed. (See pulse modulation section for an explanation of power search).
- Deep AM with ALC on provides increased AM depths and improved distortion, together with closed-loop internal leveling. This mode must be used with a repetitive AM waveform (frequency > 10 Hz) with peaks > -5 dBm (nominal, excluding step-attenuator setting).
- Modulation depths greater than 40 dB require an external input greater than ± 1 V, and are not available with the internal modulation source.
- If 600 Ω input impedance is selected, maximum input voltage is ± 6 V.
- For Options 550 and 567, maximum rate is 80 kHz from 20 GHz to 40 GHz.
- For Option 521, distortion specifications apply for envelope peaks within the range of -15 dBm to +24 dBm, excluding step-attenuator setting.

Specifications (continued)

External modulation inputs (Ext1 & Ext2) (Option UNT)	
Modulation types	AM, FM, and FM
Input impedance	50 Ω or 600 Ω (nom) switched
High/low indicator	100 Hz to 10 MHz BW, activated when input level error exceeds 3% (nom), ac coupled inputs only
Internal modulation source (Option UNT)	
Dual function generators	Provide two independent signals (internal1 and internal2) for use with AM, FM, FM, or LF out.
Waveforms	Sine, square, positive ramp, negative ramp, triangle, Gaussian noise, uniform noise, swept sine, dual sine ¹
Rate range	
Sine	0.5 Hz to 1 MHz
Square, ramp, triangle	0.5 Hz to 100 kHz
Resolution	0.5 Hz
Accuracy	Same as timebase
LF out	
Output	Internal1 or internal2. Also provides monitoring of internal1 or internal2 when used for AM, FM, or FM
Amplitude	0 to 3 V _{peak} (nom) into 50 Ω
Output impedance	50 Ω (nom)
Swept sine mode (frequency, phase continuous)	
Operating modes	Triggered or continuous sweeps
Frequency range	1 Hz to 1 MHz
Sweep rate	0.5 to 100,000 sweeps/s, equivalent to sweep times 10 μ s to 2 s
Resolution	0.5 Hz (0.5 sweep/s)

1. Internal2 is not available when using swept sine or dual sine modes.

Specifications (continued)

Pulse modulation 1 (Option UNU or UNW)		
On/off ratio	Option UNU	Option UNW
	80 dB (typ)	80 dB
Rise/fall times (Tr, Tf)		
Options 513, 520, 532, 540, 550, 567		
50 to 400 MHz	10 ns (typ)	15 ns (10 ns typ)
> 400 MHz	6 ns (typ)	10 ns (6 ns typ)
Option 521		
50 MHz to 1 GHz	25 ns (typ)	30 ns (25 ns typ)
1 to 3.2 GHz	12 ns (typ)	15 ns (12 ns typ)
> 3.2 GHz	6 ns (typ)	10 ns (6 ns typ)
Minimum pulse width		
ALC on	1 μ s	1 μ s
ALC off		
Options 513, 520, 532, 540, 550, 567		
50 to 400 MHz	150 ns	30 ns
> 400 MHz	150 ns	20 ns
Option 521		
50 MHz to 1 GHz	150 ns	60 ns
1 to 3.2 GHz	150 ns	30 ns
> 3.2 GHz	150 ns	20 ns
Repetition frequency		
ALC on	10 Hz to 500 kHz	10 Hz to 500 kHz
ALC off	dc to 3 MHz	dc to 10 MHz
Level accuracy (relative to CW)		
ALC on ²	± 0.5 dB (0.15 dB typ)	± 0.5 dB (0.15 dB typ)
ALC off with power search ³		
50 MHz to 3.2 GHz ⁴	± 0.7 dB (typ)	± 0.7 dB (typ)
> 3.2 GHz	± 0.5 dB (typ)	± 0.5 dB (typ)
Width compression (RF width relative to video out)		
	± 5 ns (typical)	± 5 ns (typical)

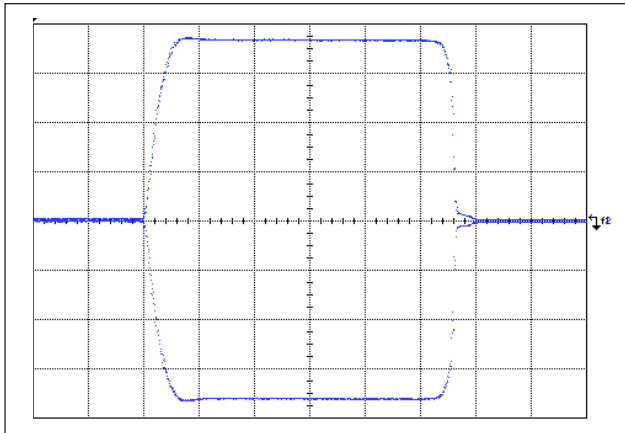
1. With ALC off, specs apply after the execution of power search. Specifications apply with Atten Hold Off (default mode for instruments with attenuator), or ALC level between -5 and $+10$ dBm or maximum specified power, whichever is lower. Above 50 GHz or below 50 MHz, pulse modulation is useable; however performance is not warranted. Pulse modulation does not operate if Option UNX or UNY low phase noise mode is on.
2. ± 0.8 dB for pulse width ≤ 1 μ s with RF frequency ≤ 100 MHz
3. Power Search is a calibration routine that improves level accuracy with ALC off. The instrument microprocessor momentarily closes the ALC loop to find the modulator drive setting necessary to make the quiescent RF level equal to an entered value, then opens the ALC loop while maintaining that modulator drive setting. When executing Power Search, RF power will be present for typically 10 to 50 ms; the step attenuator (Option 1E1) can be set to automatically switch to maximum attenuation to protect sensitive devices. Power search can be configured to operate either automatically or manually at the carrier frequency, or over a user-definable frequency range. Power search may not operate above the maximum specified output power.
4. ± 0.8 dB (typical) for Option 550 and Option 567.

Specifications (continued)

Video feed-through ¹	Option UNU	Option UNW
50 to 250 MHz	< 3% (typ)	< 3% (typ)
> 250 to 400 MHz	< 11% (typ)	< 11% (typ)
> 0.4 to 3.2 GHz	< 6% (typ)	< 6% (typ)
> 3.2 GHz without Opt 521	< 2 mV pk-pk (typ)	< 2 mV pk-pk (typ)
> 3.2 GHz with Opt 521	< 50 mV pk-pk (typ)	< 50 mV pk-pk (typ)
Video delay (ext input to video)	50 ns (nom)	50 ns (nom)
RF delay (video to RF output)		
50 to 250 MHz	35 ns (nom)	35 ns (nom)
> 0.25 to 3.2 GHz	25 ns (nom)	25 ns (nom)
> 3.2 GHz	30 ns (nom)	30 ns (nom)
Pulse overshoot		
Without Option 521	< 10% (typ)	< 10% (typ)
With Option 521	< 20% (typ)	< 20% (typ)
Input level	+1 V = RF on	+1 V = RF on
Input impedance	50 Ω (nom)	50 Ω (nom)

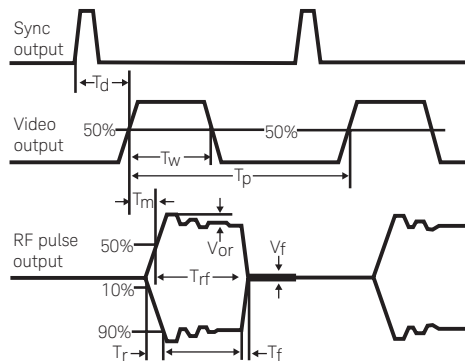
1. With Option 1E1 step attenuator in 0 dB position. Above 3.2 GHz, video feed-through decreases with step attenuator setting. Below 3.2 GHz, video feed-through is expressed as a percentage of RF output level.

Specifications (continued)



Measured pulse modulation envelope
Frequency = 9 GHz, amplitude = 10 dBm, ALC Off, 10 ns/div

Internal pulse generator (Option UNU or UNW)	
Modes	Free-run, triggered, triggered with delay, doublet, and gated. Triggered with delay, doublet, and gated require external trigger source.
Period (PRI) (T_p)	70 ns to 42 s (repetition frequency: 0.024 Hz to 14.28 MHz)
Pulse width (T_w)	10 ns to 42 s
Delay (T_d)	
Free-run mode	0 to ± 42 s
Triggered with delay and doublet modes	75 ns to 42 s with ± 10 ns jitter
Resolution	10 ns (width, delay, and PRI)
- T_d video delay (variable)	
- T_w video pulse width (variable)	
- T_p Pulse period (variable)	
- T_m RF delay	
- T_{rf} RF pulse width	
- T_f RF pulse fall time	
- T_r RF pulse rise time	
- V_{or} pulse overshoot	
- V_f video feedthrough	



Simultaneous modulation

All modulation types (FM, AM, FM, and pulse modulation) may be simultaneously enabled except: FM with FM, and linear AM with exponential AM. AM, FM, and FM can sum simultaneous inputs from any two sources (Ext1, Ext2, internal1, or internal2). Any given source (Ext1, Ext2, internal1, or internal2) may be routed to only one activated modulation type.

Specifications (continued)

Remote programming	
Interfaces	GPIB (IEEE-488.2,1987) with listen and talk, RS-232, and 10BaseT LAN interface.
Control languages	<p>SCPI version 1997.0. Completely code compatible with previous PSG signal generator models:</p> <ul style="list-style-type: none"> – E8241A – E8244A – E8251A – E8254A – E8247C – E8257C <hr/> <p>The E8257D will emulate the applicable commands for the following signal generators, providing general compatibility with ATE systems:</p> <ul style="list-style-type: none"> – Keysight 8340-Series (8340/41B) – Keysight 8360-Series (836xxB/L) – Keysight 83700-Series (837xxB) – Keysight 8662A/63A – Keysight 8664A/8665B – Keysight 8643A/8644B – Aeroflex 2040 Series
IEEE-488 functions	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT0, C0, E2.
Keysight IO libraries	Keysight's IO Library Suite ships with the E8257D to help you quickly establish an error-free connection between your PC and instruments—regardless of the vendor. It provides robust instrument control and works with the software development environment you choose.

Specifications (continued)

General specifications	
Power requirements	100/120 VAC 50/60/400 Hz; or 220/240 VAC 50/60 Hz, (automatically selected); < 250 W typical, 450 W maximum
Operating temperature range	0 to 55 °C
Storage temperature range ¹	-40 to 70 °C
Altitude	0 to 4600 m (15,000 ft.)
Humidity	Relative humidity - type tested at 95%, +40°C (non-condensing)
Environmental testing	Samples of this product have been tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of storage, transportation, and end-use; those stresses include but are not limited to temperature, humidity, shock, vibration, altitude, and power line conditions. Test methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3. ²
ISO compliant	This family of signal generators is manufactured in an ISO-9001 registered facility in concurrence with Keysight's commitment to quality.
EMC	Conforms to the immunity and emission requirements of IEC/EN 61326-1 including the conducted and radiated emission requirements of CISPR Pub 11/2003 Group 1 class A.
Acoustic noise	Normal: 51 dBA (nom) Worst case: 62 dBA (nom) ³
Storage	Memory is shared by instrument states and sweep list files. There is 14 MB of flash memory available in the E8257D PSG. Depending on how the memory is used, a maximum of 1000 instrument states can be saved.
Security	Display blanking Memory clearing functions (See Application Note, "Security Features of Keysight Technologies Signal Generators," Part Number E4400-90621) With Option 008, all user-written files are stored on an 8 GByte removable flash memory card.
Compatibility	Keysight 83550 Series millimeter heads OML millimeter source modules VDI millimeter frequency extenders Keysight 8757D scalar network analyzers Keysight EPM/EPM-P Series power meters
Self-test	Internal diagnostic routine tests most modules (including microcircuits) in a preset condition. For each module, if its node voltages are within acceptable limits, then the module "passes" the test.
Weight	< 22 kg (48 lb.) net, < 30 kg (68 lb.) shipping
Dimensions	178 mm H x 426 mm W x 515 mm D (7" H x 16.8" W x 20.3" D)
Recommended calibration cycle	24 months


1. During storage below -20 °C, instrument states may be lost.

2. As is the case with all signal generation equipment, phase noise specifications are not warranted in a vibrating environment.

3. This is louder than typical Keysight equipment: 60 dBA (nom).

Input/Output Descriptions

Front panel connectors (all connectors are BNC female unless otherwise noted.)¹

RF output	Output impedance 50 Ω (nom)
Options 513, 520 and 521	Precision APC-3.5 male, or Type-N female with Option 1ED  Caution: Option 521 output power > 1 Watt
Options 532, 540, and 550	Precision 2.4 mm male; plus 2.4 – 2.4 mm and 2.4 – 2.9 mm female adapters
Option 567	Precision 1.85 mm male; plus 1.85 – 1.85 mm and 2.4 – 2.9 mm female adapters
ALC input	Used for negative external detector leveling. Nominal input impedance 120 k Ω , damage level \pm 15 V.
LF output	Outputs the internally generated LF source. Nominal output impedance 50 Ω .
External input 1	Drives either AM, FM, or FM. Nominal input impedance 50 or 600 Ω , damage levels are 5 V _{rms} and 10 V _{peak} .
External input 2	Drives either AM, FM, or FM. Nominal input impedance 50 or 600 Ω , damage levels are 5 V _{rms} and 10 V _{peak} .
Pulse/trigger gate input	Accepts input signal for external fast pulse modulation. Also accepts external trigger pulse input for internal pulse modulation. Nominal impedance 50 Ω . Damage levels are 5 V _{rms} and 10 V _{peak} .
Pulse video out	Outputs a signal that follows the RF output in all pulse modes. TTL-level compatible, nominal source impedance 50 Ω .
Pulse sync out	Outputs a synchronizing pulse, nominally 50 ns width, during internal and triggered pulse modulation. TTL-level compatible, nominal source impedance 50 Ω .

1. Digital inputs and outputs are 3.3 V CMOS unless indicated otherwise. Inputs will accept 5 V CMOS, 3 V CMOS, or TTL voltage levels.

Input/Output Descriptions (continued)

Rear panel connectors (All connectors are BNC female unless otherwise noted.)¹

Auxiliary interface (dual mode)	Used for RS-232 serial communication and for master/slave source synchronization. (9-pin subminiature female connector). For master/slave operation, use Keysight part number 8120-8806 master/slave interface cable.
GPIO	Allows communication with compatible devices
LAN	Allows 10BaseT LAN communication
10 MHz input	Accepts a 10 MHz external reference (timebase) input. Nominal input impedance 50 Ω Damage levels > +10 dBm
10 MHz output	Outputs internal or external reference signal. Nominal output impedance 50 Ω . Nominal output power +8 dBm.
Sweep output (dual mode)	Supplies a voltage proportional to the RF power or frequency sweep ranging from 0 volts at the start of sweep to +10 volts (nom) at the end of sweep, regardless of sweep width. During CW operation, supplies a voltage proportional to the output frequency, +10 volts (nom) corresponding to the maximum specified frequency. When connected to a Keysight 8757D scalar network analyzer (Option 007), generates a selectable number of equally spaced 1 μ s pulses (nom) across a ramp (analog) sweep. Number of pulses can be set from 101 to 1601 by remote control from the 8757D. Output impedance: < 1 Ω (nom), can drive 2 k Ω .
Stop sweep in/out	Open-collector, TTL-compatible input/output. In ramp sweep operation, provides low level (nominally 0 V) during sweep retrace and bandcross intervals, and high level during the forward portion of the sweep. Sweep will stop when grounded externally, sweep will resume when allowed to go high.
Trigger output (dual mode)	Outputs a TTL signal. High at start of dwell, or when waiting for point trigger; low when dwell is over or point trigger is received. In ramp sweep mode, provides 1601 equally-spaced 1 μ s pulses (nom) across a ramp sweep. When using LF Out, provides 2 μ s pulse at start of LF sweep.
Trigger input	Accepts 3.3 V CMOS signal for triggering point-to-point in manual sweep mode, or to trigger start of LF sweep. Damage levels \geq +10 V or \leq -4 V.
Source module interface	Keysight 83550 Series mm source modules: Provides bias, flatness correction and leveling connections. OML SxxMS-AG mm source modules: Provides power to the module and returns frequency multiplication information from the module.
Source settled	Provides an output trigger that indicates when the signal generator has settled to a new frequency or power level. High indicates source not settled, Low indicates source settled.
Z-axis blank/markers	During ramp sweep, supplies +5 V (nom) level during retrace and bandswitch intervals. Supplies -5 V (nom) level when the RF frequency is at a marker frequency.
10 MHz EFC	(Option UNX or UNY) Accepts an external DC voltage, ranging from -5 V to +5 V, for electronic frequency control (EFC) of the internal 10 MHz reference oscillator. This voltage inversely tunes the oscillator about its center frequency approximately -0.07 ppm/V. The nominal input impedance is greater than 1 M Ω .
1 GHz out	(Option UNX or UNY) Low noise 1 GHz reference output signal, approximately +5 dBm (nom).
Removable flash memory drive	Accepts 8 GB compact flash memory card for optional non-volatile memory (Option 008 only). All user information (Save/Recall settings, flatness files, presets, etc) is stored on removable memory card when Option 008 is installed.

1. Digital inputs and outputs are 3.3 V CMOS unless indicated otherwise. Inputs will accept 5 V CMOS, 3 V CMOS, or TTL voltage levels.

Options, Accessories, and Related Products

Model/option	Description
E8257D-513	Frequency range from 250 kHz to 13 GHz
E8257D-520	Frequency range from 250 kHz to 20 GHz
E8257D-521	Ultrahigh output power, frequency range from 10 MHz to 20 GHz
E8257D-532	Frequency range from 250 kHz to 31.8 GHz
E8257D-540	Frequency range from 250 kHz to 40 GHz
E8257D-550	Frequency range from 250 kHz to 50 GHz
E8257D-567	Frequency range from 250 kHz to 67 GHz
E8257D-007	Analog ramp sweep
E8257D-008	8 GB removable flash memory
E8257D-UNX	Ultra low phase noise
E8257D-UNY	Enhanced ultra-low phase noise
E8257D-HY2	Enhanced ultra-low phase noise level 2
E8257D-UNT	AM, FM, phase modulation, and LF output
E8257D-UNU	Pulse modulation
E8257D-UNW	Narrow pulse modulation
E8257D-1E1	Step attenuator
E8257D-1ED	Type-N (f) RF output connector (Option 513, 520 and 521 only)
E8257D-1EH	Improved harmonics below 2 GHz (low-pass filters standard with Option 521)
E8257D-1EM	Moves all front panel connectors to the rear panel
E8257D-1EU	High output power (standard with Option 521)
E8257D-1CN	Front handle kit
E8257D-1CM	Rackmount flange kit
E8257D-1CP	Rackmount flange and front handle kit
E8257D-1SM ¹	Scan modulation (Option 513 and 520 only)
E8257D-C09	Move all front panel connectors to the rear panel except for the RF output connector
E8257D-UK6	Commercial calibration certificate and test data
E8257D-A6J	ANSI Z540-1-1994 calibration
E8257D-1A7	Calibration + uncertainties + guardbanding
E8257D-AMG	Calibration + uncertainties + guardbanding (accredited)
E8257D-CD1	CD-ROM containing the English documentation set
E8257D-ABA	Printed copy of the English documentation set
Customized product solutions	
E8257D-H1S	1 GHz external frequency reference input and output
E8257D-HCC	Connections for phase coherency > 250 MHz
Accessories	
8120-8806	Master/slave interface cable
1819-0427	8 GByte compact flash memory card
E8251-60419	Rack slide kit

1. Requires Option UNT and Option 520.

Related Keysight Literature

Keysight Microwave Signal Generators

Brochure, Literature number 5991-4876EN

E8257D PSG Microwave Analog Signal Generators Configuration Guide,

Configuration Guide, Literature number 5989-1325EN

E8267D PSG Microwave Vector Signal Generator

Data Sheet, Literature number 5989-0697EN

E8267D PSG Microwave Vector Signal Generator

Configuration Guide, Literature number 5989-1326EN

E8663D PSG RF Analog Signal Generator

Data Sheet, Literature number 5990-4136EN

E8663D PSG RF Analog Signal Generator

Configuration Guide, Literature number 5990-4137EN

Millimeter Wave Source Modules from OML, Inc. for the

Keysight PSG Signal Generators

Technical Overview Literature number 5989-2923EN

Security Features of Keysight Technologies Signal Generators

Part Number E4400-90621

Web Resources

For additional product information, visit:

www.keysight.com/find/psg

For accessory information, visit:

www.keysight.com/find/accessories

For additional description of Keysight's IO Libraries Suite features and installation requirements, please go to:

www.keysight.com/find/iosuite/database

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U2040, U2053/63 and L2050/60 X-Series USB/LAN Wide Dynamic Range Power Sensors



Accurately measure any modulated signal with the Keysight Technologies, Inc U2040, U2053/63 and L2050/60 X-Series USB/LAN wide dynamic range power sensor. With LAN connectivity, a first in the industry, and USB connectivity, the U2040, U2053/63 and LAN connectivity, the L2050/60 X-Series comes with the world's widest dynamic range in a power sensor, covering a range of -70 to +26 dBm. And because the U2049XA LAN power sensor is thermal vacuum qualified, you can get the same accuracy and performance even in thermal vacuum chambers.

X-Series Power Sensor Comparison Table

USB model	LAN model	Description	Frequency range	Power range	Supported measurements	Connector type
U2041XA	L2051XA	Wide dynamic range average power sensor	10 MHz to 6G Hz	-70 to +26 dBm	Average, time selectivity in average mode	N-type (male)
U2042XA	L2061XA	Wide dynamic range peak and average power sensor	10 MHz to 6G Hz	-70 to +26 dBm	Peak, average, peak-to-average power, time-gated and free run mode, pulse parameters analysis, pulse profiling	N-type (male)
U2043XA	L2052XA	Wide dynamic range average power sensor	10 MHz to 18 GHz	-70 to +26 dBm	Average, time selectivity in average mode	N-type (male)
U2044XA	L2062XA	Wide dynamic range peak and average power sensor	10 MHz to 18 GHz	-70 to +26 dBm	Peak, average, peak-to-average power, time-gated and free run mode, pulse parameters analysis, pulse profiling	N-type (male)
U2053XA	L2053XA	Wide dynamic range average power sensor	10 MHz to 33 GHz	-70 to +26 dBm	Average, time selectivity in average mode	3.5 mm (male)
U2063XA	L2063XA	Wide dynamic range peak and average power sensor	10 MHz to 33 GHz	-70 to +26 dBm	Peak, average, peak-to-average power, time-gated and free run mode, pulse parameters analysis, pulse profiling	3.5 mm (male)
	U2049XA	Wide dynamic range peak and average power sensor	10 MHz to 33 GHz	-70 to +20 dBm	Peak, average, peak-to-average power, time-gated and free run mode, pulse parameters analysis, pulse profiling	3.5 mm (male)
	U2049XA-TVA	Wide dynamic range peak and average power sensor with thermal vacuum option	10 MHz to 33 GHz	-70 to +20 dBm	run mode, pulse parameters analysis, pulse profiling	3.5 mm (male)

X-Series selection guide

Measurement types	USB/LAN wide dynamic range average power sensor U2041/43/53 and L2051/52/53XA	USB/LAN wide dynamic range peak and average Power Sensor U2042/44/49/63 and L2061/62/63XA
CW power	Yes	Yes
Wideband average power (example: 100 MHz bandwidth)		
Time selectivity in average mode		
Time gated average power	No	Yes
Pulse profiling (power vs time display)		
Peak power or peak-to-average power < 5 MHz bandwidth		
Pulse parameter analysis ≥ 100 ns rise time (example: rise/fall time, duty cycle, pulse width, etc.)		

X-Series Power Sensor Key Features

Widest dynamic range power sensor

The X-Series power sensor are power sensors with the widest dynamic range of 96 dB (-70 dBm to +26 dBm). The 96 dB dynamic range enables accurate power measurements of very low signal levels for a broad range of applications such as wireless chipset, power amplifier and module manufacturing, satellite payload testing, test system or instrument calibration, and radar pulse parameter measurements. The U2042/44/63 and L2061/62/63XA X-Series peak and average power sensors are able to support up to 4 pairs of gate power measurements.

Super-fast measurement speed

The X-Series power sensor takes up to 50,000 super-fast readings per second (in fast/buffer mode/ average mode), a ten times improvement over Keysight's previous sensor offerings, allowing test engineers to increase test throughput capacity and reduce cost of test especially in high volume manufacturing environments such as mobile chipset manufacturing.

This measurement speed is fast enough to measure every continuous pulse without leaving time gaps in between measurement acquisitions. While conventional sensors only provide a snapshot of continuous pulses, leaving dead time where a glitch could slip by unnoticed, the X-Series power sensor measures continuously in real time and keeps pace with very fast pulses, up to 10 kHz PRF. Users are also able to fully control which portion of the signal is measured and what throughput they can expect because the aperture duration precisely defines the maximum measurement speed as $1/\text{aperture duration}$. For example, setting the aperture duration to 20 μs offers 20 μs of measurement time per reading, equaling a measurement speed of 50,000 readings per second.

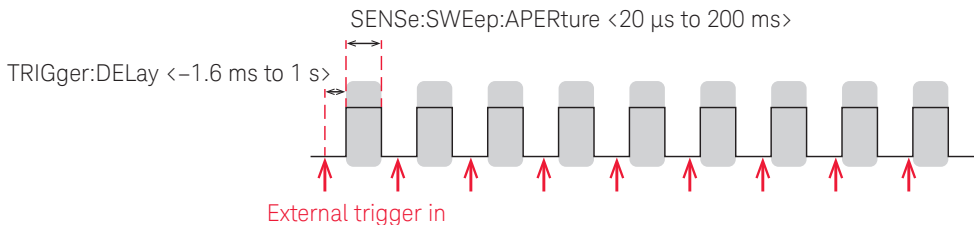


Figure 1. The X-Series power sensor offers real time measurement by measuring every consecutive pulse without dead time.

Broadband coverage for any modulated signal formats

The X-Series power sensor makes accurate average or time-selective average power measurements of any modulated signal, and covers all common wireless signals such as LTE, LTE-Advanced with 100 MHz bandwidth, and WLAN 802.11ac with 80/160 MHz bandwidth. A 4-path diode stack design with parallel data acquisition paths offers seamless range transition with high accuracy and repeatability. This design enables all the diodes to operate in their square law region, allowing the X-Series power sensor to function like thermocouple power sensors to provide accurate average or RMS power for broadband modulated signals.

Time selectivity in average mode with variable aperture duration

The X-Series power sensor offers a new feature called average mode time selectivity, whereby users are able to configure the aperture duration of measurement capture with reference to immediate trigger or external trigger. The aperture duration can be set from 20 μ s to 200 ms with a resolution of 100 ns, a resolution low enough to cover any radio format.

This new feature allows users to control which portions of the waveform to be measured, giving the same results as time-gated power measurements made in the conventional normal/peak mode. The key benefits of this feature is that it enables the sensor to measure both average and time-selective average power measurements across the full 96 dB dynamic range, and offers real time measurements of up to 50,000 readings per second. This is a significant improvement when compared to conventional power sensors; a conventional sensor's time gated power dynamic ranges is typically clipped at around 50 dB with maximum speed of 1000 readings per second.

Internal zero and calibration

Save time and reduce measurement uncertainty with the internal zero and calibration function. Each X-Series power sensor comes with technology that integrates a DC reference source and switching circuits into the body of the sensor so you can calibrate the sensor while it is connected to a device-under-test. This feature removes the need for connection and disconnection from an external calibration source, speeding up testing and reducing connector wear and tear.

This internal zero and calibration function allows continuous long distance and remote measurements by maintaining the accuracy of the sensor, and is useful in manufacturing and automated test environments where each second and each connection counts.

Built-in trigger in and out

An external trigger enables accurate triggering of low level signals close to the sensor's noise floor. The X-Series power sensor come with built-in trigger in/out connection, allowing you to connect an external trigger signal from a signal source or the device-under-test in order to achieve precise triggering timing. Once the trigger output is enabled, a TTL trigger output signal will be generated on every triggered measurement. The built-in trigger in and out is particularly useful when users need to synchronize the measurement acquisition of a series of daisy-chain power sensors.

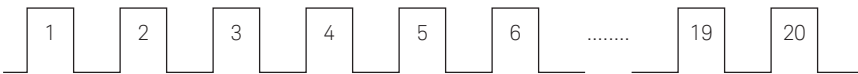


Figure 2. The external trigger input and output ports on the U2044XA.

20 automatic pulse parameter measurements

The U2042/44/49/63 and L2061/62/63 X-Series peak and average power sensor offers simultaneous pulse parameter characterization of up to 20 pulses within a single capture. Individual pulse duration, period, duty cycle, rise time, fall time and other pulse parameters can be queried through the following SCPI codes: TRACe:MEASurement:PULSe[1-20], and TRACe:MEASurement:TRANsition[1-20].

Together with a system's rise time and fall time of 100 ns and video bandwidth of 5 MHz, the X-Series peak and average power sensor enables a minimum measurable pulse width of 250 ns with its sampling interval of 50 ns. Users can quickly and accurately measure the output power and pulse parameters of pulses for radar pulse component design or manufacturing.



Pulse parameter	SCPI command
Duty cycle	TRAC:MEAS:PULS[1-20]:DCYC?
Pulse duration	TRAC:MEAS:PULS[1-20]:DUR?
Pulse period	TRAC:MEAS:PULS[1-20]:PER?
Pulse separation	TRAC:MEAS:PULS[1-20]:SEP?
Negative transition duration (fall time)	TRAC:MEAS:TRAN[1-20]:NEG:DUR?
Occurrence of a negative transition relative to trigger instant	TRAC:MEAS:TRAN[1-20]:NEG:OCC?
Positive transition duration (rise time)	TRAC:MEAS:TRAN[1-20]:POS:DUR?
Occurrence of a positive transition relative to trigger instant	TRAC:MEAS:TRAN[1-20]:POS:OCC?

Figure 3. The X-Series peak and average power sensor offers simultaneous analysis of up to 20 pulses within a single capture.

Auto burst detection

Auto burst detection helps the measurement setup of the trace of gate positions and sizes. This feature also helps set up triggering parameters on a large variety of complex modulated signals by synchronizing to the RF bursts. After a successful auto-scaling, the triggering parameters, such as trigger level, delay and hold-off, are automatically adjusted for optimum operation. The trace settings are also adjusted to align the RF burst to the center of the trace display.

Built-in radar and wireless presets

Begin testing faster; the X-Series power sensor comes with built-in radar and wireless presets for common signals such as DME, GSM, EDGE, WCDMA, WLAN and LTE.

Gamma correction

In an ideal measurement scenario, the reference impedance of the power sensor and device-under-test (DUT) impedance should equal the reference impedance (Z_0); however, this is rarely the case in practice. The mismatch in impedance values results in a portion of the signal voltage being reflected, and this reflection is quantified by the reflection coefficient, gamma.

Using the gamma correction function, users can simply input the DUT's gamma into the X-Series power sensor using SCPI commands or the Keysight BenchVue software. This will remove the mismatch error, yielding more accurate measurements.

S-parameter correction

Additional errors are often caused by components that are inserted between the DUT and the power sensor, such as in base station testing where a high power attenuator is connected between the sensor and base station to reduce the output power to the measurable power range of the sensor. The S-parameters of these components can be obtained with a vector network analyzer in the touchstone format, and inputted into the sensor using SCPI commands or through the Keysight BenchVue software. This error can now be corrected using the X-Series power sensor's S-parameter correction function. The sensor will behave as though it is connected directly to the DUT, giving users highly accurate power measurements.

Compact and portable form factor

The X-Series power sensor are standalone sensors that operate without the need of a power meter or an external power supply. The sensors draw power from a USB/LAN port and do not need additional triggering modules to operate, making them portable and lightweight solutions for field applications such as base station testing. Simply plug the sensor to the USB/LAN port of your PC or laptop with Keysight BenchVue software's BV0007B Power Meter/Power Sensor Control and Analysis app and start your power measurements.

U2049XA and L2050/60 X-Series LAN Power Sensor: The Ideal Solution for Remote Monitoring of Satellite Systems

Get the same accuracy and performance in thermal vacuum (TVAC) chambers with the world's first TVAC qualified power sensor. With best-in-class long term drift performance, a frequency range of 10 MHz to 33 GHz and a dynamic range spanning 90 dB, the U2049XA LAN power sensor is ideal for fault detection and monitoring of satellite systems. And with LAN/power over Ethernet (PoE) connectivity, a first in the industry, you can perform long distance, remote monitoring of satellite systems with ease and confidence.

LAN/Power over ethernet connectivity

Overcome the cable length limitations associated with USB connectivity. With Power over Ethernet (PoE)/LAN connectivity, the LAN power sensor is capable of long distance remote monitoring of up to 100 meters. The PoE connectivity is also compliant to the IEEE 802.3af or 802.3at Type 1 standards.

Note that the typical LAN port found on a PC or Keysight instruments will not be able to power up the LAN power sensor. A typical LAN port is only used for data transfer and communication. The LAN power sensor must connect to a PoE port, which can be used to supply the DC power required to power up the sensor and to transfer data.

Thermal vacuum option

The U2049XA LAN power sensor comes with a thermal vacuum option (Option-TVA) for use within a thermal vacuum chamber. This option has been meticulously designed by selecting components with minimum outgassing properties. Each of the sensors is also subject to temperature cycling in a vacuum chamber to stabilize the materials and to remove outgassing particles.



Figure 4. U2049XA Option 100.



Figure 5. U2049XA Option TVA.

Performance Specifications

Specification definitions

There are two types of product specifications:

- Warranted specifications are specifications which are covered by the product warranty and apply over a range of 0 to 55 °C unless otherwise noted. Warranted specifications include measurement uncertainty calculated with a 95% confidence.
- Characteristic specifications are specifications that are not warranted. They describe product performance that is useful in the application of the product. These characteristics are shown in italics.

Characteristic information is representative of the product. In many cases, it may also be supplemental to a warranted specification. Characteristic specifications are not verified on all units. These are several types of characteristic specifications. They can be divided into two groups:

One group of characteristic types describes 'attributes' common to all products of a given model or option. Examples of characteristics that describe 'attributes' are the product weight and '50-ohm input Type-N connector'. In these examples, product weight is an 'approximate' value and a 50-ohm input is 'nominal'. These two terms are most widely used when describing a product's 'attributes'.

The second group describes 'statistically' the aggregate performance of the population of products. These characteristics describe the expected behavior of the population of products. They do not guarantee the performance of any individual product. No measurement uncertainty value is accounted for in the specification. These specifications are referred to as 'typical'.

The power sensor will meet its specifications when:

- Stored for a minimum of two hours at a stable temperature within the operating temperature range, and turned on for at least 30 minutes
- The power sensor is within its recommended calibration period, and
- Used in accordance to the information provided in the *User's Guide*
- For power measurements below -60 dBm, it is recommended to turn on the power sensor for 1.5 hours (with the X-Series power sensor connected to the device-under-test)

Specifications

Key specifications

U2041/43/53 and L2051/52/53XA wide dynamic range average power sensor

	U2041/43XA	U2053 and L2053XA	L2051/52XA
Frequency	U2041XA: 10 MHz to 6 GHz U2043XA: 10 MHz to 18 GHz	U2053XA: 10 MHz to 33 GHz L2053XA: 10 MHz to 33 GHz	L2051XA: 10 MHz to 6 GHz L2052XA: 10 MHz to 18 GHz
Average power range (Average only mode)	-70 dBm to +26 dBm		
Maximum power (Damage level)	Average: +29 dBm		
	Peak: +32 dBm for < 10 μs duration		
	Voltage: ≤ 20 VDC	Voltage: ≤ 10 VDC	
Zero and calibration	Internal zero and calibration supported		
Maximum sampling rate	20 Msamples/second continuous sampling		
Power linearity at 5 dB step ¹	Average mode: < 1.0%		
Basic accuracy of average power measurement ²	≤ ± 0.21 dB or ± 4.7% for < 30 MHz	≤ ± 0.20 dB or ± 4.6% for < 30 MHz	≤ ± 0.20 dB or ± 4.5% for < 30 MHz
	≤ ± 0.18 dB or ± 4.1% for ≥ 30 MHz to ≤ 10 GHz	≤ ± 0.22 dB or ± 5.0% for ≥ 30 MHz to ≤ 26.5 GHz	≤ ± 0.18 dB or ± 4.0% for ≥ 30 MHz to ≤ 10 GHz
	≤ ± 0.19 dB or ± 4.3% for > 10 GHz to 18 GHz	≤ ± 0.26 dB or ± 5.8% for > 26.5 GHz to ≤ 33 GHz	≤ ± 0.18 dB or ± 4.1% for > 10 GHz to 18 GHz

1. Any relative power measurement of up to 5 dB will have <1% error, excluding zero set, zero drift and noise effects. With default aperture and averaging, for power levels above -50 dBm, zero set, zero drift and noise effects can be disregarded.
2. For all USB/LAN peak and average power sensor except U2049XA, specification is valid over a range of -45 to +26 dBm, DUT Max SWR < 1.2. For U2049XA, specification is valid over a range of -45 to +20 dBm, DUT Max SWR < 1.2. For all models, averaging set to 32, in Free Run mode. For power levels below -45 dBm, the effect of zero drift, zero set and measurement noise have to be considered separately base on the uncertainty calculation method shown in Appendix A.

Specifications (Continued)

Key specifications (Continued)

U2042/44/49/63 and L2061/62/63XA wide dynamic range peak and average power sensor

	U2042/44XA	U2049XA	U2063XA	L2061/62/63XA
Frequency	U2042XA: 10 MHz to 6 GHz	U2049XA: 10 MHz to 33 GHz	U2063XA: 10 MHz to 33 GHz	L2061XA: 10 MHz to 6 GHz
	U2044XA: 10 MHz to 18 GHz			L2062XA: 10 MHz to 18 GHz
Average power range (Average only mode)	-70 dBm to +26 dBm	-70 dBm to +20 dBm	-70 dBm to +26 dBm	
Normal mode power range (Peak mode)	Off: -40 to +26 dBm	Off: -40 to +20 dBm	Off: -40 to +26 dBm	
	High/5 MHz: -40 to +26 dBm	High/5 MHz: -40 to +20 dBm	High/5 MHz: -40 to +26 dBm	
	Medium/1.5 MHz: -45 to +26 dBm	Medium/1.5 MHz: -45 to +20 dBm	Medium/1.5 MHz: -45 to +26 dBm	
	Low/300 kHz: -45 to +26 dBm	Low/300 kHz: -45 to +20 dBm	Low/300 kHz: -45 to +26 dBm	
Maximum power (Damage level)	Average: +29 dBm			
	Peak: +32 dBm for < 10 μs duration			
	Voltage: ≤ 20 VDC		Voltage: ≤ 10 VDC	
Zero and calibration	Internal zero and calibration supported			
Rise/fall time ³	≤ 100 ns			
Maximum sampling rate	20 Msamples/second continuous sampling			
Power linearity at 5 dB step ¹	Average mode: < 1.0%			
	Normal mode: < 1.3%	Normal mode: < 1.0%	Normal mode: < 1.3%	
Basic accuracy of average power measurement ²	≤ ± 0.21 dB or ± 4.7% for < 30 MHz	≤ ± 0.30 dB or ± 6.6% for < 30 MHz	≤ ± 0.20 dB or ± 4.6% for < 30 MHz	≤ ± 0.20 dB or ± 4.5% for < 30 MHz
	≤ ± 0.18 dB or ± 4.1% for ≥ 30 MHz to ≤ 10 GHz	≤ ± 0.23 dB or ± 5.2% for ≥ 30 MHz to ≤ 26.5 GHz	≤ ± 0.22 dB or ± 5.0% for ≥ 30 MHz to ≤ 26.5 GHz	≤ ± 0.18 dB or ± 4.0% for ≥ 30 MHz to ≤ 10 GHz
	≤ ± 0.19 dB or ± 4.3% for > 10 GHz to 18 GHz	≤ ± 0.27 dB or ± 5.9% for > 26.5 GHz to ≤ 33 GHz	≤ ± 0.26 dB or ± 5.8% for > 26.5 GHz to ≤ 33 GHz	≤ ± 0.18 dB or ± 4.1% for > 10 GHz to 18 GHz
Signal bandwidth	VBW for peak power: ≤ 5 MHz ⁴			
	Wideband average power			
Single shot bandwidth	5 MHz			
Minimum pulse width	250 ns			
Maximum capture length	1 s (decimated)			
	6.5 ms (at full sampling rate)			
Maximum pulse repetition rate	2 MHz (based on 10 samples/period)			

- Any relative power measurement of up to 5 dB will have <1% error, excluding zero set, zero drift and noise effects. With default aperture and averaging, for power levels above -50 dBm, zero set, zero drift and noise effects can be disregarded.
- For all USB/LAN peak and average power sensor except U2049XA, specification is valid over a range of -45 to +26 dBm, DUT Max SWR < 1.2. For U2049XA, specification is valid over a range of -45 to +20 dBm, DUT Max SWR < 1.2. For all models, averaging set to 32, in Free Run mode. For power levels below -45 dBm, the effect of zero drift, zero set and measurement noise have to be considered separately base on the uncertainty calculation method shown in Appendix A.
- With video bandwidth OFF setting and carrier frequency ≥ 300 MHz.
- Five MHz video bandwidth is applicable for carrier frequency ≥ 300 MHz. For carrier frequency < 300 MHz, video bandwidth of LOW/MED is 90 kHz, video bandwidth of HIGH/OFF is 240 kHz. Refer to Characteristic peak flatness section for details.

Specifications (Continued)

Noise and drift

U2041/42/43/44/49XA

Mode	VBW setting	Zero set ¹		Zero drift ²	Measurement noise	Noise per sample
		External zero	Internal zero			
Normal ³	LOW/MED	± 16 nW	± 23 nW	± 10 nW	± 10 nW ⁴	± 0.15 μW
	HIGH/OFF	± 50 nW	± 60 nW	± 15 nW	± 32 nW ⁴	± 0.8 μW
Average	-	± 100 pW for < 300 MHz	± 1 nW	± 25 pW	± 80 pW ⁵	-
		± 70 pW for ≥ 300 MHz				

1. After 1 hour of warm up and at a constant temperature.
2. After 1 hour of warm up and at a constant temperature, measurements taken over a period of 4 hours after zeroing. Drift is calculated based on the average difference of any two measurements 1 hour apart.
3. Only applicable to U2042/44/49XA.
4. Noise defined for 1 average at free run mode.
5. Noise defined for 16 averages at 50 ms aperture.

U2053/63 and L2051/52/53/61/62/63XA

Mode	VBW setting	Zero set ¹		Zero drift ²	Measurement noise	Noise per sample
		External zero	Internal zero			
Normal ³	LOW/MED	± 12 nW	± 15 nW	± 10 nW	± 10 nW ⁴	± 0.15 μW
	HIGH/OFF	± 27 nW	± 30 nW	± 15 nW	± 32 nW ⁴	± 0.8 μW
Average	-	± 90 pW for < 300 MHz	± 1 nW	± 25 pW	± 80 pW ⁵	-
		± 70 pW for ≥ 300 MHz				

1. After 1 hour of warm up and at a constant temperature.
2. After 1 hour of warm up and at a constant temperature, measurements taken over a period of 4 hours after zeroing. Drift is calculated based on the average difference of any two measurements 1 hour apart.
3. Only applicable to U2063 and L2061/62/63XA.
4. Noise defined for 1 average at free run mode.
5. Noise defined for 16 averages at 50 ms aperture.

Noise multipliers

The measurement noise for the X-Series power sensor is dependent on the measurement mode and the time for the measurement. In general, average only mode is lower noise than normal mode, and the longer a measurement takes the lower the noise is. We will define three measurement modes and how the noise can be adjusted.

Average-only mode

The measurement noise due to the X-Series power sensor is dependent on the measurement time. In general, the longer a measurement takes the lower the noise is. The measurement noise specification is defined for 16 averages with an aperture of 50 ms, or a total time of 800 ms. Noise will reduce or increase with the square root ratio of the measurement time to the specification measurement time. Thus a noise multiplier factor can be derived for any combination of averaging and aperture:

$$N_{\text{mult}} = \sqrt{\frac{0.8}{N_{\text{ave}} \times t_a}}$$

Increasing measurement time will reduce noise at this rate until around 3 seconds. As the measurement time increases beyond 3.2 seconds the noise reduction exponent changes from 0.5 to 0.2.

$$N_{\text{mult}} = 0.89 \times \left(\frac{1}{N_{\text{ave}} \times t_a} \right)^{0.5}, \text{ for } N_{\text{ave}} \times t_a \leq 3.2$$

$$N_{\text{mult}} = 0.63 \times \left(\frac{1}{N_{\text{ave}} \times t_a} \right)^{0.2}, \text{ for } N_{\text{ave}} \times t_a > 3.2$$

$$\text{Noise}_{\text{actual}} = N_{\text{mult}} \times \text{Noise}_{\text{spec}}$$

Where N_{ave} ^{def} number of averages and t_a ^{def} aperture in seconds.

Free-run normal mode

The measurement noise specification is defined for 1 average. Although the noise will reduce with increased averaging, it will not have a significant impact on the measurement uncertainty, and the figure of 32 nW (High/Off VBW) or 10 nW (Low/Med VBW) without any multiplier should be used in the uncertainty calculations. (Refer to the measurement noise in the noise and drift table above.)

Gated-average normal mode

The measurement noise on a time-gated average power measurement in normal mode will depend on the time gate length. 20 averages are carried out every 1 μ s of gate length. The noise-per-sample contribution in this mode can be reduced by approximately

$\sqrt{\frac{\text{gate length}}{50 \text{ ns}}}$ to a limit of 32 nW. (Refer to the noise and drift table above for the noise-per-sample.)

Maximum SWR

Frequency band	U2041/42XA		U2043/44XA		L2051/61XA		L2052/62XA	
	-70 to < +15 dBm	+15 to +26 dBm	-70 to < +15 dBm	+15 to +26 dBm	-70 to +15 dBm	> +15 to +26 dBm	-70 to +15 dBm	> +15 to +26 dBm
10 MHz to 6 GHz	< 1.2	< 1.29	< 1.20	< 1.29	< 1.15	< 1.24	< 1.15	< 1.24
> 6 GHz to 18 GHz			< 1.26	< 1.30			< 1.26	< 1.30

Frequency band	U2049XA	
Power level	-70 to < +15 dBm	+15 to +20 dBm
10 MHz to 30 MHz	< 2.18	< 2.21
> 30 MHz to 50 MHz	< 1.35	< 1.37
> 50 MHz to 100 MHz	< 1.22	< 1.24
> 100 MHz to 11.5 GHz	< 1.17	< 1.21
> 11.5 GHz to 30 GHz	< 1.29	< 1.33
> 30 GHz to 33 GHz	< 1.33	< 1.36

Frequency band	U2053/63XA and L2053/63XA	
Power level	-70 to +15 dBm	> +15 to +26 dBm
10 MHz to 6 GHz	< 1.16	< 1.24
> 6 GHz to 16 GHz	< 1.24	< 1.27
> 16 GHz to 26.5 GHz	< 1.33	< 1.40
> 26.5 GHz to 33 GHz	< 1.41	< 1.53

Calibration uncertainty

Definition: Uncertainty resulting from non-linearity in the X-Series power sensor detection and correction process. This can be considered as a combination of traditional linearity, calibration factor and temperature specifications and the uncertainty associated with the internal calibration process.

Average mode

Frequency band	U2041/42XA	U2043/44	U2049XA	L2051/61XA	L2052/62XA	U2053/63 and L2053/63XA
10 MHz to 30 MHz	4.40%	4.40%	4.50%	4.30%	4.30%	4.40%
> 30 MHz to 500 MHz	3.70%	3.70%	3.90%	3.50%	3.50%	3.90%
> 500 MHz to 1 GHz	3.70%	3.70%	3.80%	3.50%	3.50%	3.90%
> 1 GHz to 6 GHz	3.70%	3.70%	3.90%	3.50%	3.50%	3.90%
> 6 GHz to 10 GHz	–	3.70%	4.00%	–	3.60%	4.00%
> 10 GHz to 18 GHz	–	4.00%	4.20%	–	3.70%	4.20%
> 18 GHz to 26.5 GHz	–	–	4.90%	–	–	4.50%
> 26.5 GHz to 33 GHz	–	–	5.60%	–	–	5.10%

Normal mode

Frequency band	VBW OFF/HIGH			VBW MED/LOW			VBW OFF/HIGH			VBW MED/LOW		
	U2042XA ¹	U2044XA ¹	U2049XA	U2042XA	U2044XA	U2049XA	L2061XA	L2062XA	U2063 and L2063XA	L2061XA	L2062XA	U2063 and L2063XA
10 MHz to 30 MHz	5.70%	5.70%	4.50%	4.40%	4.40%	4.50%	4.30%	4.30%	4.40%	4.50%	4.50%	4.30%
> 30 MHz to 500 MHz	5.20%	5.20%	4.10%	3.70%	3.70%	3.90%	3.60%	3.60%	4.10%	3.80%	3.80%	4.00%
> 500 MHz to 1 GHz	5.20%	5.20%	3.90%	3.70%	3.70%	3.90%	3.60%	3.60%	4.10%	3.80%	3.80%	4.00%
> 1 GHz to 6 GHz	5.30%	5.30%	4.00%	3.70%	3.70%	4.00%	3.60%	3.60%	4.10%	3.70%	3.70%	4.00%
> 6 GHz to 10 GHz	–	5.30%	4.10%	–	3.70%	4.10%	–	3.60%	4.10%	–	3.70%	4.10%
> 10 GHz to 18 GHz	–	5.40%	4.30%	–	4.00%	4.20%	–	3.80%	4.30%	–	3.80%	4.30%
> 18 GHz to 26.5 GHz	–	–	5.00%	–	–	4.90%	–	–	4.60%	–	–	4.50%
> 26.5 GHz to 33 GHz	–	–	5.70%	–	–	5.60%	–	–	5.20%	–	–	5.20%

1. Specification valid for environment up to 70% relative humidity. Additional 1.6% to be included for environment up to 95% relative humidity.

Timebase and Trigger Specifications

Timebase	U2042/44/49XA	U2063 and L2061/62/63XA
Range	2 ns to 100 ms/div	
Accuracy	$\pm 25 \text{ ppm}$	$\pm 2.0 \text{ ppm}^1$
Jitter	$\leq 1 \text{ ns}$	
Trigger		
Internal trigger range	U2042/44XA: -25 to +26 dBm	-25 to +26 dBm
	U2049XA: -25 to +20 dBm	
Resolution	0.1 dB	
Level accuracy	$\pm 0.5 \text{ dB}$	
Latency	$1.5 \mu\text{s} \pm 50 \text{ ns}$	$1.95 \mu\text{s} \pm 50 \text{ ns}$
Jitter	$\leq 5 \text{ ns rms}$	
External TTL trigger input		
High	$> 2.4 \text{ V}$	
Low	$< 0.7 \text{ V}$	
Latency	$500 \text{ ns} \pm 50 \text{ ns}$	$950 \text{ ns} \pm 50 \text{ ns}$
Minimum trigger pulse width	150 ns (average mode)	
	50 ns (normal mode)	
Minimum trigger repetition period	300 ns (average mode)	
	100 ns (normal mode)	
Maximum trigger voltage input	5 V EMF from 50 Ω DC (current $< 100 \text{ mA}$) or 5 V EMF from 50 Ω pulse width $< 1 \text{ s}$ (current $< 100 \text{ mA}$)	
Impedance	100 k Ω (default), 50 Ω	
Jitter	$\leq 15 \text{ ns rms}$	
External TTL trigger output		
High	$> 2.4 \text{ V}$	
Low	$< 0.7 \text{ V}$	
Latency	$500 \text{ ns} \pm 50 \text{ ns}$	$950 \text{ ns} \pm 50 \text{ ns}$
Impedance	$> 2.4 \text{ V}$	
Jitter	$\leq 15 \text{ ns rms}$	
Trigger delay		
Range	Normal mode: $\pm 1.0 \text{ s}$	
	Average only mode: -1.6 ms to +1 s	
Resolution	1% of delay setting, 50 ns minimum	
Trigger hold off		
Range	1 μs to 400 ms	
Resolution	1% of selected value (to a minimum of 50 ns)	
Trigger level threshold hysteresis		
Range	$\pm 3 \text{ dB}$	
Resolution	0.05 dB	

1. $\pm 2.0 \text{ ppm}$ for first year. Typically $\pm 2.7 \text{ ppm}$ after first year.

General Specifications

Inputs/Outputs	
Current requirement	U2041/42/43/44/53/63XA: Approximately < 500 mA U2049 and L2051/52/53/61/62/63XA: 3W, 802.3af or 802.3at Type 1 standard
Trigger input	Input has TTL compatible logic levels and uses a SMB connector
Trigger output	Output provides TTL compatible logic levels and uses a SMB connector
Remote programming	
Interface	U2041/42/43/44/53/63XA: USB 2.0 interface USB-TMC compliance U2049 and L2051/52/53/61/62/63XA: 10/100 Mbps RJ-45 Power Over Ethernet port, transfers data and power on one single cable, 802.3af or 802.3 at Type 1 compliant
Command language	SCPI standard interface commands, IVI-COM, IVI-C drivers
Maximum measurement speed (Applicable for USB & LAN socket connectivity)	
Free run trigger measurement	25,000 readings per second ¹
External trigger time-gated measurement	20,000 readings per second ²
Average mode real time measurement	50,000 readings per second ³

1. Tested under normal mode and fast mode, with buffer mode trigger count of 100, output in binary format, unit in watt, auto-zeroing, auto-calibration, and step detect disabled.
2. Tested under normal mode and fast mode, with buffer mode trigger count of 100, pulsed signal with PRF of 20 kHz, and pulse width at 15 μ s.
3. Tested under average only mode and fast mode, with buffer mode trigger count of 200, aperture duration of 20 μ s, data format set to real, external trigger or immediate trigger setting. For LAN socket connectivity, network traffic might affect the measurement speed intermediately. Direct LAN connection to computer via PoE injector would provide the fastest measurement speed.

Mechanical Characteristic

Mechanical characteristics such as center conductor protrusion and pin depth are not performance specifications. They are, however, important supplemental characteristics related to electrical performance. At no time should the pin depth of the connector be protruding.

General Characteristics

Environmental compliance					
Temperature	All models except U2049XA-TVA: – Operating condition: 0 to 55 °C – Storage condition: –40 to 70 °C For U2049XA-TVA: – Operating Condition: 0 to 55 °C – For U2049XA Option TVA, this operating condition is applicable for both standard Atmospheric environment and thermal vacuum environment. – Storage condition: –40 to 70 °C – –40 to 100 °C (for U2049XA Option TVA)				
Humidity	Operating condition: Maximum 95% at 40 °C (non-condensing) Storage condition: Up to 90% at 65 °C (non-condensing)				
Altitude	Operating condition: Up to 3,000 m (9,840 ft) Storage condition: Up to 15,420 m (50,000 ft)				
Regulatory compliance					
The X-Series complies with the following safety and EMC requirements	IEC 61010-1:2001/EN61010-1:2001 (2nd edition) IEC 61326:2002/EN 61326:1997 + A1:1998 +A3:2003 Canada: ICES-001:2004 Australia/New Zealand: AS/NZS CISPR11:2004 Canada: ICES-001:2004 Australia/New Zealand: AS/NZS CISPR11:2004				
Others	U2041/42/43/44XA	U2053/63XA	L2051/52/61/62XA	L2053/63XA	U2049XA
Dimensions (Length x Width x Height)	168 mm x 46 mm x 35 mm	148 mm x 44 mm x 35 mm	180 mm x 46 mm x 36 mm	169 mm x 46 mm x 36 mm	197 mm x 40 mm x 24 mm
Net weight	≤ 0.3 kg				≤ 0.37 kg
Shipping weight	≤ 1.3 kg				≤ 1.4 kg
Recommended calibration interval	1 year				

Additional Specifications for U2042/44/49/63 and L2061/62/63XA X-Series Peak and Average Power Sensor

Measured rise time percentage error versus signal-under-test rise time

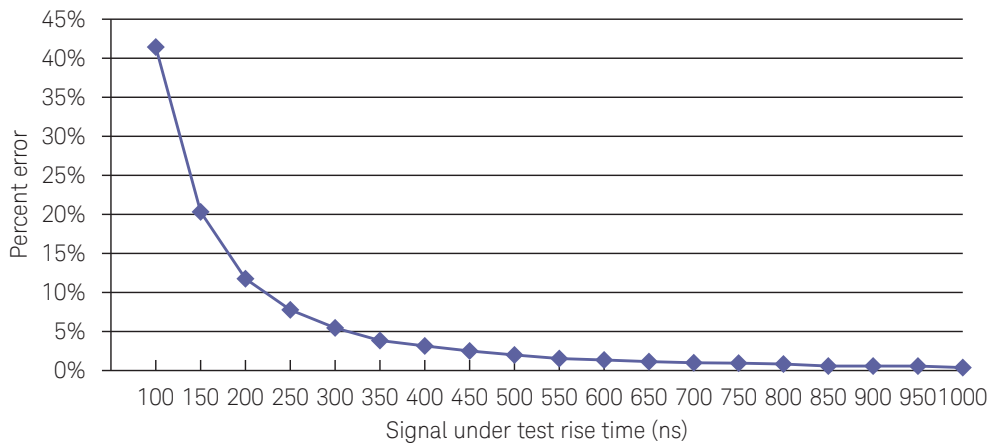


Figure 6. Measured rise time percentage error versus signal under test rise time.

Although the rise time specification is ≤ 100 ns, this does not mean that the U2042/44/49/63 and L2061/62/63XA X-Series peak and average power sensor can accurately measure a signal with a known rise time of 100 ns. The measured rise time is the root sum squares (RSS) of the signal-under-test (SUT) rise time and the system rise time:

$$\text{Measured rise time} = \sqrt{[(\text{SUT rise time})^2 + (\text{system rise time})^2]}$$

And the % error is:

$$\% \text{ error} = \left[\frac{\text{measured rise time} - \text{SUT rise time}}{\text{SUT rise time}} \right] \times 100$$

Video bandwidth

The video bandwidth in the normal mode of the X-Series peak and average power sensor can be set to High (5 MHz), Medium (1.5 MHz), Low (300 KHz), and Off. The video bandwidths stated below are not the 3 dB bandwidths, as the video bandwidths are corrected for optimal flatness (except the Off filter). Refer to Figure 6, "Characteristic peak flatness," for information on the flatness response. The Off video bandwidth setting provides the warranted rise time and fall time specifications and is the recommended setting for minimizing overshoot on pulse signals.

Additional Specifications for U2042/44/49/63 and L2061/62/63XA X-Series Peak and Average Power Sensor (Continued)

U2042/44/49XA

Video bandwidth setting (Normal mode)		LOW	MED	HIGH	OFF
Rise/fall time	< 300 MHz	6.9 μ s	6.9 μ s	2.0 μ s	2.0 μ s
	\geq 300 MHz	0.6 μ s	0.3 μ s	0.1 μ s	0.1 μ s
Overshoot ¹	< 300 MHz	2%	2%	3%	4%
	\geq 300 MHz	12%	15%	9%	5%

U2063 and L2061/62/63XA

Video bandwidth setting (Normal mode)		LOW	MED	HIGH	OFF
Rise/fall time ²	< 300 MHz	5.3 μ s	5.4 μ s	1.8 μ s	1.8 μ s
	\geq 300 MHz	0.6 μ s	0.64 μ s	0.1 μ s	0.1 μ s
Overshoot ¹	< 300 MHz	2%	2%	3%	4%
	\geq 300 MHz	12%	15%	9%	5%

The average mode of the X-Series peak and average power sensor provide accurate average power measurements for broadband modulated signals similar to a thermocouple sensor. This is due to the X-Series power sensor' four path diode design, which enables all the diodes to operate in their square-law region.

1. Specification is based on pulse signal with \geq 80 ns rise time.
2. Specification is based on pulse signal with 5 ns rise time.

Characteristic peak flatness

The peak flatness is the flatness of a peak-to-average ratio measurement for various tone separations of an equal two-tone RF input. Figure 5 below refers to the relative error in peak-to-average ratio measurements as the tone separation is varied. The measurements were performed at -10 dBm and applicable for carrier frequency \geq 300 MHz.

Additional Specifications for U2042/44/49/63 and L2061/62/63XA X-Series Peak and Average Power Sensor (Continued)

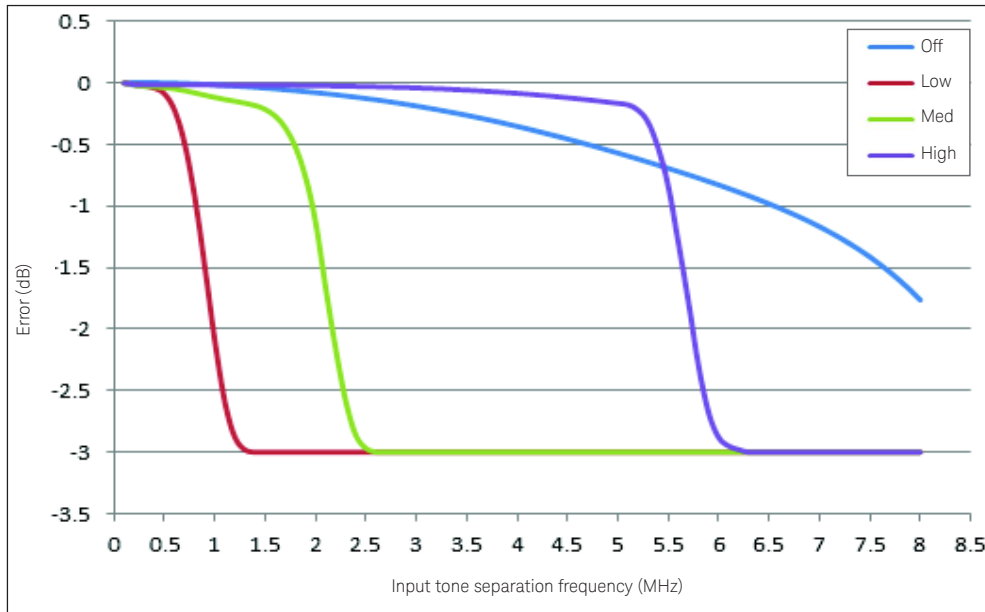


Figure 7. U2042/44/49XA error in peak-to-average ratio measurements for a two-tone input (High, Medium, Low and Off video bandwidth settings).

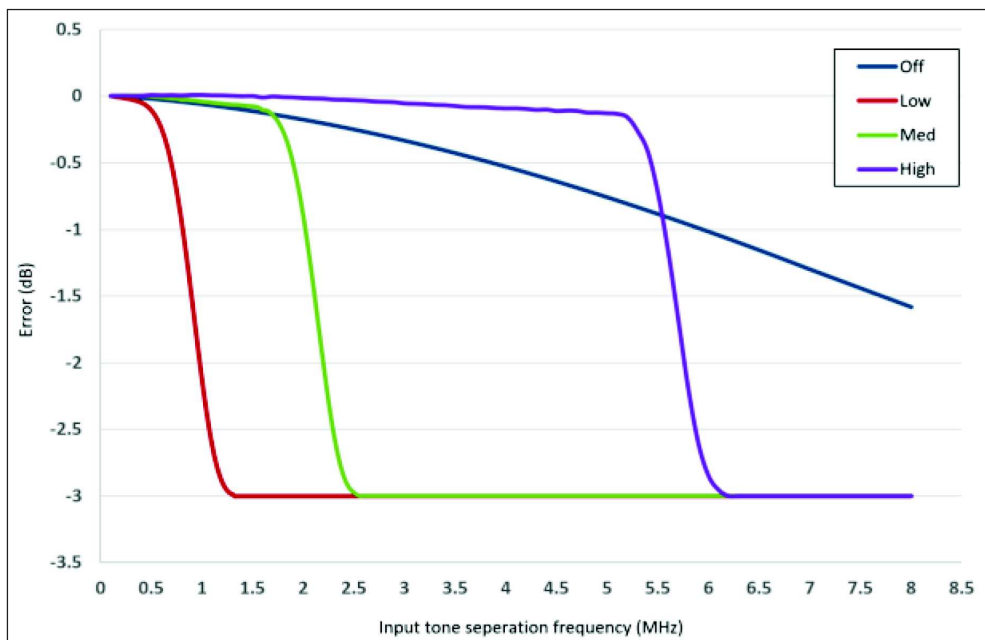


Figure 8 U2063 and L2061/62/63XA error in peak-to-average ratio measurements for a two-tone input (High, Medium, Low and Off video bandwidth settings).

Using the X-Series Power Sensor with the BenchVue Software

Keysight BenchVue software for the PC accelerates testing by providing intuitive, multiple instrument measurement visibility and data capture with no programming necessary. You can derive answers faster than ever by easily viewing, capturing and exporting measurement data and screen shots. The X-Series power sensor is supported by the Keysight BenchVue software and BV0007B power meter/sensor control and analysis app. Once you plug the X-Series power sensor into a PC and run the software you can see measurement results in a wide array of display formats and log data without any programming.

For more information, www.keysight.com/find/BenchVue

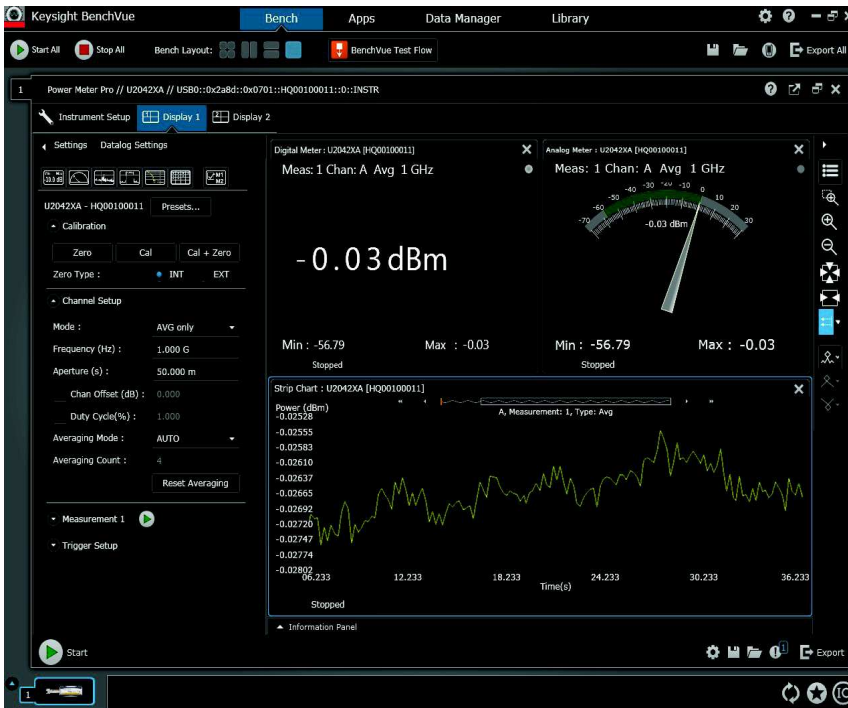


Figure 8. Digital meter, analog meter and datalog view.



Figure 9. Multi-channel trace display with 4-pairs of gates and automatic pulse parameters measurement (sample screen shot with two U2042XAs).

Using the X-Series Power Sensor with the BenchVue Software (Continued)

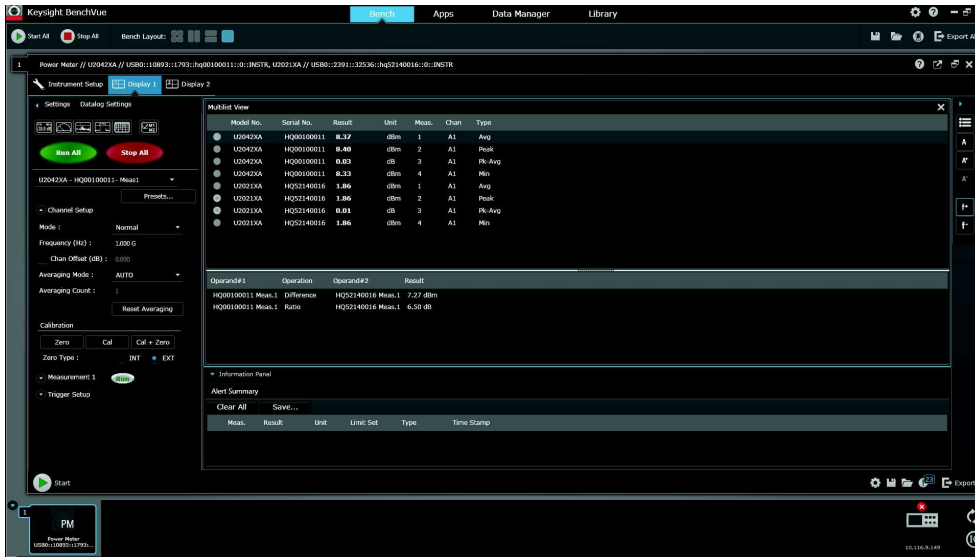


Figure 10. Multi-list view with ratio/difference function.

Supported functionality	
Measurement displays	Digital meter
	Analog meter
	Data log view
	Trace view (up to 4 channels or traces on one graph)
	Multilist with ratio/delta function
	Compact mode display
Graph functions	Single marker (up to 5 markers per graph)
	Dual marker (up to 2 sets of markers per graph)
	Graph autoscaling
	Graph zooming
Pulse characterization functions	Gate measurement analysis (up to 4-pair of gates)
Instrument settings	17-point automatic pulse parameters characterization
	Save and recall instrument state including graph settings
	Instrument preset settings (DME, GSM, WCDMA, WLAN, LTE, etc.)
	FDO tables
	Gamma and S-parameters tables
Limit and alert function	Full instrumentation control include frequency/average/trigger settings, zero and calibration, etc.
	Sensors Limit and alert notification
	Alert summary
Export data or screen shots	Data logging (HDF5/MATLAB/Microsoft Excel/Microsoft Word/CSV)
	Save screen capture (PNG/JPEG/BMP)

System and Installation Requirements

PC operating system	
Windows 10, 8 and 7	Windows 10 32-bit and 64-bit (Professional, Enterprise, Education, Home versions) Windows 8 32-bit and 64-bit (Core, Professional, Enterprise) Windows 7 SP1 and later 32-bit and 64-bit (Professional, Enterprise, Ultimate)
Computer hardware	Processor: 1 GHz or faster (2 GHz or greater recommended) RAM: 1 GB (32-bit) or 2 GB (64-bit) (3 GB or greater recommended)
Windows XP SP3 32-bit (Professional)	Processor: 600 MHz or faster (1 GHz or greater recommended) RAM: 1 GB (2 GB or greater recommended)
Interfaces	USB, GPIB, LAN, RS-232
Display resolution	1024 x 768 minimum for single instrument view (higher resolutions are recommended for multiple instrument view)

Additional requirements

Software: BenchVue requires a VISA (Keysight or National Instruments) when used to connect to physical instruments. Keysight IO Libraries, which contains the necessary VISA, will be installed automatically when BenchVue is installed. IO Libraries information is available at: www.keysight.com/find/iosuite.

Ordering Information

Model	Description
U4241XA	USB wide dynamic range average power sensor, 10 MHz to 6 GHz
U4242XA	USB peak and average power sensor, 10 MHz to 6 GHz
U2043XA	USB wide dynamic range average power sensor, 10 MHz to 18 GHz
U2044XA	USB peak and average power sensor, 10 MHz to 18 GHz
U2049XA, Option 100	LAN peak and average power sensor, 10 MHz to 33 GHz
U2049XA, Option TVA	LAN peak and average power sensor, 10 MHz to 33 GHz, thermal vacuum option
U2053XA	USB wide dynamic range average power sensor, 10 MHz to 33 GHz
U2063XA	USB wide dynamic range peak and average power sensor, 10 MHz to 33 GHz
L2051XA	LAN wide dynamic range average power sensor, 10 MHz to 6 GHz
L2052XA	LAN wide dynamic range average power sensor, 10 MHz to 18 GHz
L2053XA	LAN wide dynamic range average power sensor, 10 MHz to 33 GHz
L2061XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 6 GHz
L2062XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 18 GHz
L2063XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 33 GHz
Standard shipped items	
U2041/42/43/44/53/63XA USB power sensor	USB cable 5 ft (1.5 m), default cable length BNC male to SMB female trigger cable, 50 Ω, 1.5 m (Quantity: 2) Certificate of calibration Documentation CD-ROM Keysight Instrument Control DVD <ul style="list-style-type: none"> - IO libraries suite - Command expert - BenchVue software platform - 30-day free trial of BenchVue power meter/sensor control and analysis app
U2049 and L2051/52/53/61/62/63XA LAN power sensor	LAN cable 5 ft (1.5 m), default cable length Standard LAN cable BNC male to SMB female trigger cable, 50 Ω, 1.5 m (Quantity: 2) Certificate of calibration Documentation CD-ROM Keysight Instrument Control DVD <ul style="list-style-type: none"> - IO libraries suite - Command expert - BenchVue software platform - 30-day free trial of BenchVue power meter/sensor control and analysis app

Ordering Information (Continued)

U2041/42/43/44/53/63XA USB power sensor options

Options	Description
Accessories	
U2000A-201	Transit case
U2000A-202	Soft carrying case
U2000A-203	Holster
U2000A-204	Soft carrying pouch
Cables (selectable during sensor purchase)	
U2000A-301	USB cable 5 ft (1.5 m) – default selection
U2000A-302	USB cable 10 ft (3 m)
U2000A-303	USB cable 16.4 ft (5 m)
Cables (ordered standalone)	
U2031A	USB cable 5 ft (1.5 m)
U2031B	USB cable 10 ft (3 m)
U2031C	USB cable 16.4 ft (5 m)
U2032A	BNC male to SMB female trigger cable, 50 Ω , 1.5 m
Software	
BV0007B	BenchVue power meter/sensor control and analysis app license
Calibration	
UK6	Commercial calibration with test data

U2049 and L2051/52/53/61/62/63XA LAN power sensor options ¹

Options	Description
Standard LAN cables (selectable during sensor purchase and orderable standalone)	
U2034A	LAN cable 5 ft (1.5 m) – default selection Options 100 and TVA
U2034B	LAN cable 10 ft (3 m)
U2034C	LAN cable 16.4 ft (5 m)
U2034D	LAN cable 50 ft (15.2 m)
U2034E	LAN cable 100 ft (30.5 m)
U2034F	LAN cable 200 ft (61 m)
Trigger cable	
U2032A	Standard trigger cable BNC Male to SMB female, 50 Ω , 1.5 m
Software	
BV0007B	BenchVue power meter/sensor control and analysis app license
Calibration	
UK6	Commercial calibration with test data

1. PoE injector is not included. A commercially-available general PoE injector can be used with the U2049, L2051/52/53/61/62/63XA.

Appendix A

Uncertainty calculations for a power measurement (settled, average power)

(Specification values from this document are in **bold italic**, values calculated on this page are underlined.)

Process	
1. Measured power level.....	W
2. Frequency of measured signal (use to get calibration uncertainty and SWR)	Hz
3. Calculate sensor uncertainty: Calculate noise contribution (from page 11)	
– Average-only mode: Noise = Measurement noise x average-only-mode noise multiplier	
– Free-run normal mode: <u>Noise</u> = Measurement noise for video bandwidth setting	
– Gated-average normal mode (Trigger normal mode), Noise = Noise-per-sample x noise-per-sample multiplier	
Convert noise contribution to a relative term 1 = Noise/Power	%
Convert zero drift to relative term = Drift/Power =	%
RSS of above terms =	%
4. Zero uncertainty	
(Mode and frequency dependent) = Zero set/Power =	%
5. Sensor calibration uncertainty (from page 12)	
(Sensor, measurement mode, frequency, and humidity dependent) =	%
6. System contribution, coverage factor of $2 \geq \text{sys}_{RSS}$ =	%
(RSS three terms from steps 3, 4 and 5)	
7. Standard uncertainty of mismatch	
Max SWR (frequency dependent) =	
Convert to reflection coefficient, $ \rho_{\text{Sensor}} = (\text{SWR}-1)/(\text{SWR}+1) =$	
Max DUT SWR (frequency dependent) =	
Convert to reflection coefficient, $ \rho_{\text{DUT}} = (\text{SWR}-1)/(\text{SWR}+1) =$	
8. Combined measurement uncertainty @ k = 1	
$U_C = \sqrt{\left(\frac{\text{Max}(\rho_{\text{DUT}}) \cdot \text{Max}(\rho_{\text{Sensor}})}{\sqrt{2}}\right)^2 + \left(\frac{\text{sys}_{RSS}}{2}\right)^2}$	%
Expanded uncertainty, k = 2, = UC · 2 =	%

1. The noise to power ratio for average only mode is capped at 0.01% for MU calculation purposes.

Worked Example for U2041XA

Uncertainty calculations for a power measurement (settled, average power)

(Specification values from this document are in **bold italic**, values calculated on this page are underlined.)

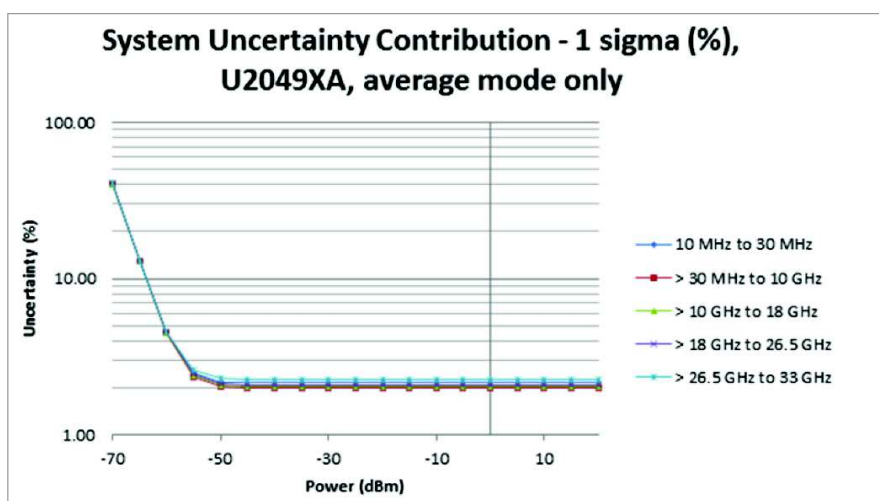
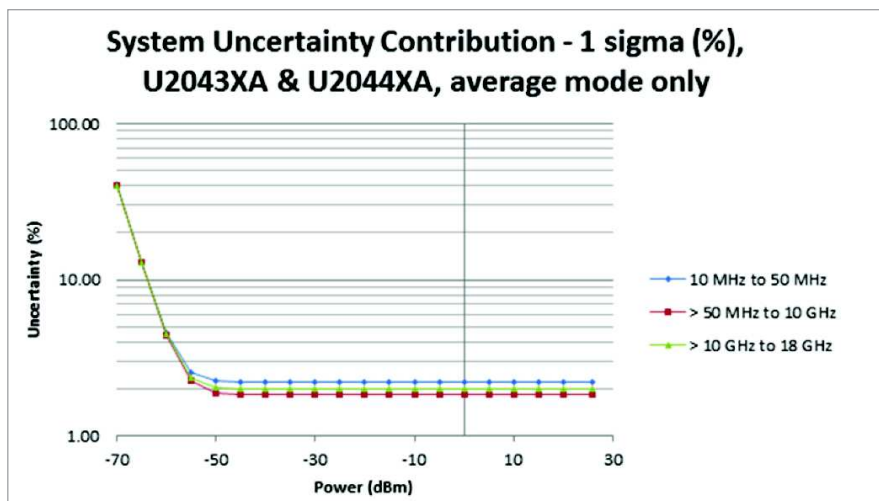
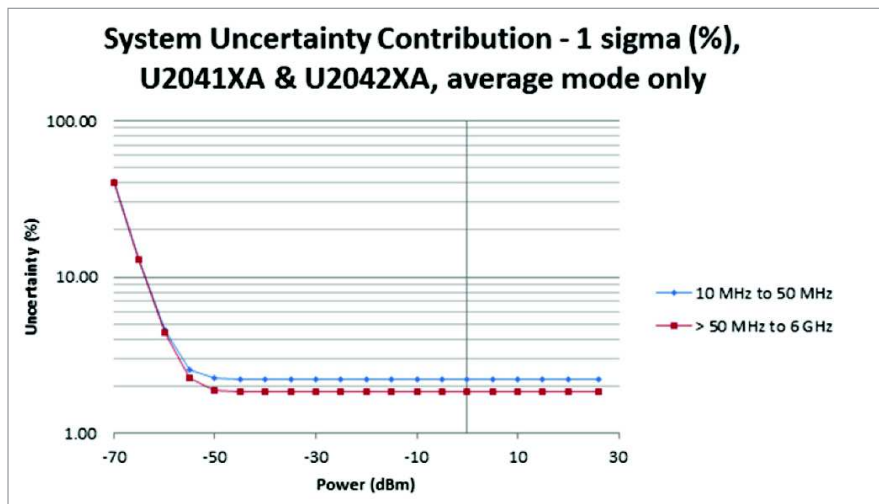
Process

1. Measured power level.....	1 mW
2. Frequency of measured signal (use to get calibration uncertainty and SWR)	1 GHz
3. Calculate sensor uncertainty: In Free Run, auto zero mode average = 1 Calculate noise contribution, assuming 50 ms aperture (default) (from page 11) – Average-only mode: Noise = Measurement noise x average-only-mode noise multiplier = 80 pW x 4.0 = 0.32 nW – Free-run normal mode: <u>Noise</u> = Measurement noise for video bandwidth setting – Gated-average normal mode (Trigger normal mode), <u>Noise</u> = Noise-per-sample x noise-per-sample multiplier Convert noise contribution to a relative term 1 = Noise/Power = 0.32 nW/1 mW = 0.000032%, value clipped to 0.01% =	0.01%
Convert zero drift to relative term = Drift/Power = 25 pW/1 mW.....	0.0000025%
RSS of above terms =	0.01%
4. Zero uncertainty (Mode and frequency dependent) = Zero set/Power = 70 pW/1 mW.....	0.000007%
5. Sensor calibration uncertainty (from page 12) (Sensor, measurement mode, frequency, and humidity dependent) =	3.7%
6. System contribution, coverage factor of $2 \geq \text{sys}_{\text{RSS}}$ =	3.7%
(RSS three terms from steps 3, 4 and 5)	
7. Standard uncertainty of mismatch Max SWR (frequency dependent) =	1.20
Convert to reflection coefficient, $ \rho_{\text{Sensor}} = (\text{SWR}-1)/(\text{SWR}+1) =$	0.091
Max DUT SWR (frequency dependent) =	1.26
Convert to reflection coefficient, $ \rho_{\text{DUT}} = (\text{SWR}-1)/(\text{SWR}+1) =$	0.115
8. Combined measurement uncertainty @ k = 1 $U_C = \sqrt{\left(\frac{\text{Max}(\rho_{\text{DUT}}) \cdot \text{Max}(\rho_{\text{Sensor}})}{\sqrt{2}}\right)^2 + \left(\frac{\text{sys}_{\text{RSS}}}{2}\right)^2} \quad U_C = \sqrt{\left(\frac{0.091 \cdot 0.155}{\sqrt{2}}\right)^2 + \left(\frac{0.037}{2}\right)^2}$	1.99%
Expanded uncertainty, k = 2, = UC · 2 =	3.98%

1. The noise to power ratio for average only mode is capped at 0.01% for measurement uncertainty calculation purposes.

Graphical Example

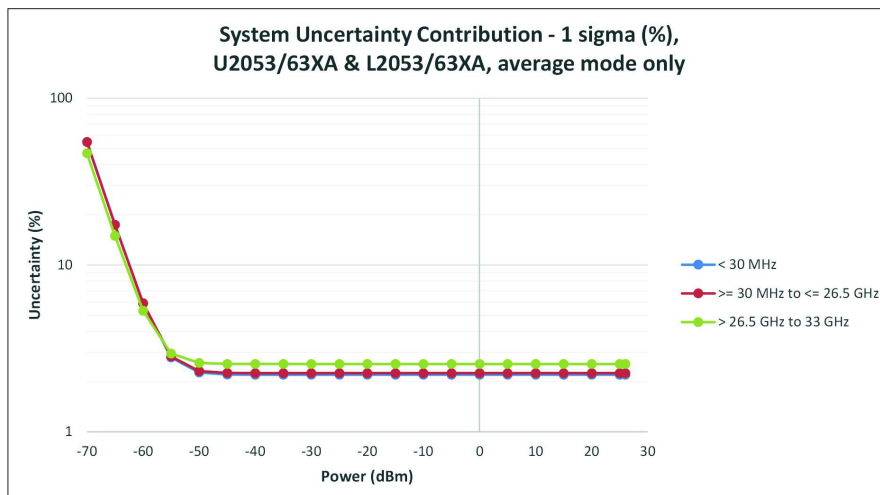
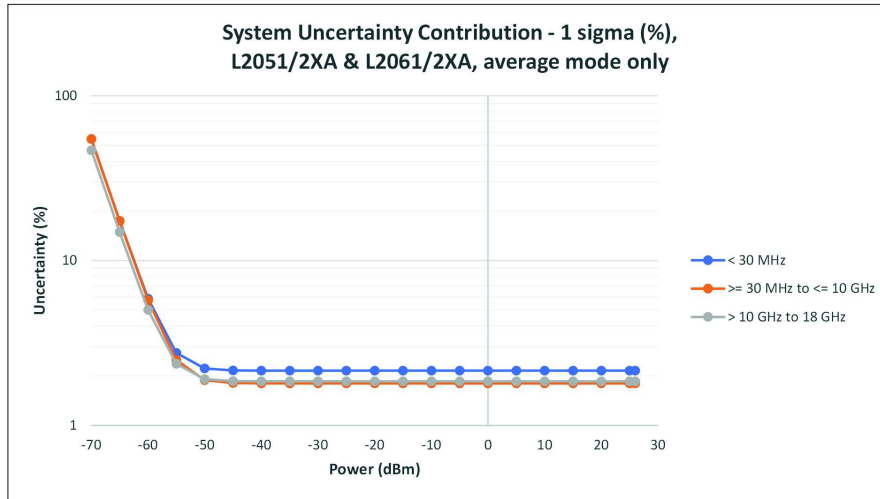
A. System contribution to measurement uncertainty versus power level (equates to step 6 result/2)



Note: The above graph is valid for conditions of free-run operation, with a signal within the video bandwidth setting on the system. Humidity < 70 %.

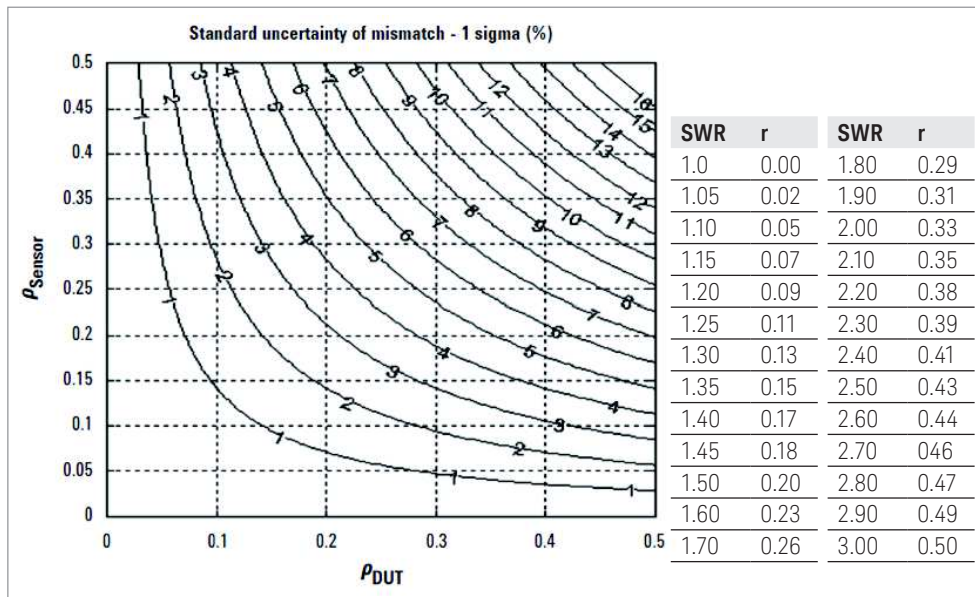
Graphical Example (Continued)

A. System contribution to measurement uncertainty versus power level (equates to step 6 result/2 (Continued))



Graphical Example (Continued)

B. Standard uncertainty of mismatch



Note: The above graph shows the Standard Uncertainty of Mismatch = $\rho_{DUT} \cdot \rho_{Sensor} / \sqrt{2}$, rather than the Mismatch Uncertainty Limits. This term assumes that both the Source and Load have uniform magnitude and uniform phase probability distributions.

C. Combine A and B

$$U_c = \sqrt{(\text{Value from Graph A})^2 + (\text{Value from Graph B})^2}$$

Expanded uncertainty, $k = 2$, = $U_c \cdot 2 = \dots\dots\dots \pm \dots\dots\dots \%$

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